Fiscal foundations of inflation: imperfect knowledge

Stefano Eusepi
Federal Reserve Bank of New York

Bruce Preston
Monash University

Motivation

- Fiscal conditions and inflation stability

- 'Standard' view of monetary policy
  - Monetary authority alone determines inflation

- Alternative views: 'Unpleasant arithmetic' and Fiscal theory of the price level
  - Outstanding nominal liabilities not fully backed up by future taxes
  - "Nominal anchor" shifts to fiscal policy: fiscal dominance

Motivation

- Fiscal conditions and inflation stability

- This presentation:

  - Departure from rational expectations
  - Expectations inconsistent with policy objectives
  - Fiscal policy affects inflation regardless of the policy regime

What we do

- Simple NK model with government debt of multiple maturities
- Departure from rational expectations:
  - Agents have an incomplete knowledge about the economy: learning
  - Implication: departures from Ricardian Equivalence
- Explore constraints imposed on monetary policy by choice of fiscal policy
  - Specifically: scale and composition of government debt
  - Implications for the great moderation

Model Overview

- **Households**: consumption decision rule
- **Firms**: Phillips curve
- **Monetary and fiscal authorities:** policy rules

Maturity of Public Debt

- Issues two kinds of debt
  - B_t^s: One period debt in zero net supply with price $P_t^s = (1 + i_t)^{-1}$
  - B_t^m: An asset in positive supply that has declining payoff structure

$$\rho^{T-(t+1)} \text{ for } T \geq t + 1$$

- P_t^m denotes the price of this second asset.
- Duration of the debt is $(1 - \beta\rho)^{-1}$; β discount rate

Monetary and Fiscal Authorities

- Flow budget constraint

$$P_t^m B_t^m = \underbrace{B_{t-1}^m \left(1 + \rho P_t^m\right)}_{l_t} - P_t S_t$$

- Surplus

$$S_t = T_t / P_t - G_t$$

  where:

  – Tax revenues T_t include lump-sum and distortionary labor taxes

Monetary and Fiscal Authorities

- Flow budget constraint

$$P_t^m B_t^m = \underbrace{B_{t-1}^m \left(1 + \rho P_t^m\right)}_{l_t} - P_t S_t$$

- Fiscal policy maintains intertemporal solvency ('Passive')

$$\tau_t^i = \bar{\tau}^i \left(\frac{l_t}{P_{t-1}} / \frac{\bar{P}}{\bar{l}} \right)^{\tau_l^i} ; \tau_l^i > \tau_l^{*,i}$$

Monetary and Fiscal Authorities

- Flow budget constraint

$$P_t^m B_t^m = \underbrace{B_{t-1}^m \left(1 + \rho P_t^m\right)}_{l_t} - P_t S_t$$

- Fiscal policy maintains intertemporal solvency ('Passive')

$$\tau_t^i = \bar{\tau}^i \left(\frac{l_t}{P_{t-1}} / \frac{\bar{P}}{\bar{l}} \right)^{\tau_l^i} ; \tau_l^i > \tau_l^{*,i}$$

- Monetary policy controls inflation ('Active')

$$\frac{1 + i_t}{1 + \bar{\imath}} = e^{m_t} \left(\frac{\pi_t}{\pi^*} \right)^{\phi_\pi} ; \ \pi^* = 1, \ \phi_\pi > 1$$

Monetary and Fiscal Authorities

- Flow budget constraint

$$P_t^m B_t^m = \underbrace{B_{t-1}^m \left(1 + \rho P_t^m\right)}_{l_t} - P_t S_t$$

- Fiscal policy maintains intertemporal solvency ('Passive')

$$\tau_t^i = \bar{\tau}^i \left(\frac{l_t}{P_{t-1}} / \frac{\bar{P}}{\bar{l}} \right)^{\tau_l^i} ; \tau_l^i > \tau_l^{*,i}$$

- Monetary policy controls inflation ('Active')

$$\frac{1 + i_t}{1 + \bar{\imath}} = e^{m_t} \left(\frac{\pi_t}{\pi^*} \right)^{\phi_\pi} ; \ \pi^* = 1, \ \phi_\pi > 1$$

- Under rational expectations: standard view of monetary policy

Consumption and govt. debt

Consumption Decision

- Combining Euler eqs., labor supply, budget constraint to log-linear approx. provides

$$\hat{C}_t^i = (1 - \iota\sigma^{-1})\Theta\hat{H}_t^i - \underbrace{\sigma^{-1}}_{\textit{Intert. Subst.}} \beta\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left(\hat{\imath}_T - \hat{\pi}_{T+1}\right)$$

$$+\underbrace{\bar{s}_C^{-1} \cdot \frac{\bar{P}^m \bar{B}^m}{\bar{Y}}}_{\textit{Wealth effects}} \times$$

$$\left[\hat{b}_{t-1}^{m,i} - \hat{\pi}_t + \rho\beta\hat{P}_t^m + \beta\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left(\hat{\imath}_T - \hat{\pi}_{T+1}\right) - (1-\beta)\,\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \hat{\tau}_T^{LS}\right]$$

+ P.D.V. of after-tax wages and profits...

