Applying Monetary-Fiscal Policy Interactions: Part II

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Overview

- These notes discuss empirical issues that arise with monetary-fiscal policy interactions
  1. Observational equivalence
  2. Two problems with surplus-debt regressions that arise from the existence of the forward-looking bond-valuation condition
  3. Confronting fiscal data

The Issue

1. **Observational Equivalence (OE):** two or more underlying entities are indistinguishable on the basis of their observable implications
2. In econometrics, two *structures* are observationally equivalent if they imply the same probability distribution of data
3. Consider two distinct policy regimes: **M:** active M/passive F and **F:** passive M/active F
4. **M** and **F** are OE if they produce equilibrium data with the same covariance generating process
5. Two structures, θ_q and θ_r, are OE if and only if $F(\gamma|\theta_q) = F(\gamma|\theta_r)$ for all γ

The Issue

1. There is related idea: structure q is **nearly observational equivalence** to r if $F(\cdot|\theta_q)$ is “close to” $F(\cdot|\theta_r)$
2. Near equivalence of members of the sequence $\{\theta_k\}$ to θ_r implies that for any $\varepsilon > 0$ we can find a k such that $F(\gamma|\theta_k) - F(\gamma|\theta_r) < \varepsilon$ for all γ [Faust(1996)]
3. Near OE preserves many of the implications of strict OE
4. For practical empirical purposes, near OE is most relevant
5. Equivalence makes it difficult to identify

Result #1

- Cochrane (2010,2011) shows that indeterminant equilibria can generate time series that are indistinguishable from determinant ones
- Employs a Fisherian model

$$R_t = r + E_t \pi_{t+1}$$
$$R_t = r + \alpha \pi_t + x_t$$
$$x_t = b(L) \varepsilon_{x,t}$$

R: nominal interest rate, π: inflation rate, r constant real rate, x_t is square summable, $\sum_j b_j^2 < \infty$

Result #1

Proposition

(Cochrane) *For any stationary time series process for* $\{R_t, \pi_t\}$ *that solves*

$$E_t \pi_{t+1} = \alpha \pi_t + x_t \tag{1}$$

and for any α*, one can construct an* x_t *process that generates the same process for the observables* $\{R_t, \pi_t\}$ *as a solution to* (1) *using the alternative* α*. If* $\alpha > 1$*, the observables are generated as the unique bounded forward-looking solution. Given an assumed* α *and the process* $\pi_t = a(L)\varepsilon_{x,t}$*, where* $a(L)$ *is a polynomial in the lag operator* L*, we can construct* $x_t = b(L)\varepsilon_{x,t}$ *with*

$$b_j = a_{j+1} - \alpha a_j$$

or

$$b(L) = (L^{-1} - \alpha)a(L) - a(0)L^{-1} \tag{2}$$

Result #1

Proof.

To prove the proposition note that for $\alpha > 1$ and $x_t = b(L)\varepsilon_{x,t}$, the unique π_t is given by

$$\pi_t = \left(\frac{Lb(L) - \alpha^{-1}b(\alpha^{-1})}{1 - \alpha L}\right)\varepsilon_{x,t} = a(L)\varepsilon_{x,t} \quad (3)$$

For $\alpha < 1$, the equilibrium will not be uniquely determined and one may construct a π_t solved "backward" to obtain, $\pi_t = x_t/(1 - \alpha L)$. Specifying $b(L)$ as (2) and substituting into (3) gives $\pi_t = x_t/(1 - \alpha L)$. Under this restriction, the inflation process generated by $\alpha < 1$ will be identical to the inflation process generated by $\alpha > 1$. Proving the converse (starting with $\alpha < 1$ and showing that there exists an $\alpha > 1$ that generates the observational equivalence) is straightforward since one can always write the solution as $\pi_{t+1} = \alpha\pi_t + x_t + \delta_{t+1}$, where δ_{t+1} is an arbitrary shock. In this case, setting $\delta_{t+1} = a_0\varepsilon_{t+1}$ delivers the result. Note that because $R_t = r + E_t\pi_{t+1}$, matching the inflation process also delivers an equivalence in the nominal interest rate. □

Meaning of the Proposition

- Illustrates that important identifying restrictions are imposed through the assumed exogenous processes
- Cross-equation restrictions in (3) show tight relationship between exogenous & endogenous variables
- Cochrane (2011) emphasizes that for an exogenous process like (2) cannot tell if observed time series generated by determinate or indeterminate eqm
- Cochrane's proposition relies on indeterminate equilibria taking particular form
- But there are an infinite number of indeterminate equilibria
- Now show observational equivalence between *unique* equilibria from decoupled determinacy regions

Result #2

- Example of strict OE
- Extend Fisherian economy to include fiscal policy
- The log-linearized equilibrium equations are

$$R_t = \pi_{t+1} \tag{4}$$

$$b_t + (\beta^{-1} - 1)s_t = \beta^{-1} b_{t-1} + \beta^{-1}(R_{t-1} - \pi_t) \tag{5}$$

  where we have used that in steady state, $s/b = \beta^{-1} - 1$; equations hold for $t \geq 0$, given $R_{-1} b_{-1} > 0$
- Add linearized policy rules

$$R_t = \alpha \pi_t \tag{6}$$

$$s_t = \gamma b_{t-1} \tag{7}$$

Result #2

- Substitute rules (6) & (7) into (4) & (5) to get system

$$\pi_{t+1} = \alpha \pi_t, \quad t \geq 0$$
$$b_t + \beta^{-1}\pi_t = \gamma^* b_{t-1} + \alpha\beta^{-1}\pi_{t-1}, \quad t \geq 1$$
$$b_0 + (\beta^{-1} - 1)s_0 = \beta^{-1}(b_{-1} + R_{-1})$$

  where $\gamma^* \equiv \beta^{-1} - \gamma(\beta^{-1} - 1)$

- Consider special case where $b_{-1} = R_{-1} = 0$ (not necessary)

Result #2

- With $\alpha > 1$ & $\gamma > 1$, unique bounded eqm is

$$\pi_t = 0, \quad R_t = 0, \quad b_t = 0, \quad s_t = 0, \quad \text{for all } t \geq 0$$

- Can implement eqm in (11) with PM/AF rules

$$R_t = 0, \qquad s_t = 0$$

  for $t \geq 0$ (these rules emerge when $\alpha = \gamma = 0$)
- With constant r, the MP rule implies $\pi_{t+j} = 0,\ j \geq 1$
- $R_t = 0$ & $s_t = 0$ for $t \geq 0$ implies debt process

$$b_t = \beta^{-1} b_{t-1} - \beta^{-1} \pi_t \tag{8}$$

- Iterating forward and taking expectations yields

$$b_t = \sum_{j=1}^{\infty} \beta^j \pi_{t+j} = 0$$

- If $b_t = 0$, then (8) implies that $\pi_t = 0$

The Literature

- Three approaches to observational equivalence
  1. Ignore it due to ignorance [Canzoneri, Cumby, Diba]
  2. Acknowledge it and push one interpretation [Cochrane]
  3. Acknowledge it and try to break it
- Those who ignore it seem to think you can “test” if eqm condition holds

$$\frac{B_{t-1}}{P_t} = \sum_{T=t}^{\infty} E_t q_{t,T} s_T$$

  - if it fails to hold in data, “reject” fiscal theory
- Only one problem with this: eqm condition holds in both regimes
- Some DSGE evidence

