Dormant Shocks and Fiscal Virtue

Francesco Bianchi
Duke University

Leonardo Melosi
London Business School

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Relation between fiscal discipline and inflation is not stable:

1. Periods of fiscal imbalance are not necessarily inflationary
2. When they are, the spurs of inflation can be:
   - Short lasting and remarkably violent (emerging economies) or...
   - Unfolding over many decades, starting with small increases and then gaining momentum (USA in the '70s)

Traditional DSGE models have a hard time in generating:

1. Heterogeneity in the link over time and across countries
2. Persistent and accelerating increases in inflation

Dormant shocks and Fiscal Virtue

We build a model in which the current behavior of policy makers influence agents' beliefs about the way debt will be stabilized:

- Policy makers are generally virtuous
  1. The fiscal authority controls debt
  2. The monetary authority has full control of inflation

  $\Longrightarrow$ Shocks that hit the debt-to-GDP ratio are dormant

- Policy makers can deviate from the virtuous policy mix
- These deviations can be short or long lasting
- When observing a deviation, agents conduct Bayesian learning to infer its likely duration

Dormant shocks and Fiscal Virtue

- As agents observe more and more deviations, they grow increasingly pessimistic about a prompt return to the Virtuous regime
- Drift in beliefs $\Longrightarrow$ drift in inflation and uncertainty as dormant shocks start manifesting themselves
- Inflation accelerates as initially optimistic agents become relatively pessimistic
- The speed with which these effects unfold critically depends on the country's Fiscal Virtue

Main results

1. Spurs of inflation can unfold over decades. Inflation starts moving slowly, but it accelerates over time
2. Countries with similar levels of inflation during regular times can experience very different outcomes as they start deviating
3. The strict distinction between non-Ricardian and Ricardian regimes typical of the Fiscal Theory of Price Level breaks down
4. We compare the model with US data:
    - The model can explain the run-up in inflation of the '70s and the risk of deflation in the early 2000s
    - Past Fiscal Virtue can hide the current risk of inflation
    - Contradictory statements can conduct to undesirable outcomes

Related literature

- Sargent and Wallace (1981)
- Leeper (1991), Sims (1994), Woodford (1994, 1995, 2001), Cochrane (1998, 2001)
- Bianchi and Ilut (2012) and Sims (2009)
- DSGE models with parameter instability: Schorfheide (2005), Bianchi (2012), Davig and Doh (2011), Fernández-Villaverde et al. (2010), and Liu et al. (2011)
- Modeling the Evolution of Public Expectations and Uncertainty: Bianchi and Melosi (2012)

Two models

- To inspect the mechanism
  $\longrightarrow$ Basic three equations new-Keynesian model augmented with a fiscal rule
- Quantitative analysis
  $\longrightarrow$ Richer model based on Bianchi and Ilut (2012)

Household ▸ Linearized Model

- The representative household maximizes:

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t e^{d_t} \left[\log \left(C_t \right) - h_t \right] \right]$$

subject to the budget constraint:

$$P_t C_t + B_t + P_t T_t = P_t W_t h_t + R_{t-1} B_{t-1}$$

- We assume $d_t = \rho_d d_{t-1} + \sigma_d \epsilon_{d,t}$

Firms ▸ Linearized Model

- Each of the monopolistically competitive firms faces a downward-sloping demand curve:

$$Y_t(j) = \left(P_t(j)/P_t\right)^{-1/\upsilon} Y_t$$

where $1/\upsilon$ is the elasticity of substitution between two differentiated goods

- Whenever a firm wants to change its price, it faces quadratic adjustment costs represented by an output loss:

$$AC_t(j) = \frac{\varphi}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - \Pi\right)^2 Y_t(j)\frac{P_t(j)}{P_t}$$

Technology ▸ Linearized Model

Labor is the only input in a linear production function:

$$Y_t(j) = A_t h_t(j)$$

where total factor productivity A_t evolves according to:

$$\begin{aligned} \ln A_t &= \ln \overline{A} + z_t \\ z_t &= \rho_z z_{t-1} + \sigma_z \epsilon_{z,t} \end{aligned}$$