Public Debt and policy expectations

- Evolution of public Debt

$$\hat{b}_t^m = \beta^{-1}\left(\hat{b}_{t-1}^m - \hat{\pi}_t\right) + (1-\rho)\,\hat{\imath}_t - \left(\beta^{-1} - 1\right)\hat{s}_t$$

$$+ (1-\rho)\,\rho\beta\hat{E}_t \sum_{T=t}^{\infty} (\rho\beta)^{T-t}\,\hat{\imath}_{T+1}$$

where $\hat{s}_t$ is surplus and we use the price of government debt

$$\hat{P}_t^m = \underbrace{-\hat{E}_t \sum_{T=t}^{\infty} (\rho\beta)^{T-t}\,\hat{\imath}_T}_{\textit{Expectation Hypothesis}}$$

  - Intermediate values of ρ debt is most sensitive to changes in policy expectations

Information and learning

Knowledge and learning

- Agents know only their own preferences and constraints
  - Simple model: agents are in fact identical but not aware of it
- Observe aggregate variables, prices and disturbances
- Do not know true economic model determining variables outside their control
  - Forecasts using an econometric model
  - Model of anticipated utility: optimization ignores future model revisions

Forecasting Model: Rational Expectations

- The minimum-state-variable solution under RE

$$\mathbb{Z}_t = \bar{\omega}_b^{RE} \hat{b}_{t-1}^m + \bar{\Omega}_{\mathbb{S}}^{RE} \mathbb{S}_{t-1} + \bar{\Omega}_{\epsilon}^{RE} \epsilon_t$$

$$\mathbb{S}_t = F\mathbb{S}_{t-1} + Q\epsilon_t$$

where the vectors

$$\mathbb{Z}_t = \text{endog. forecasting variables}$$

$$\mathbb{S}_t = \text{exog. disturbances}$$

A Simple Forecasting Model

- Agents learn *only about the long-run trends*: for example, average inflation rate

- Assume agents forecast $\mathbb{Z}_t$ using the model

$$\mathbb{Z}_t = \Omega_{0,t-1} + \bar{\omega}_b^{RE} \hat{b}_{t-1}^m + \bar{\Omega}_{\mathbb{S}}^{RE} \mathbb{S}_{t-1} + e_t^k$$

  where the perceived law of motion for the drift $\Omega_{0,t}$ is defined as

$$\Omega_{0,t} = \Omega_{0,t-1} + \nu_t$$

- Use this model to construct relevant forecasts

Updating Parameters

- Agents update their estimates every period according to

$$\hat{\Omega}_{0,t} = \hat{\Omega}_{0,t-1} + g\left(\mathbb{Z}_t - \hat{\Omega}_{0,t-1} - \bar{\omega}_b^{RE}\hat{b}_{t-1}^m - \bar{\Omega}_{\mathbb{S}}^{RE}\mathbb{S}_{t-1}\right)$$

where the constant-gain parameter g is the same for each variable.

- Constant-gain algorithm captures shifting views about long-term trends
  - Discount past observations
  - $\hat{\Omega}_{0,t}$ never converge to REE ($\Omega_{0,t} = \mathbf{0}$) — however they will be ergodically distributed around RE values

Actual Law of Motion

- Given forecasts, the true data generating process is

$$\mathbb{Z}_t = T\left(\bar{\Omega}_{\mathbb{Z}}^{RE}, \bar{\Omega}_{\mathbb{S}}^{RE}\right) \cdot \hat{\Omega}_{0,t-1} + \bar{\omega}_z^{RE} \hat{b}_{t-1}^m + \bar{\Omega}_{\mathbb{S}}^{RE} \mathbb{S}_{t-1} + \bar{\Omega}_{\epsilon}^{RE} \epsilon_t$$

- Actual drift $\left(T\left(\bar{\Omega}_{\mathbb{Z}}^{RE}, \bar{\Omega}_{\mathbb{S}}^{RE}\right) \cdot \hat{\Omega}_{0,t-1}\right) \neq$ Perceived drift $\left(\hat{\Omega}_{0,t-1}\right)$
  - Only under RE: $\hat{\Omega}_{0,t} = \mathbf{0}$

- The model is self-referential: systematic forecast errors
  - Non-Ricardian effects : changes to government debt $\neq$ P.D.V. of taxes

Fiscal policy and inflation during the Great Moderation

Fiscal policy and Great Moderation

- US data: 1984Q1-2007Q2
  - relative stability of the US economy
  - gradual decline in long-term inflation expectations