Traum & Yang (2011)

- A medium-size NK model estimated to U.S. postwar data
- Includes only one-period government bonds & income taxes

	Log Bayes Factor for Regime M
1955–1966	9.8
1967–1979	7.9
1984–2007	22

- Consistently strong evidence in favor of M
- Very strong evidence in favor of M post–1982

Tan (2014)

- Smaller scale NK model estimated to U.S. postwar data
- Includes only one-period & long bonds & lump-sum taxes

	Log Bayes Factor for Regime M	
	Short	Long
1955–1966	85.6	35.3
1967–1979	240.2	49.1
1984–2007	86.9	-5.8

- Consistently very strong evidence in favor of M
- Exception is post–1984 with long debt

Leeper, Traum & Walker (2017)

- A medium-size NK model estimated to U.S. postwar data
- Includes long government bonds & factor taxes & steady state tax rates

	Log Bayes Factor for Regime M
1955–2014	-8
1955–2007	11
1955–1979	4
1982–2007	12

- Far weaker evidence in favor of M
- Generally, data do not favor one regime over the other

Wrap Up

- Surprising that Regimes M & F can display OE
- Exogenous shocks to MP & FP have starkly different impacts in the two regimes
- What's going on?
- Exogenous shocks are not observables
- In a stochastic model, OE entails finding shock processes that deliver the same covariance generating process for **endogenous** variables
  - e.g., shocks might be AR(1) in M, but ARMA(2,3) in F to deliver OE
  - in Cochrane's prop, we are solving for the b_j's that deliver identical $\{\pi_t\}$
- If impose identical processes across regimes, no OE: but get identification from strong assumptions about unobservables
- Much work remains to be done on this topic

Surplus-Debt Regressions I

- Many studies follow Bohn (1998) to estimate fiscal reaction functions of the form

$$s_t = \gamma b_{t-1} + \mu_t$$

  s and b: primary surplus and government debt as shares of GDP; $\mu_t = \delta X_t + \varepsilon_t$, X "controls" and ε fiscal disturbance
  - Bohn interprets positive estimates of γ to mean "the government is taking actions—reducing noninterest outlays or raising revenue—that counteract the changes in debt"
  - those fiscal actions, Bohn argues, imply that fiscal policy is sustainable
- Regressions like this play key role in policy analysis
  - underpin IMF's fiscal space calculations
  - basis for literature that tests for sustainability

Scrutinizing Surplus-Debt Regressions

- Estimates seem justified econometrically
  - b_{t-1} determined at $t-1$, should be predetermined for s_t
  - this view reflects the "backward" interpretation of debt: accumulation of past gross deficits
  - predeterminedness requires $E[\varepsilon_t | b_{t-1}] = 0$
- What could be wrong with this econometric argument?
  - policy rule is just one of many equations describing equilibrium
    1. asset-pricing relations determine bond yields
    2. monetary policy determines relationship between inflation & bond yields
    3. bond valuation equation: "forward" representation determines *value* of government debt

Scrutinizing Surplus-Debt Regressions

- Bond valuation: embeds asset prices & optimizing behavior

$$b_{t-1} = E_{t-1} \sum_{T=t}^{\infty} q_{t-1,T} s_T$$

$b_{t-1} = B_{t-1}/P_{t-1}$, q real discount factor, s primary surplus

  - *in any equilibrium* real debt positively *correlated* with expected surpluses (not about causality)
  - if ε_t serially correlated, $E[\varepsilon_t | b_{t-1}] \neq 0$

- Monetary policy: if the price of bonds, $1/P_{t-1}$, depends on expected surpluses
  - debt-GDP ratio depends on future surpluses
  - if ε_t serially correlated, $E[\varepsilon_t | b_{t-1}] \neq 0$

- Single-equation estimates of γ cannot control for these features of the general equilibrium

Illustrative Model

- Cashless, constant-endowment, infinite-horizon
  - $1/\beta$ constant gross real interest rate
  - government purchases zero, issues nominal bonds that sell at price $1/R_t$, levies lump-sum taxes
  - log-linearized around deterministic steady state

$$\text{Fisher relation}: \quad R_t = E_t \pi_{t+1}$$

$$\text{Monetary policy}: \quad R_t = \alpha \pi_t + \varepsilon_t^R$$

$$\text{Fiscal policy}: \quad s_t = \gamma b_{t-1} + \varepsilon_t^S$$

$$\text{Government budget}: \quad b_{t-1} = \beta b_t - \beta R_t + \pi_t + (1-\beta) s_t$$

$\varepsilon^R, \varepsilon^S$ exogenous $AR(1)$ with $0 \leq \rho_R, \rho_S < 1$ & innovations $\xi^R, \xi^S \sim N(0,1)$

- Two regimes deliver unique bounded equilibria

$|\alpha| > 1, |\gamma| > 1$: active monetary/passive fiscal "Regime M"

$|\alpha| < 1, |\gamma| < 1$: passive monetary/active fiscal "Regime F"

Model Solution

- Regime M: $\alpha > 1, \gamma > 1$

$$\pi_t = -\frac{1}{\alpha - \rho_R}\varepsilon_t^R$$

$$b_{t-1} = (1 - \Gamma L)^{-1}\left[\frac{1 - \beta\rho_R}{\beta(\alpha - \rho_R)}\varepsilon_{t-1}^R - (\beta^{-1} - 1)\varepsilon_{t-1}^S\right]$$

$$s_t = \gamma b_{t-1} + \varepsilon_t^S$$

$$\Gamma \equiv \beta^{-1} - \gamma(\beta^{-1} - 1) < 1$$

- Regime F: $0 \leq \alpha < 1, \gamma = 0$

$$\pi_t = b_{t-1} - \frac{1 - \beta}{1 - \beta\rho_S}\varepsilon_t^S$$

$$b_{t-1} = (1 - \alpha L)^{-1}\left[\varepsilon_{t-1}^R + \left(\frac{(1 - \beta)(\rho_S - \alpha)}{1 - \beta\rho_S}\right)\varepsilon_{t-1}^S\right]$$

$$s_t = \varepsilon_t^S$$

Using the Model

- Treat the model as the data-generating process
- Use equilibrium $\{s_t, b_{t-1}\}$ in each regime to compute the linear projection

$$\mathcal{P}[s_t | b_{t-1}] = \phi b_{t-1}$$

- Note that can write

$$\phi = \frac{E(s_t b_{t-1})}{E b_{t-1}^2} = \gamma + \frac{E(b_{t-1} \varepsilon_t^S)}{E b_{t-1}^2} = \gamma + \frac{\text{cov}(b_{t-1}, \varepsilon_t^S)}{\text{var}(b_{t-1})}$$