Monetary authority ▸ Linearized Model

The Central Bank moves the FFR according to the rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R(\xi_t)} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\psi_\pi(\xi_t)} \left(\frac{Y_t}{Y_t^n}\right)^{\psi_y(\xi_t)}\right]^{(1-\rho_R(\xi_t))} e^{\sigma_R \epsilon_{R,t}}$$

where R is the steady-state gross nominal interest rate, Y_t^n is natural output, Π is the target level for gross inflation, and ξ_t is a hidden variable that determines the regime in place at time t.

Fiscal authority Back

- The Government budget constraint is given by:

$$b_t = b_{t-1}\left(Y_t\Pi_t/Y_{t-1}\right)^{-1}R_{t-1} - s_t$$

where $b_t = B_t/\left(P_tY_t\right)$ and $s_t = S_t/\left(P_tY_t\right)$

- The government moves primary surpluses according to the rule:

$$s_t = \left(1-\rho_s\right)\delta_b\left(\xi_t\right)b_{t-1} + \rho_s s_{t-1} + \sigma_s\epsilon_{s,t}$$

- In order to completely isolate the effects of fiscal discipline, we assume that the government only provides a subsidy or raises taxes $\left(T_t = S_t\right)$.

Households and firms ▸ Full Model

- Linearized Euler Equation:

$$y_t = E_t(y_{t+1}) - (R_t - E_t(\pi_{t+1})) + (1 - \rho_d)\, d_t \qquad (1)$$

- Expectation augmented Phillips curve:

$$\pi_t = \beta E_t(\pi_{t+1}) + \kappa(y_t - z_t) \qquad (2)$$

- Stochastic processes of the shocks:

$$d_t = \rho_d d_{t-1} + \sigma_d \epsilon_{d,t} \qquad (3)$$
$$z_t = \rho_z z_{t-1} + \sigma_z \epsilon_{z,t} \qquad (4)$$

where $\epsilon_{d,t} \sim N(0,1)$ and $\epsilon_{z,t} \sim N(0,1)$

Policy makers

- Linearized government budget constraint:

$$b_t = \beta^{-1} b_{t-1} + b\beta^{-1} \left(R_{t-1} - \pi_t - \Delta y_t \right) - s_t \qquad (5)$$

- Fiscal rule:

$$s_t = \rho_s s_{t-1} + \left(1 - \rho_s\right) \delta_{b,\xi_t} b_{t-1} + \sigma_s \epsilon_{s,t} \qquad (6)$$

- Monetary rule:

$$R_t = \left(1 - \rho_{R,\xi_t}\right) \left(\psi_{\pi,\xi_t} \pi_t + \psi_{y,\xi_t} \left[y_t - z_t \right] \right) \qquad (7)$$

$$+\rho_{R,\xi_t} R_{t-1} + \sigma_R \epsilon_{R,t} \qquad (8)$$

where $\epsilon_{R,t} \sim N\left(0,1\right)$ and $\epsilon_{s,t} \sim N\left(0,1\right)$

Monetary/Fiscal Policy Mix

When regimes are taken in isolation, the two policy rules and the linearized budget constraint are key to determine existence and uniqueness of a solution:

$$R_t = \rho_{R,\xi_t} R_{t-1} + \left(1 - \rho_{R,\xi_t}\right) \psi_{\pi,\xi_t} \pi_t + \ldots$$

$$s_t = \rho_s s_{t-1} + (1 - \rho_s) \delta_{b,\xi_t} b_{t-1} + \ldots$$

$$\begin{aligned} b_t &= \beta^{-1} b_{t-1} + \ldots - s_t \\ &\rightarrow b_t = \left(\beta^{-1} - \delta_{b,\xi_t}\right) b_{t-1} + \ldots \end{aligned}$$