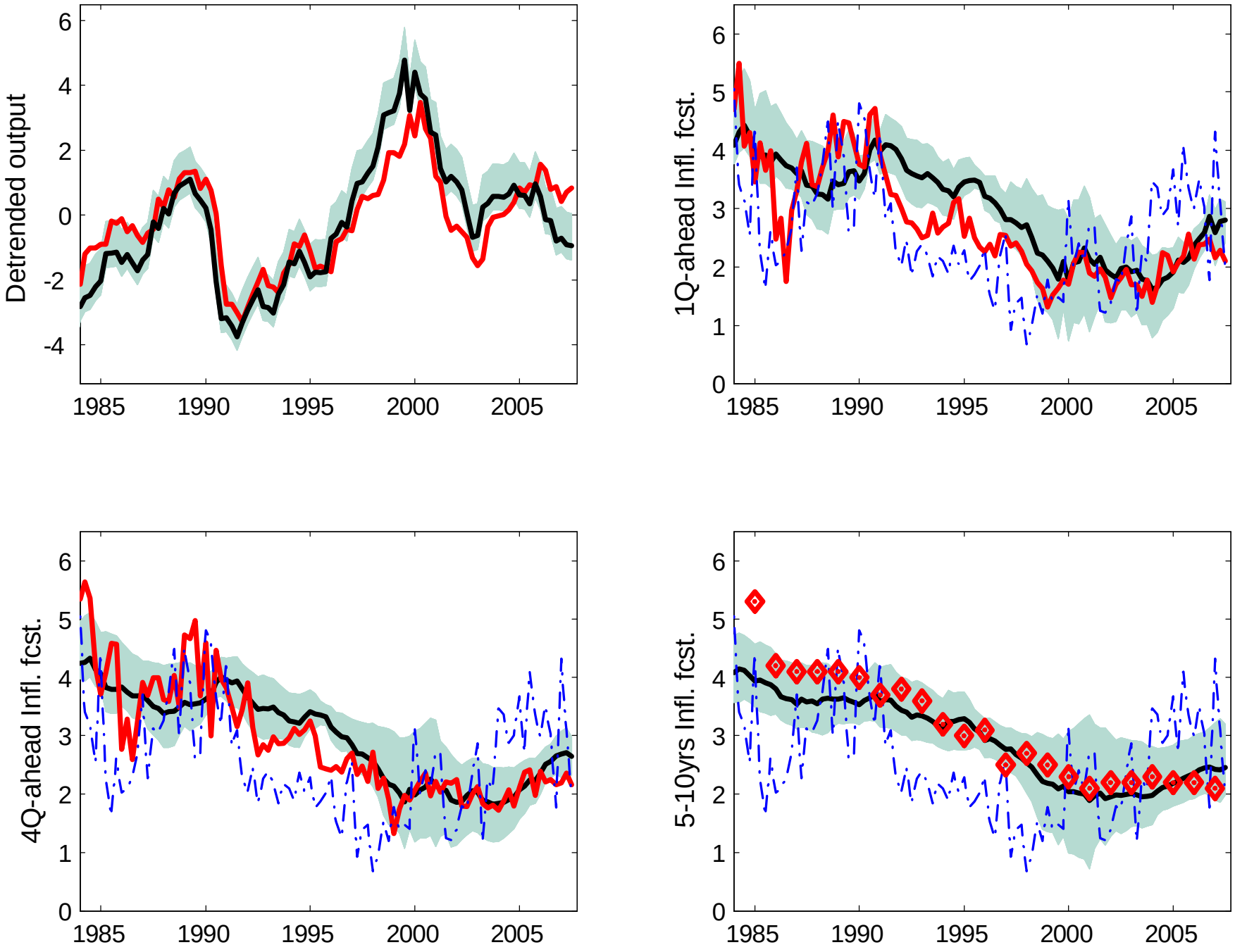
- Role of fiscal policy?
  - Average size and maturity of government debt

Calibration

- IES: $\sigma^{-1} = 1/4$
  - Consistent with medium-scale DSGE models (Coen et. al. 2012)
- Constant gain: $g = 0.025$: 25-years-old obs. with weight < 0.1
- Key policy parameters:
  - Fiscal: debt-to-GDP: 0.4. Average maturity: 5.4;
  - Monetary: $\phi_\pi = 1.5$; $\phi_y = 0.5/4$