- Ask if $\phi = \gamma$
  - $\text{cov}(b_{t-1}, \varepsilon_t^S)/\text{var}(b_{t-1})$ is the bias
  - turns out the bias depends on policy regime and policy parameters
- Note: equilibrium real debt an $AR(2)$ in innovations to policy shocks

Bias in Regime M

$$\phi = \gamma - (1 - \Gamma^2) \frac{\frac{\rho_S(\beta^{-1}-1)}{1-\Gamma\rho_S}}{(\beta^{-1}-1)^2\left(\frac{1+\Gamma\rho_S}{1-\Gamma\rho_S}\right) + \left(\frac{\beta^{-1}-\rho_R}{\alpha-\rho_R}\right)^2\left(\frac{1+\Gamma\rho_R}{1-\Gamma\rho_R}\right)\frac{\text{var}(\varepsilon_t^R)}{\text{var}(\varepsilon_t^S)}}$$

- Bias disappears if $\rho_S = 0$: no change in expectations
- Bias negative if $0 < \rho_S < 1$: serial correlation of shocks dominates endogenous response to debt in short run
- Size of bias increases with α: more aggressive MP reduces debt volatility
- Bias increasing in var(ε^S)/var(ε^R): more volatile FP makes bias worse
- In regime M: $\gamma > 1$ and estimates will tend to find *larger* values, but this doesn't affect qualitative inferences of fiscal behavior

Bias in Regime F

$$\phi = \gamma + (1-\alpha^2)\frac{\frac{\rho_S(1-\beta)(\rho_S-\alpha)}{(1-\beta\rho_S)(1-\alpha\rho_S)}}{\left(\frac{(1-\beta)(\rho_S-\alpha)}{1-\beta\rho_S}\right)^2\left(\frac{1+\alpha\rho_S}{1-\alpha\rho_S}\right)+\left(\frac{1+\alpha\rho_R}{1-\alpha\rho_R}\right)\frac{\text{var}(\varepsilon_t^R)}{\text{var}(\varepsilon_t^S)}}$$

- In this case, $\gamma = 0$ so $\phi =$ bias
- Bias disappears if $\rho_S = 0$: no change in expectations
- sign(bias) $=$ sign$(\rho_S - \alpha)$
  - $\rho_S > \alpha$: serial correlation dominates effect on bond prices, so b_{t-1} moves with ε_{t-1}^S
  - $\alpha > \rho_S$: effect on bond prices dominates serial correlation, so b_{t-1} moves against ε_{t-1}^S
- Bias increasing in var(ε^S)/var(ε^R): more volatile FP makes bias worse
- In regime F: $\gamma = 0$ but estimates may find either positive or negative values, which could affect qualitative inferences of fiscal behavior

Summary

- Regressions most likely to be unreliable in cases where surpluses *do not* respond to debt
  - if $H_0 : \gamma = 0$, reason to believe may reject even when hypothesis is true
  - type I error
- This exposition simply *illustrates* that single-equation surplus-debt regressions may be unreliable
- This becomes a quantitative question: how big is the bias?
- But also a qualitative question: what monetary-fiscal regime prevails?
- Can we use data to distinguish between regime M & regime F?

Surplus-Debt Regressions II

- Two types of surpluses & government bonds
  1. fully backed ("ordinary")
  2. unbacked ("emergency")
- The government budget identity is

$$\frac{B_t^e + B_t^o}{P_t} + s_t^e + s_t^o = \frac{(1 + i_{t-1})(B_{t-1}^e + B_{t-1}^o)}{P_t}$$

  total debt $B_t = B_t^e + B_t^o$; total surplus $s_t = s_t^o + s_t^e$
- Model economy with representative HH
  - constant endowment, cashless, no govt purchases
  - utility depends only on consumption, c_t
  - nominal debt, B_t, pays gross interest, $1 + i_t$
  - primary surplus, s_t, is lump-sum taxes net of transfers

Model

- HH's intertemporal budget constraint in period t

$$E_t \sum_{T=t}^{\infty} q_{t,T} c_T = \frac{(1+i_{t-1})B_{t-1}}{P_t} + E_t \sum_{T=t}^{\infty} q_{t,T} \left[y_T - s_T \right]$$

- Yields an equilibrium condition at t

$$\frac{(1+i_{t-1})(B^o_{t-1} + B^e_{t-1})}{P_t} = E_t \sum_{j=0}^{\infty} \beta^j s_{t+j} = s^o_t + s^e_t + \beta E_t PV(s^o + s^e)$$

- Ordinary & emergency distinguished by fiscal rules
  - ordinary debt fully backed by future surpluses
  - marginal changes in emergency debt unbacked

$$s^o_t = \bar{s}^o + \gamma \left[\frac{(1+i_{t-1})B^o_{t-1}}{P_t} - \bar{b}^o \right]$$

  $\{s^e_t\}$ a stationary stochastic process with innovation ε_t
- Assume MP pegs nominal rate: $i_t = \bar{i}$, all t

Equilibrium

- s^e: "emergency" net taxes—unbacked
  - $ds^e_t < 0$ & set $\beta d(PV(s^e)) = 0 \Rightarrow$ increase nominal wealth/demand
- s^o: "ordinary" net taxes—backed by future taxes
  - $ds^0_t = -\beta d(PV(s^o)) \Rightarrow$ no change in wealth/demand
- Ricardian equiv $\Rightarrow$ all "ordinary" terms cancel *for any* $\{P_t\}$ sequence (not just eqm prices)
- Reduces eqm condition to involve only "emergency" terms

$$\frac{(1+\bar{i})B^e_{t-1}}{P_t} = E_t \sum_{j=0}^{\infty} \beta^j s^e_{t+j} \tag{9}$$

- Determines eqm price level & nominal aggregate demand
  - shocks that raise s^e are deflationary

Equilibrium

- Given eqm $\{P_t\}$ from (9), ordinary debt evolves as

$$\frac{B_t^o}{P_t} = (\gamma \bar{b}^o - \bar{s}^o) + (1-\gamma)\left[\frac{(1+\bar{i})B_{t-1}^o}{P_t}\right]$$

  γ chosen to stabilize ordinary debt: $\gamma > 1 - \beta$
- What does the *aggregate* fiscal rule look like?
- Remember that the "e"/"o" distinction does not typically occur in actual data
- We have data on aggregate surpluses & debt
- Let steady-state real debt levels be

$$\bar{b}^o \equiv \left(\overline{\frac{B^o}{P}}\right), \quad \bar{b}^e \equiv \left(\overline{\frac{B^e}{P}}\right), \quad \bar{s} = \bar{s}^o + \bar{s}^e$$