Monetary/Fiscal Policy Mix ▸ Four cases

Leeper (1991) shows that two determinacy regions exist:

	ψ_{π,ξ_t}	δ_{b,ξ_t}
Active Monetary, Passive Fiscal	> 1	$> \beta^{-1} - 1$
Passive Monetary, Active Fiscal	< 1	$< \beta^{-1} - 1$

- AM/PF $\longrightarrow$ Taylor principle is satisfied, fiscal police accommodates behavior of monetary authority $\longrightarrow$ Ricardian regime
- PM/AF $\longrightarrow$ Taylor principle is not satisfied, inflation is free to move to keep debt on a stable path $\longrightarrow$ non-Ricardian regime

Allowing for regime changes

- We assume that the policy mix is generally virtuous:

$$AM/PF \rightarrow \psi_{\pi}(\xi_t = 1) = \psi_{\pi}^{A} > 1,\ \delta_b(\xi_t = 1) = \delta_b^{P} > \beta^{-1} - 1$$

- However, policy makers can deviate from the Virtuous regime:

$$PM/AF \rightarrow \psi_{\pi}(\xi_t = 2) = \psi_{\pi}^{P} < 1,\ \delta_b(\xi_t = 2) = \delta_b^{A} < \beta^{-1} - 1$$

$$PM/AF \rightarrow \psi_{\pi}(\xi_t = 3) = \psi_{\pi}^{P} < 1,\ \delta_b(\xi_t = 3) = \delta_b^{A} < \beta^{-1} - 1$$

Allowing for regime changes

- These deviations can be short or long lasting:

$$p_{22} << p_{33}$$

- Short lasting deviations are (conditionally) more frequent:

$$p_{12} > p_{13}$$

- Transition matrix:

$$H = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ 1 - p_{22} & p_{22} & \\ 1 - p_{33} & & p_{33} \end{bmatrix}$$

Model Solution

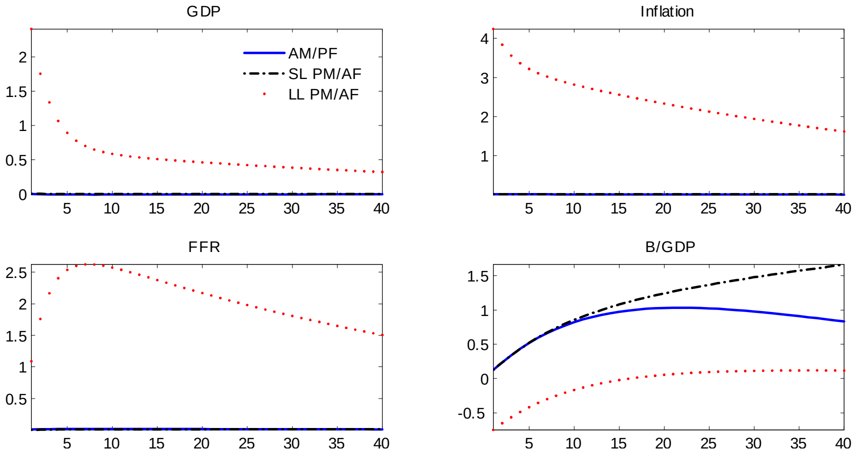
- Agents are aware of the possibility of regime changes $\Longrightarrow$ standard solution methods do not apply
- The solution algorithm employed in this paper is based on the work of Farmer, *et al.* (2010)
- When a solution exists, it can be characterized as a regime switching vector-autoregression:

$$S_t = T(\xi_t, \theta, H) S_{t-1} + R(\xi_t, \theta, H) \varepsilon_t \tag{9}$$