Maximum Likelihood

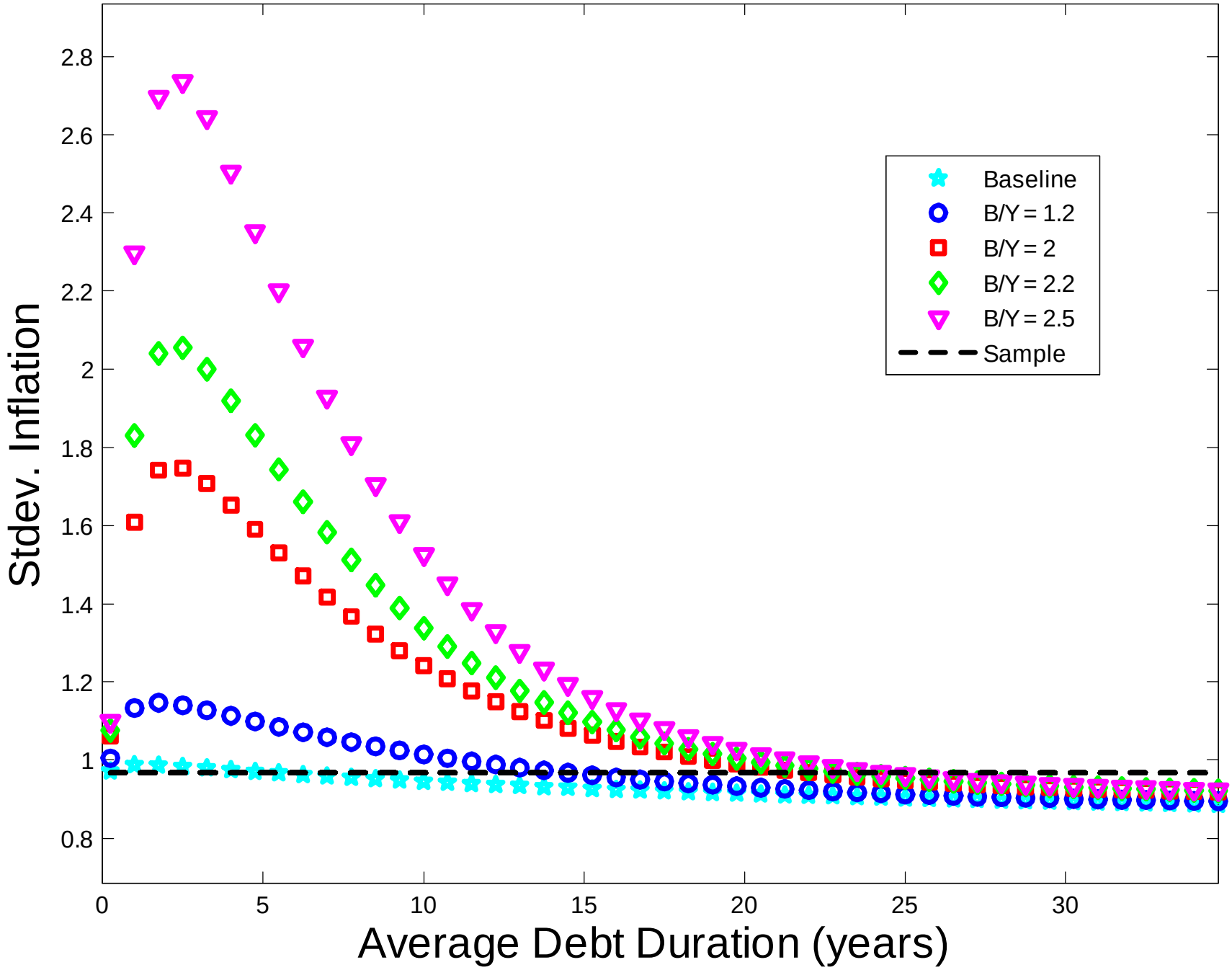
- Estimate the four exogenous disturbances (F, Q)
- Data: GDP growth, 3 months T-Bill rate, GDP deflator inflation and debt-to-GDP ratio
- Given estimates:
  - Counterfactuals under different policy assumptions


Detrended output
1Q-ahead Infl. fcst.
4Q-ahead Infl. fcst.
5-10yrs Infl. fcst.
1985
1990
1995
2000
2005

Counterfactuals

- Suppose the economy experiences the same shocks as the Great Moderation benchmark
  - How does the scale and composition of debt affect dynamic responses to shocks?

- Look at volatility of inflation and output gap


Stdev. Inflation
Average Debt Duration (years)
Baseline
B/Y = 1.2
B/Y = 2
B/Y = 2.2
B/Y = 2.5
Sample
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
0
5
10
15
20
25
30

Inspecting the mechanism

- Consider an increase in inflation expectations

- Low level of steady state debt
  - Higher expected real rate reduces consumption and inflation: stabilizing
  - Key role of substitution effects

- High level of steady state debt
  - Higher government debt produces higher taxes: destabilizing
  - Effects are largest for average maturities of $2-5$ years (most industrialized countries, except UK!)

Self-referentiality and Non-Ricardian effects

Mon. Policy expectations

$\Uparrow$ $\searrow$ $\underbrace{(\frac{1}{\sigma} > 0)}_{Intert.\ Subst.}$

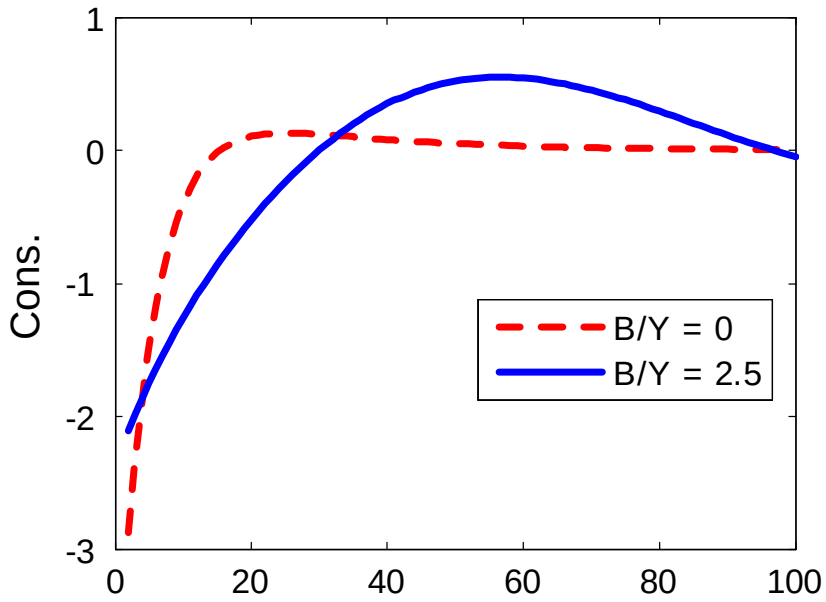
Short-term interest rate $\Longleftarrow$ **Aggr. demand and inflation**