Aggregate Fiscal Rule

- Write the fiscal rule as

$$s_t^o + s_t^e = \bar{s}^o + s_t^e + \gamma(1+\bar{i})\left[\frac{B_{t-1}^o}{P_t} + \frac{B_{t-1}^e}{P_t} - \frac{\bar{b}^o}{1+\bar{\pi}} - \frac{B_{t-1}^e}{P_t}\right] \quad (10)$$

- Suppose emergency surpluses obey

$$s_t^e = \bar{s}^e + \varepsilon_t, \quad E_t\varepsilon_{t+1} = 0$$

- From eqm condition (9) & steady state relation $\bar{s}^e = (\beta^{-1} - 1)\bar{b}^e$, it follows that

$$\left(\frac{1+\bar{i}}{1+\pi_t}\right) b_t^e - \left(\frac{1+\bar{i}}{1+\bar{\pi}}\right) \bar{b}^e = \varepsilon_t \quad (11)$$

- Use (11) to replace the second B_{t-1}^e/P_t term in (10)

Aggregate Fiscal Rule

- With that replacement, the aggregate fiscal rule becomes

$$s_t^o + s_t^e = \bar{s}^o + \bar{s}^e + \gamma(1+\bar{i})\left[\frac{b_{t-1}^o + b_{t-1}^e}{1+\pi_t} - \frac{\bar{b}^o + \bar{b}^e}{1+\bar{\pi}}\right] + \gamma(1+\bar{i})\varepsilon_t$$

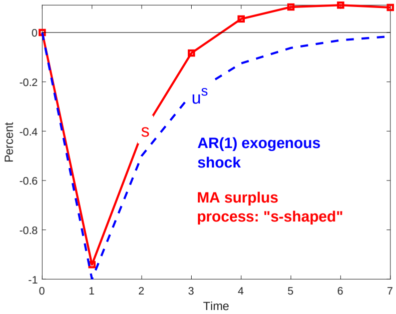
or

$$s_t = \bar{s} + \gamma(1+\bar{i})\left[\frac{B_{t-1}}{P_t} - \frac{\bar{b}}{1+\bar{\pi}}\right] + \xi_t \qquad (12)$$

- If $\gamma > 1 - \beta$, infer fiscal behavior is passive
  - the same condition that stabilizes ordinary debt
  - infer that shocks that raise s do not affect price level
- Can generalize $\{s_t^e\}$ process and (12) will take different forms, but message that would infer aggregate fiscal behavior is passive remains

Confronting Fiscal Data

- Fiscal policy poses a host of new issues relative to MP
  - “Fiscal Analysis is Darned Hard” discusses many
- Here focus narrowly on a topic Cochrane emphasizes: “s-shaped” primary surplus

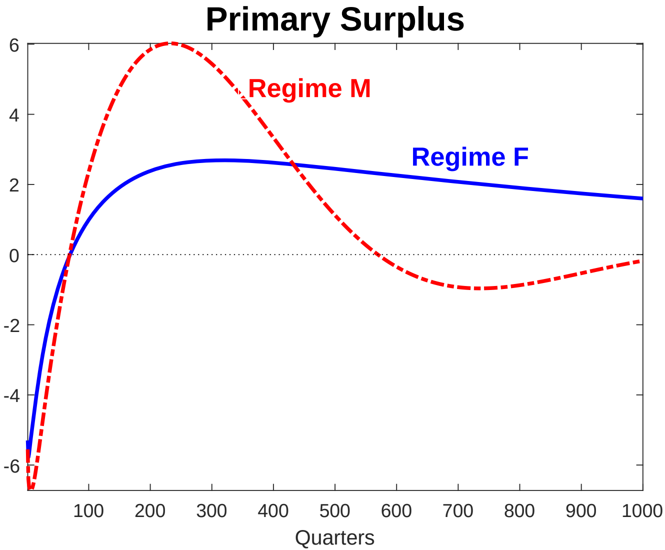


- Deficits tend to be followed by surpluses

s-shaped Surplus

- For good institutional reasons, surpluses are *not* $AR(1)$
  - $AR(1)$ convenient for theory
  - disaster for interpreting data
- Some reasons
  1. Governments can sell debt only if investors assured debts will be paid off
  2. Surpluses strongly cyclical: low in recessions, high in recoveries
  3. Even when FP does not adjust instruments in response to debt, tax codes & spending programs still remain in place
  4. An $AR(1)$ denies all these
- Medium-scale DSGE models with sufficient fiscal detail & fit to data estimate s-shape, but at *very* low frequency
  - holds regardless of monetary-fiscal regime

s-shaped Surplus From Data



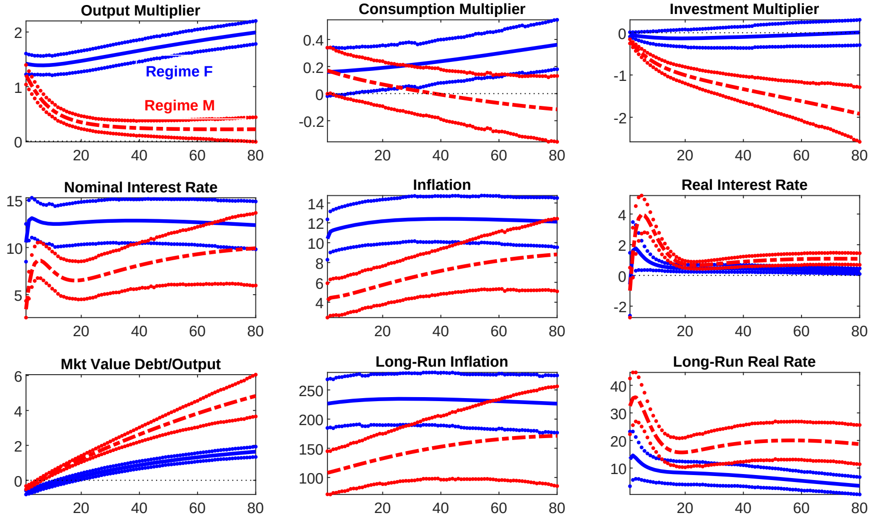
Following government purchase increase.

Source: Leeper-Traum-Walker (2017)

Policy Identification

- Despite observational equivalence, much at stake in identifying policy regime
- My approach to observational equivalence:
  1. Continue to work on identifying policy
  2. In meantime, acknowledge OE and be agnostic
- Agnosticism: examine policy impacts in both Regime M & F
- If data cannot choose between regimes, policy makers need to know it
- Prevailing regime becomes part of our uncertainty
- Example: government purchase multipliers

Fiscal Impacts Conditional on Regime



Following government purchase increase.