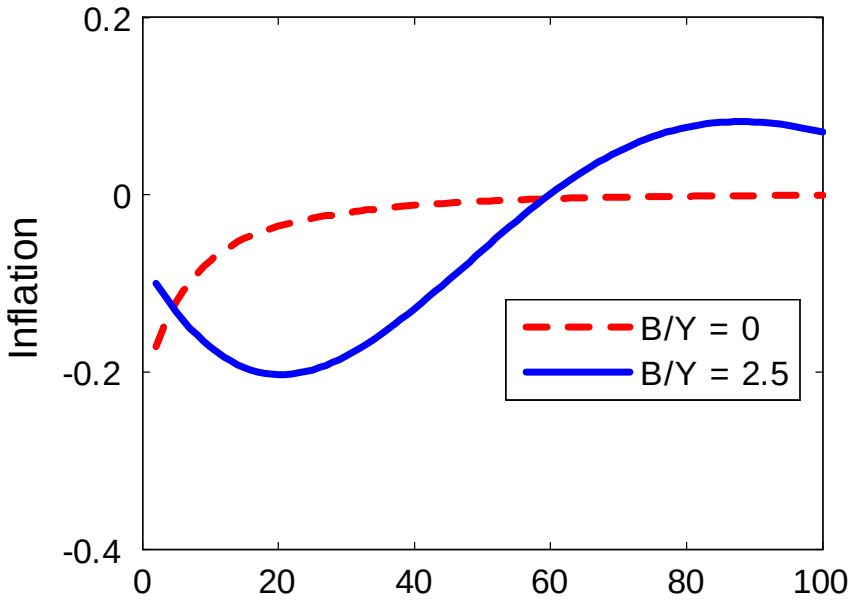
Self-referentiality and Non-Ricardian effects

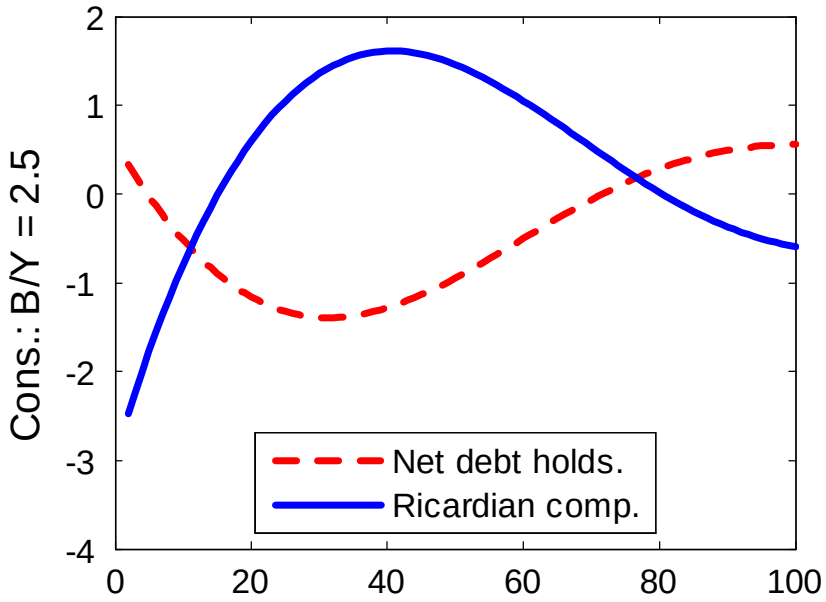
Mon. Policy expectations $\Longrightarrow$ $(\rho \neq 1, 0)$ **Gov. debt and taxes**

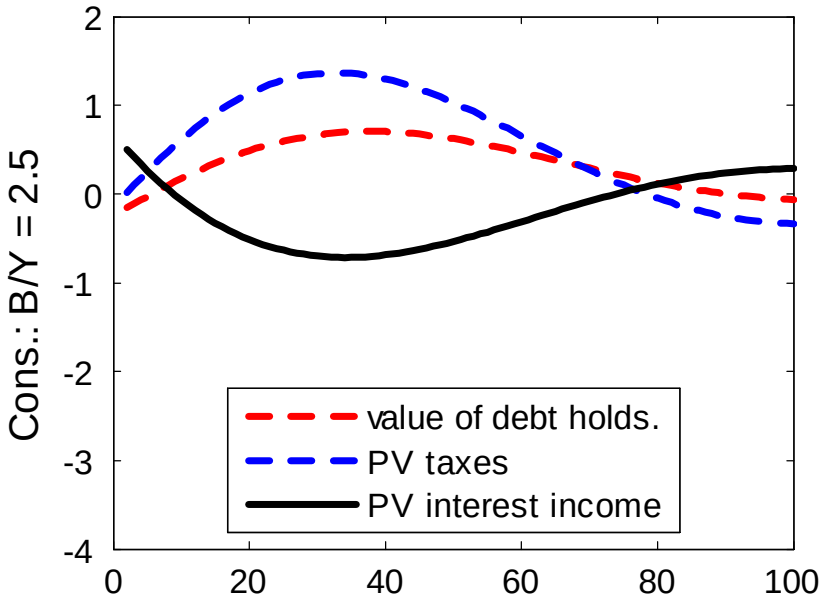
$\Uparrow$ $\searrow$ $\underbrace{(\frac{1}{\sigma} > 0)}_{\textit{Intert. Subst.}}$ $\Downarrow$ $\underbrace{\bar{s}_C^{-1} \cdot \frac{\bar{P}^m \bar{B}^m}{\bar{Y}} > 0}_{\textit{Wealth effects}}$