Source: Leeper-Traum-Walker (2017)

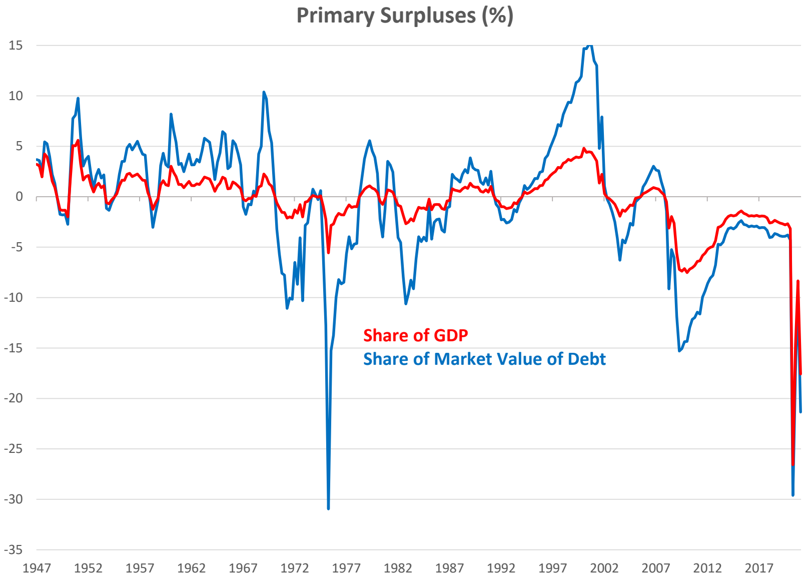
Fiscal Data

- We showed: conventional theory consistent with range of patterns of correlation
- Have the equilibrium condition

$$\frac{\sum_{j=0}^{\infty} Q_t^{(t+j)} B_{t-1}^{(t+j)}}{P_t} = E_t \sum_{j=0}^{\infty} q_{t,t+j} s_{t+j}$$

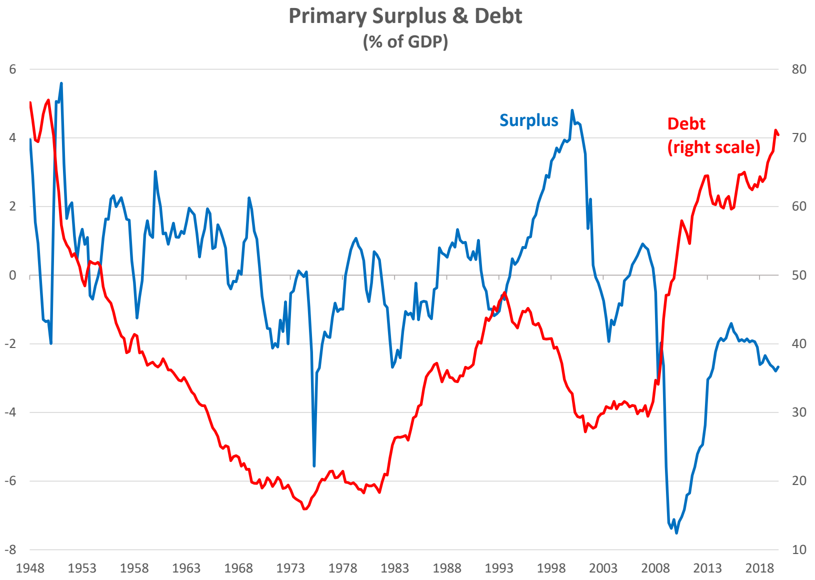
- Consider $ds_t < 0$ financed by $dB_t^{(t+j)} > 0$: possible adjustments
  - $P_t \uparrow$ (usual fiscal theory outcome)
  - $Q_t^{(t+j)} \downarrow \Rightarrow P_{t+j} \uparrow$
  - $s_{t+j} \uparrow \Rightarrow$ outcome depends on $dPV(s)$
  - $q_{t,t+j} \uparrow \Rightarrow$ outcome depends on $dPV(s)$
  - even possible $P_t \downarrow \Rightarrow$ all inflation in future
- Theoretical predictions—like data—hinge on how monetary & fiscal policies react

Primary Surpluses



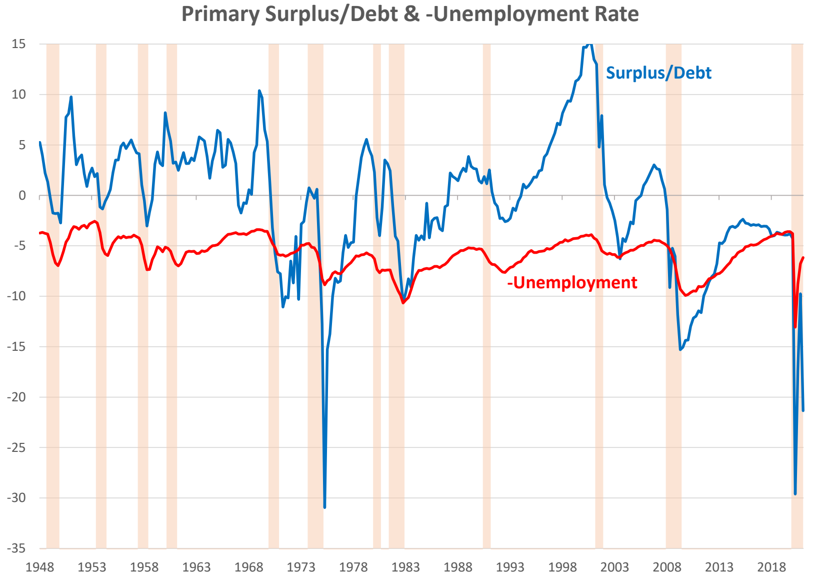
What is a “fiscal impulse?”

Surplus & Debt



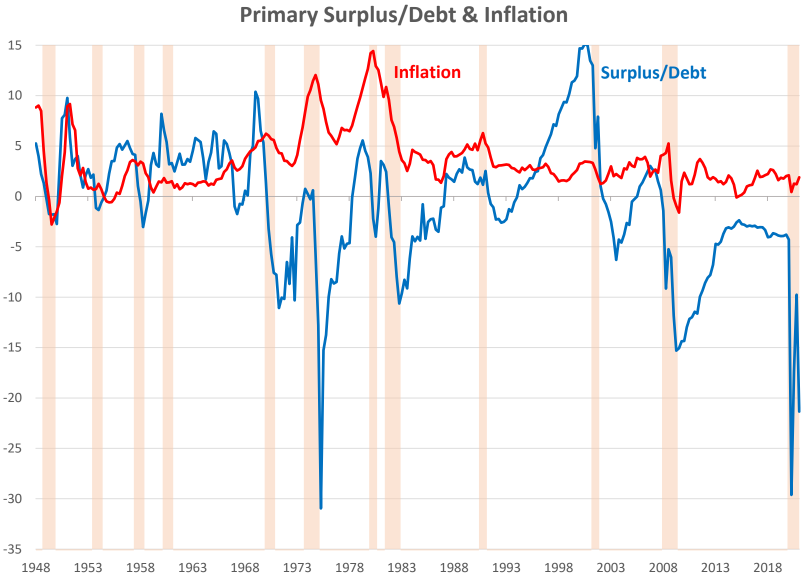
Surpluses help to retire debt

Surplus & Unemployment



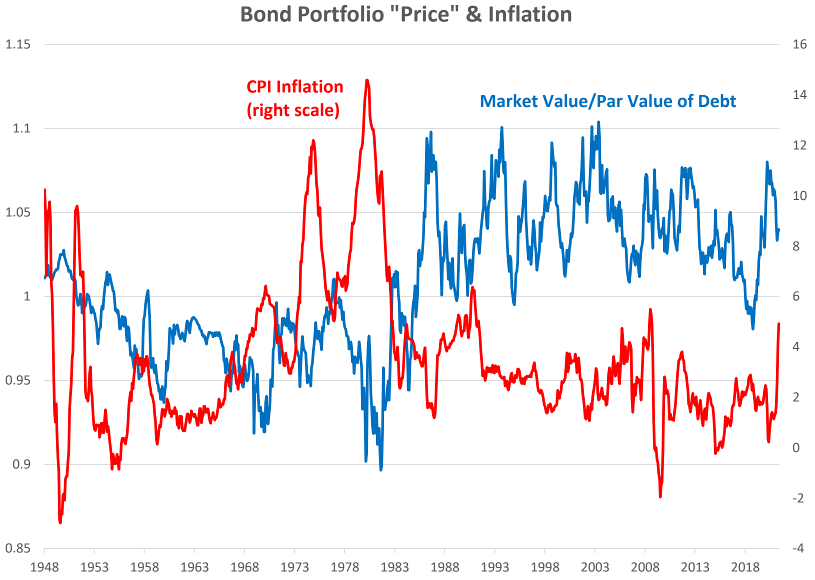
Surpluses move strongly with business cycle

Surplus & Inflation



Subtle dynamic correlation between surpluses & inflation

Bond Prices & Inflation



Bond prices generally reflect inflation trends

Going Beyond Pictures

- Cochrane's "Fiscal Roots of Inflation"
- A (largely) reduced-form exploration of dynamic correlations among components of the government's budget identity
- Some suggestive identification of "shocks"
- Obtains certain provocative results
- Don't need to buy his interpretations to find results useful
- Creative, full of ideas for further work

Budget Identity

- V_t is market value of nominal government liabilities

$$V_t \equiv M_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)}$$

M_t: non-interest bearing money ("high-powered")
B_t^{t+j}: zero-coupon bonds sold at t, due at $t+j$

- Define liability-GDP ratio

$$v_t \equiv \log\left(\frac{V_t}{P_t Y_t}\right)$$

- Nominal return on government portfolio

$$R_{t+1}^n \equiv \frac{M_t + \sum_{j=1}^{\infty} Q_{t+1}^{(t+j)} B_t^{(t+j)}}{M_t + \sum_{j=1}^{\infty} Q_t^{(t+j)} B_t^{(t+j)}}$$

- Further definitions

$$r_{t+1}^n \equiv \log(R_{t+1}^n), \quad \pi_t \equiv \log(P_t/P_{t-1}), \quad g_t \equiv \log(Y_t/Y_{t-1})$$

Budget Identity

- In levels

$$\sum_{j=0}^{\infty} Q_t^{(t+j)} B_{t-1}^{(t+j)} + M_{t-1} = P_t sp_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)} + M_t$$

- Log-linearize around $\rho = e^{-(r-g)}$ with $r > g$

$$\rho v_{t+1} = v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} + s_{t+1}$$

$$v_t = \sum_{j=1}^{\infty} \rho^{j-1} s_{t+j} - \sum_{j=1}^{\infty} \rho^{j-1} (r_{t+j}^n - \pi_{t+j} - g_{t+j})$$

- Take innovations: $\Delta E_{t+1} \equiv E_{t+1} - E_t$ to yield surprise inflation identity

$$\begin{aligned} &\Delta E_{t+1}\pi_{t+1} - \Delta E_{t+1}(r_{t+1}^n - g_{t+1}) \\ &= -\sum_{j=0}^{\infty} \rho^j \Delta E_{t+1} s_{t+1+j} + \sum_{j=1}^{\infty} \rho^j \Delta E_{t+1}(r_{t+1+j}^n - \pi_{t+1+j} - g_{t+1+j}) \end{aligned} \quad (13)$$

Budget Identity Interpretations

- Interpretation
  - $\Delta E_{t+1}\pi_{t+1}$: surprise inflation
  - $\Delta E_{t+1}(r^n_{t+1} - g_{t+1})$: surprise return net of growth
  - $\sum_{j=0}^{\infty} \rho^j \Delta E_{t+1} s_{t+1+j}$: surprise in PV real primary surpluses
  - $\sum_{j=1}^{\infty} \rho^j \Delta E_{t+1}(r^n_{t+1+j} - \pi_{t+1+j} - g_{t+1+j})$: surprise in growth-adjusted real discount rate

$$\Delta E_{t+1}\pi_{t+1} - \Delta E_{t+1}(r^n_{t+1} - g_{t+1}) = -\sum_{j=0}^{\infty} \rho^j \Delta E_{t+1} s_{t+1+j} + \sum_{j=1}^{\infty} \rho^j \Delta E_{t+1}(r^n_{t+1+j} - \pi_{t+1+j} - g_{t+1+j}) \tag{13}$$

- What accounts for changes in surprise inflation?
  - current growth-adjusted returns
  - changes in path of surpluses
  - changes in real discount rates

Budget Identity Interpretations

- In the absence of identifying restrictions, an accounting exercise
- Akin to exercises in Leeper-Traum-Walker (2017) or Leeper-Zhou (2021) from structural models
  - in those, shocks are identified—given unambiguous structural interpretation
- Here we cannot make *causal* statements without further restrictions
- Cochrane employs some sign restrictions to identify a variety of “shocks”
  - but they are hard to map into a DSGE model
- Mostly, he just interprets results through lens of “fiscal theory of monetary policy”

Data

- Cochrane uses annual data on
  - market value of liabilities, V_t
  - nominal return on portfolio, R^m_{t+1}
  - inflation, π_t
  - growth rate of output, g_t
  - 3-month Treasury bill rate
  - 10-year constant maturity bond yield
- Uses linearized flow condition to back out $\{s_t\}$

$$\rho v_{t+1} = v_t + r^n_{t+1} - \pi_{t+1} - g_{t+1} + s_{t+1}$$

- Identity holds exactly, so a VAR with $\{v_t, r^n_t, \pi_t, g_t, s_t\}$ is stochastically singular