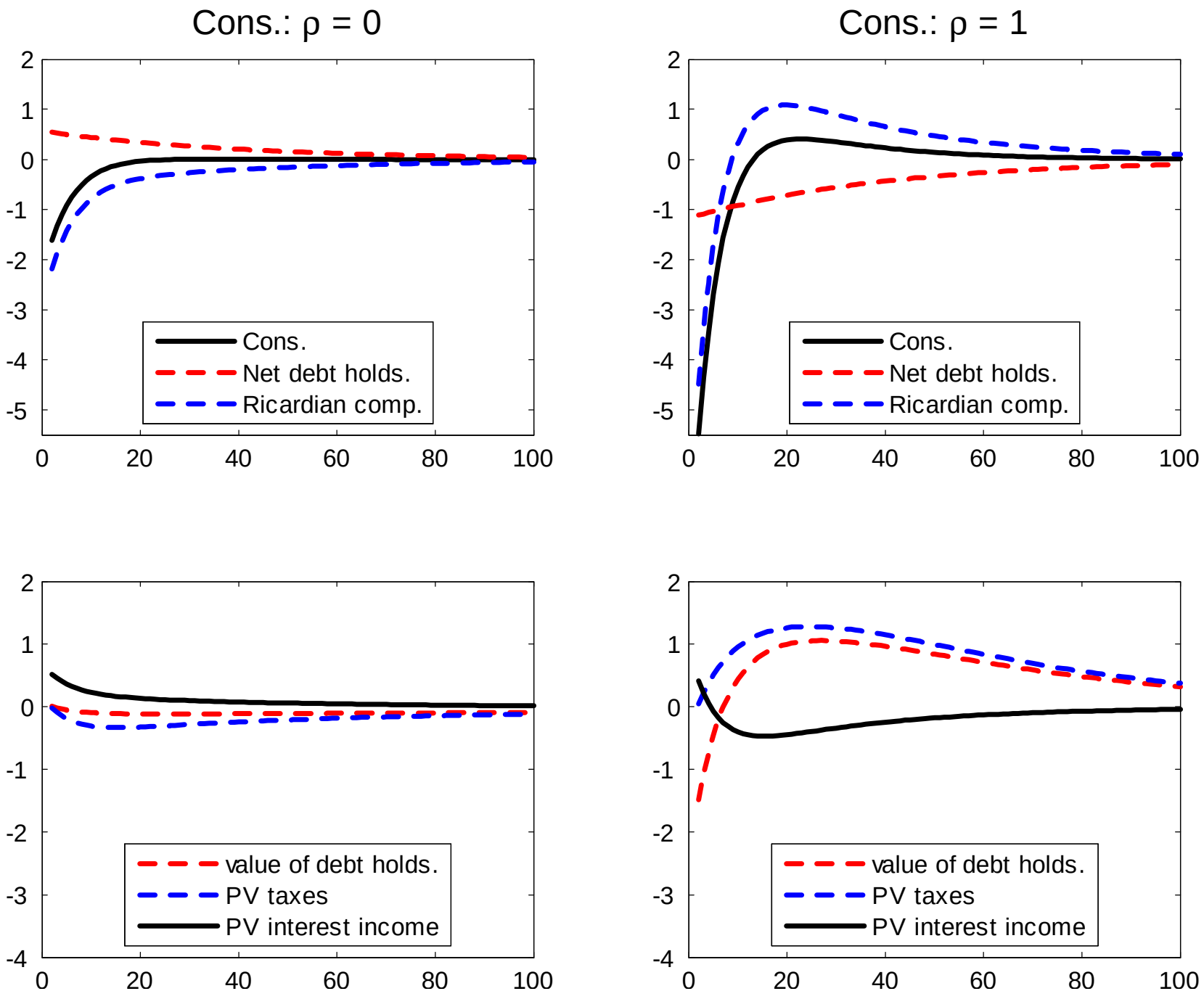
Short-term interest rate $\Longleftarrow$ **Aggr. demand and inflation**


Cons.
1
0
-1
-2
-3
0
20
40
60
80
100
B/Y = 0
B/Y = 2.5


Inflation
0.2
0
-0.2
-0.4
0
20
40
60
80
100
B/Y = 0
B/Y = 2.5


Cons.: B/Y = 2.5
2
1
0
-1
-2
-3
-4
0
20
40
60
80
100
Net debt holds.
Ricardian comp.