Maturity Structure

- Geometric structure: face value of maturity j debt declines at rate ω^j
- Then return on portfolio is

$$\Delta E_{t+1} r^n_{t+1} = -\sum_{j=1}^{\infty} \omega^j \Delta E_{t+1} r^n_{t+1+j}$$
$$= -\sum_{j=1}^{\infty} \omega^j \Delta E_{t+1} [(r^n_{t+1+j} - \pi_{t+1+j}) + \pi_{t+1+j}] \qquad (14)$$

- Lower bond prices correspond to higher bond expected nominal returns
- Bond return responses, $\Delta E_{t+1} r^n_{t+1}$ are large
  - mostly associated with expected inflation
  - not with expected real returns

Cochrane's Procedure

- Experiment with different orthogonalizations
- Not necessarily about "exogenous shocks" as in DSGE models
- Value of procedure
  - not about giving a "structural" interpretation to data
  - seeks interesting patterns of correlation
  - provides grist for future research
- I like this approach

"Inflation Shock"

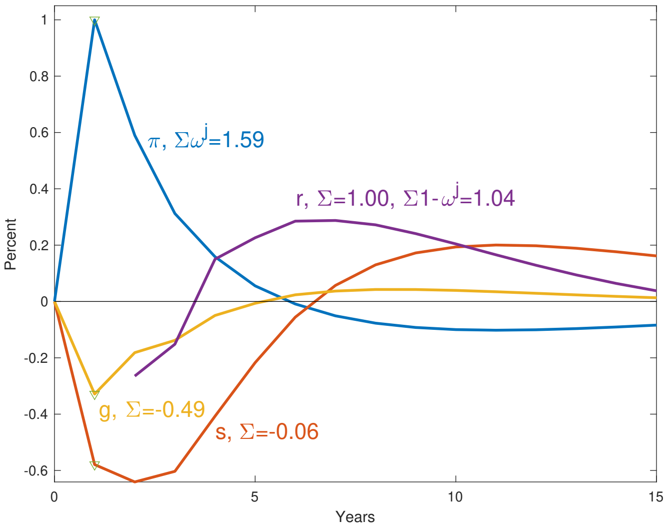
- Unexpected change in $\Delta E_1 \pi_1$
- Set $\varepsilon_1^\pi = 1$
- All variables move contemporaneously with ε_1^π
- For each variable z, regress

$$\varepsilon_{t+1}^z = b_{z,\pi} \varepsilon_{t+1}^\pi + \eta_{t+1}$$

- Start VAR at

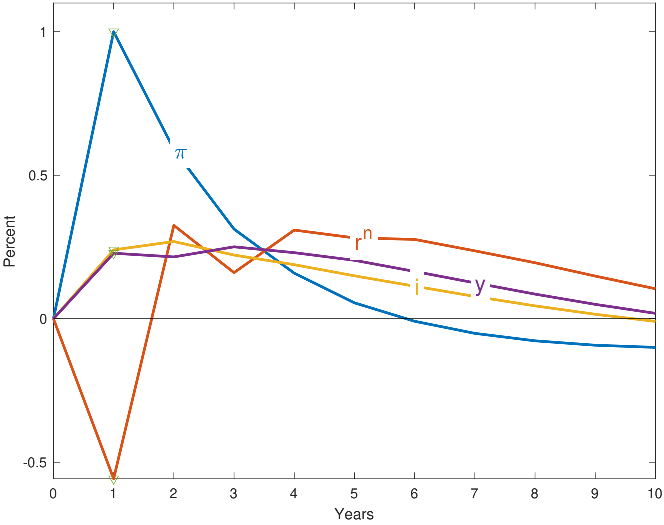
$$\varepsilon_1 = -[b_{r^n,\pi} \quad b_{g,\pi} \quad \varepsilon_1^\pi = 1 \quad b_{s,\pi} \quad \ldots]'$$

“Inflation Shock”



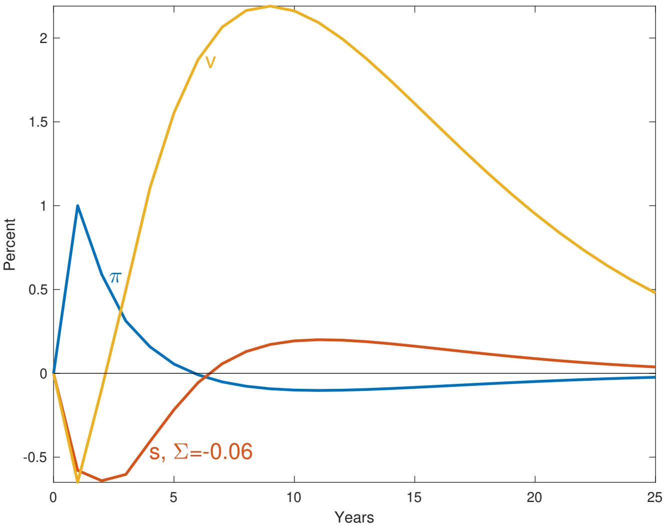
π: inflation, r: discount rate, g: growth rate, s: surplus

"Inflation Shock"



π: inflation, r^n: nominal return on bond portfolio, i: short nominal rate, y: long nominal rate

“Inflation Shock”



π: inflation, v: value of debt, s: surplus

"Inflation Shock"

$$\sum_{j=0}^{\infty}\omega^j \Delta E_1 \pi_{1+j} = -\sum_{j=0}^{\infty}\Delta E_1 s_{1+j} - \sum_{j=0}^{\infty}\Delta E_1 g_{1+j} + \sum_{j=1}^{\infty}(1-\omega^j)\Delta E_1 r_{1+j}$$

	π	$=$	s	g	r
Inflation	1.59	=	-(-0.06)	-(-0.49)	+(1.04)
Recession	-2.36	=	-(-1.15)	-(-1.46)	+(-4.96)

$$\Delta E_1 \pi_1 - \Delta E_1 r_1^n = -\sum_{j=0}^{\infty}\Delta E_1 s_{1+j} - \sum_{j=0}^{\infty}\Delta E_1 g_{1+j} + \sum_{j=1}^{\infty}\Delta E_1 r_{1+j}$$

	π	r^n	$=$	s	g	r
Inflation	1.00	-(-0.56)	=	-(-0.06)	-(-0.49)	+(1.00)
Recession	-1.00	-(1.19)	=	-(-1.15)	-(-1.46)	+(-4.79)

$$\Delta E_1 r_1^n = -\sum_{j=1}^{\infty}\omega^j \Delta E_1 r_{1+j} - \sum_{j=1}^{\infty}\omega^j \Delta E_1 \pi_{1+j}$$

	r^n	$=$	r	π
Inflation	-0.56	=	-(-0.03)	-(0.59)
Recession	1.19	=	-(0.17)	-(-1.36)