Cons.: B/Y = 2.5
2
1
0
-1
-2
-3
-4
0
20
40
60
80
100
value of debt holds.
PV taxes
PV interest income


Cons.: ρ = 0
Cons.
Net debt holds.
Ricardian comp.
Cons.: ρ = 1
Cons.
Net debt holds.
Ricardian comp.
value of debt holds.
PV taxes
PV interest income
value of debt holds.
PV taxes
PV interest income

Consumption Decision

- Combining Euler eqs., labor supply, budget constraint to log-linear approx. provides

$$\hat{C}_t^i = (1 - \iota\sigma^{-1})\Theta\hat{H}_t^i - \underbrace{\sigma^{-1}}_{\textit{Intert. Subst.}} \beta\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left(\hat{\imath}_T - \hat{\pi}_{T+1}\right)$$

$$+\underbrace{\bar{s}_C^{-1} \cdot \frac{\bar{P}^m \bar{B}^m}{\bar{Y}}}_{\textit{Wealth effects}} \times$$

$$\left[\hat{b}_{t-1}^{m,i} - \hat{\pi}_t + \rho\beta\hat{P}_t^m + \beta\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left(\hat{\imath}_T - \hat{\pi}_{T+1}\right) - (1-\beta)\,\hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \hat{\tau}_T^{LS}\right]$$

+ P.D.V. of after-tax wages and profits...

Benefits of long-term debt

- Stable economy even with large debt: why?

- Government debt: debt dynamics independent of bond prices (inflation expectations)

- Households: higher inflation expectations produce negative wealth effects as the value of bond holdings drops

  – Stabilizing effects on aggregate demand

The importance of responding to output

- In high debt economies, more aggressive policy rules are stabilizing
- In contrast with the benchmark model under RE...
- ...monetary policy rules should respond to output
  - Mutes non-Ricardian effects on aggregate demand from fiscal policy