π: inflation, s: surplus, g: growth rate, r: discount rate, r^n: nominal return on bond portfolio

Key Findings

- Unexpected inflation associated more strongly with rise in real discount rates than with surpluses
- Argues critical for understanding fiscal underpinnings of standard models
- Example: in 2008, why did inflation fall when deficits rose? Use (13)
  1. Perhaps $s_t < 0 \Rightarrow E_t s_{t+j} > 0$, with future s large enough to drive down π_t
  2. Real & nominal interest rates fell sharply, which plausibly raised value of unchanged s
- Consider $-\Delta E_{t+1}(r^n_{t+1} - g_{t+1})$
  - if $PV(s) \downarrow$, decline in long-term bond prices and $\Delta E_{t+1} r^n_{t+1}$ can lower real value of debt without higher inflation

“Recession Shock”

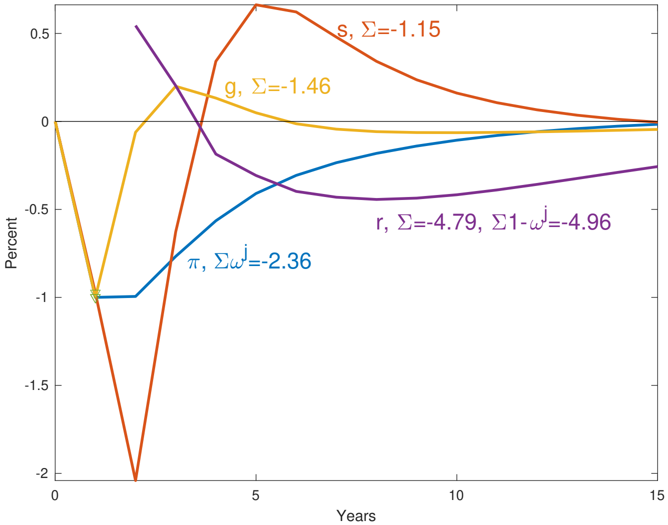
- Shock in which inflation & GDP go in same direction
- Set $\varepsilon_1^\pi = -1$ & $\varepsilon_1^g = -1$
- All variables move contemporaneously with these
- For each variable z, regress

$$\varepsilon_{t+1}^z = b_{z,\pi}\varepsilon_{t+1}^\pi + b_{z,g}\varepsilon_{t+1}^g \eta_{t+1}$$

- Start VAR at

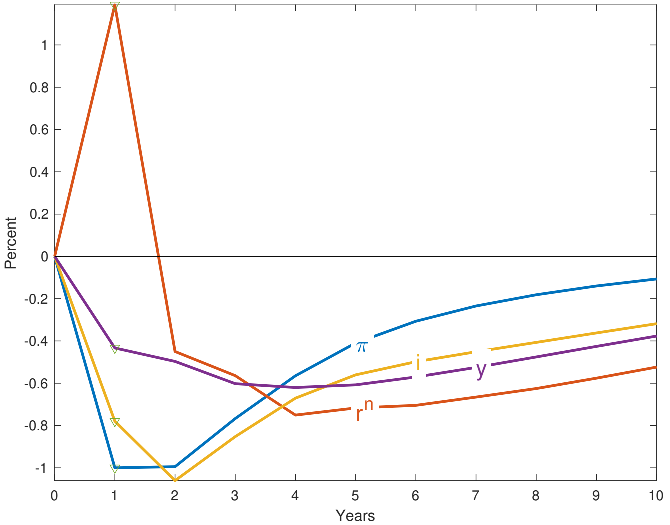
$$\varepsilon_1 = -[b_{r^n,\pi} + b_{r^n,g} \quad \varepsilon_1^g = 1 \quad \varepsilon_1^\pi = 1 \quad b_{s,\pi} + b_{s,g} \quad \ldots\ ]'$$

“Recession Shock”



π: inflation, r: discount rate, g: growth rate, s: surplus

“Recession Shock”



π: inflation, r^n: nominal return on bond portfolio, i: short nominal rate, y: long nominal rate

"Recession Shock"

$$\sum_{j=0}^{\infty} \omega^j \Delta E_1 \pi_{1+j} = -\sum_{j=0}^{\infty} \Delta E_1 s_{1+j} - \sum_{j=0}^{\infty} \Delta E_1 g_{1+j} + \sum_{j=1}^{\infty} (1-\omega^j) \Delta E_1 r_{1+j}$$

	π	=	s	g	r
Inflation	1.59	=	-(-0.06)	-(-0.49)	+(1.04)
Recession	-2.36	=	-(-1.15)	-(-1.46)	+(-4.96)

$$\Delta E_1 \pi_1 - \Delta E_1 r_1^n = -\sum_{j=0}^{\infty} \Delta E_1 s_{1+j} - \sum_{j=0}^{\infty} \Delta E_1 g_{1+j} + \sum_{j=1}^{\infty} \Delta E_1 r_{1+j}$$

	π	r^n	=	s	g	r
Inflation	1.00	-(-0.56)	=	-(-0.06)	-(-0.49)	+(1.00)
Recession	-1.00	-(1.19)	=	-(-1.15)	-(-1.46)	+(-4.79)

$$\Delta E_1 r_1^n = -\sum_{j=1}^{\infty} \omega^j \Delta E_1 r_{1+j} - \sum_{j=1}^{\infty} \omega^j \Delta E_1 \pi_{1+j}$$

	r^n	=	r	π
Inflation	-0.56	=	-(-0.03)	-(0.59)
Recession	1.19	=	-(0.17)	-(-1.36)

π: inflation, s: surplus, g: growth rate, r: discount rate, r^n: nominal return on bond portfolio

Key Findings

- Disinflation in recessions driven by lower discount rate, along with lower short and long nominal rates
- Near-term deficits very large in recessions, but recover within a few years to become surpluses
- Persistent decline in inflation consistent with sharply lower discount rates that overcome inflation effects of deficits
- Suggests need to separately identify aggregate demand & supply

Wrap Up

- Cochrane considers other shocks
- Why is this approach useful?
  1. A way to ask interesting questions about the data: To what variables are surprise increases in inflation related and how are they related?
  2. It provokes reader to ask more structural questions: What underlying shock(s) generate the patterns associated with surprise inflation?
  3. It points to important & new variables to model: Real discount rates matter a lot
- We need more exploratory empirical work like this

Wrap Up

- Observation about discount rates: a crucial nexus of monetary-fiscal interactions
  - real interest rates are the linchpin of the MP transmission mechanism
  - surely, connection to discount rates is tight
  - discount rates affect $EPV(s)$ & value of debt
- Our macro models notoriously poor along asset-pricing dimensions
  - discount rates
  - time-varying term premia
  - exchange rates
- All critical components for understanding monetary & fiscal policies