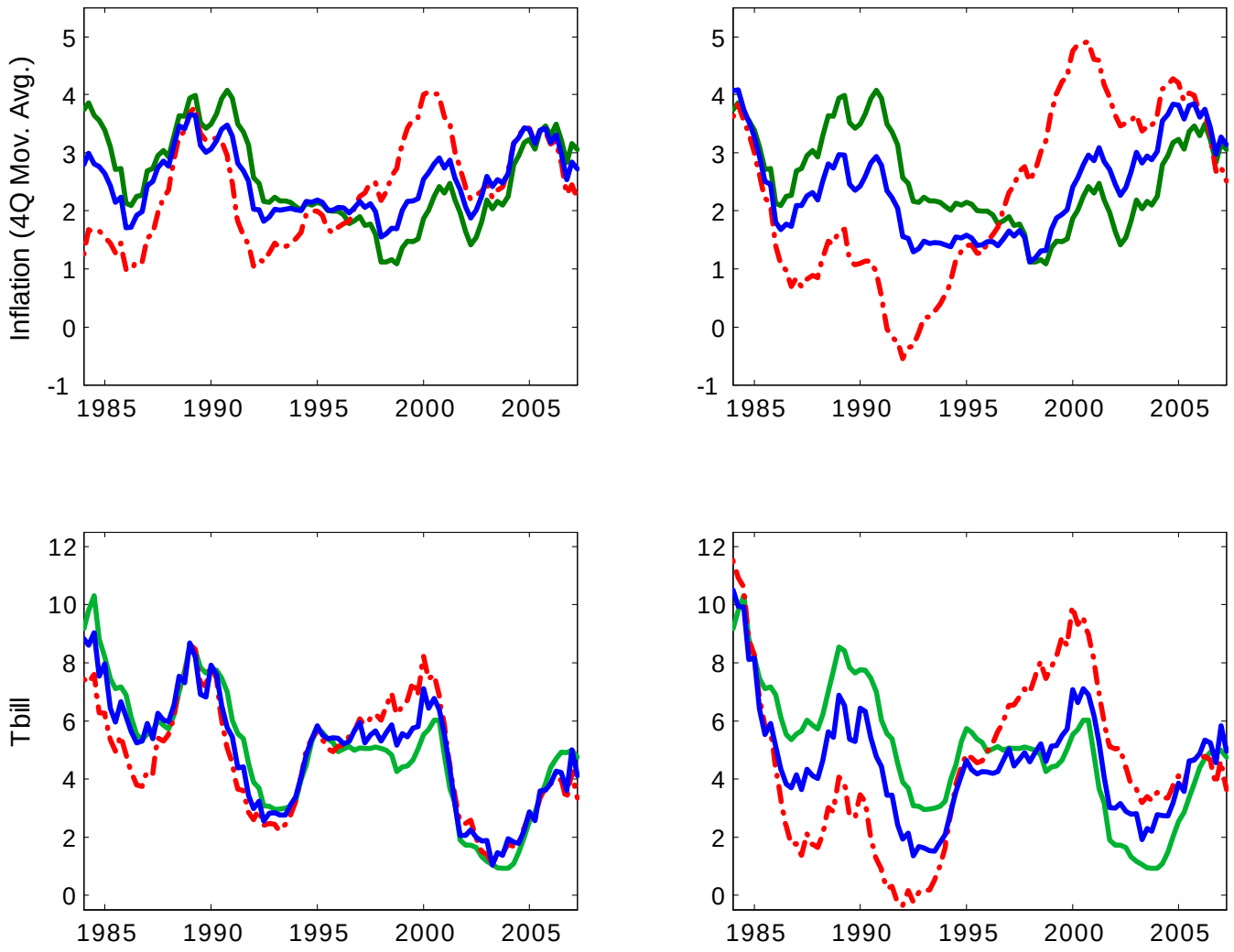


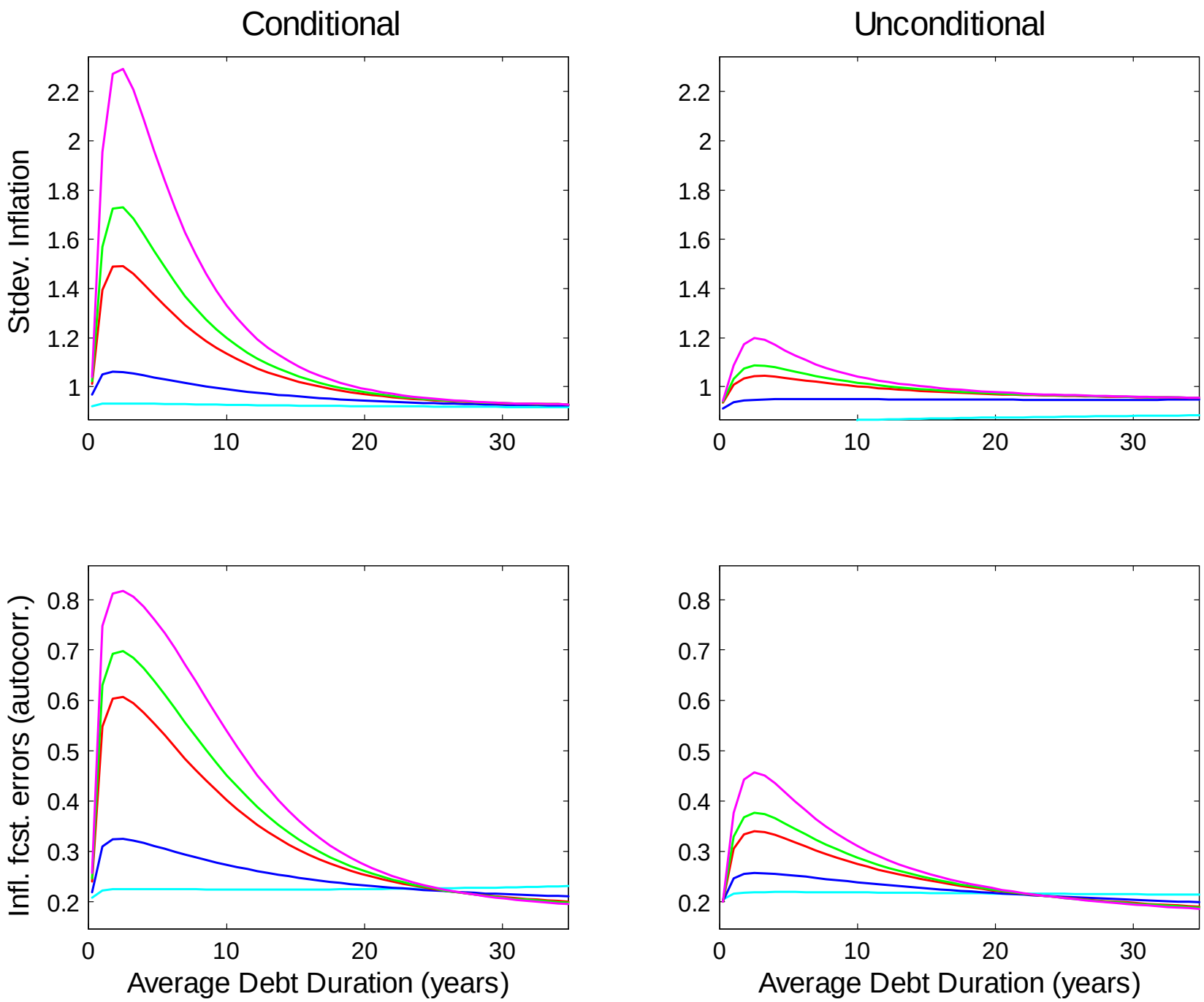
Figure 1: Solid green line: US data. Solid blue line: monetary policy with inflation response of 2, and output response 0.5/4. Red dashed line: inflation response of 2, and output response 0.1/4. Left panel: baseline; right panel average debt 200 percent; average maturity 3.5.

The Role of Inflation Expectations Revisited

- Higher debt with low maturity could have rendered the Great Moderation less moderate

- Final experiment: most of the volatility in inflation is due to the adjustment of inflation expectations over the sample

- Had beliefs closer to their stationary distribution, volatility would be more compressed


Conditional
Unconditional
Stdev. Inflation
Infl. fcst. errors (autocorr.)
Average Debt Duration (years)
Average Debt Duration (years)
0
10
20
30
1
1.2
1.4
1.6
1.8
2
2.2
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Conclusion

- Uncertainty about economic environment (i.e. policy regime) can induce drift in expectations

- High debt levels and short to medium maturity debt induce instability
  - Instability generated through wealth effects

- Fundamentally changes the nature of housd and firm responses to shocks — even if expectations stable in the long-run
  - Great Moderation not so moderate under different fiscal conditions

Extra slides