Calibration

Parameter	Value	Parameter	Value	Parameter	Value
ψ_π^A	2.00	ρ_s	0.90	$100\sigma_R$	0.20
ψ_y^A	0.10	ρ_z	0.90	$100\sigma_s$	0.50
ρ_R^A	0.75	ρ_d	0.90	$100\sigma_z$	0.70
δ_b^P	0.03	b	1.00	$100\sigma_d$	0.40
ψ_π^P	0.80	κ	0.05	p_{11}	0.95
ψ_y^P	0.10	β	0.99	p_{12}	0.495
ρ_R^P	0.75			p_{22}	0.70
δ_b^A	0			p_{33}	0.99

Impulse responses: Primary deficit shock ▸ MP

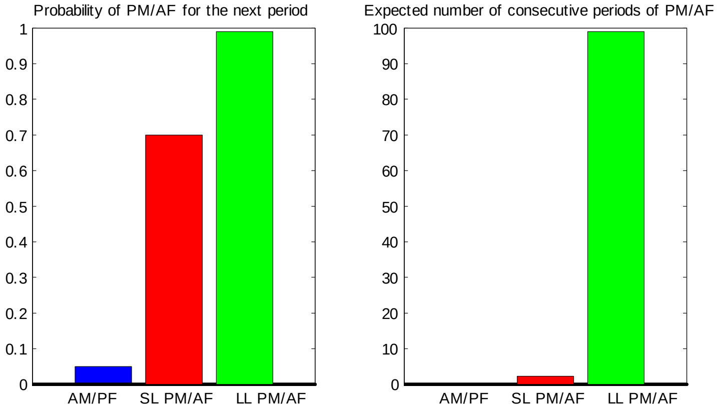


Agents' Beliefs

The interaction between agents' beliefs and policy makers' behavior implies that:

1. Virtuous regime and short lasting deviations are Ricardian
2. Long lasting deviations are non-Ricardian

Agents' Beliefs



Information set

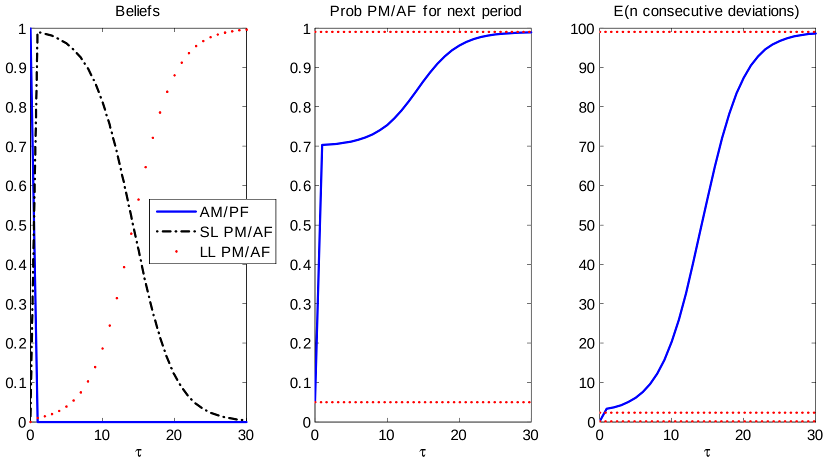
We assume that agents...

1. ...can observe the history of the endogenous variables and structural shocks
2. ...cannot observe the history of regimes, instead they conduct Bayesian learning

Then:

1. The Virtuous regime is fully revealing
2. The nature of an unobserved deviation is unknown $\Longrightarrow$ *As policy makers keep deviating, agents grow more and more pessimistic about moving back to the Virtuous regime*

Evolution of Agents' Beliefs ▸ Details



Solving the model with learning

Model dynamics cannot be captured by the three policy regimes:

- Expanded number of regimes defined as a combination between policy makers' behavior and agents' beliefs
- If $\tau = x$, the economy can only move to:
  1. $\theta^{AM/PF}, \tau = 0$
  2. $\theta^{PM/AF}, \tau = x + 1$

  $\Longrightarrow$ Transition matrix $H \rightarrow$ transition matrix $\widetilde{H}$
- Upper bound to pessimism: For each $\varepsilon > 0$, $\exists$ integer $\tau^* > 0$ s.t.

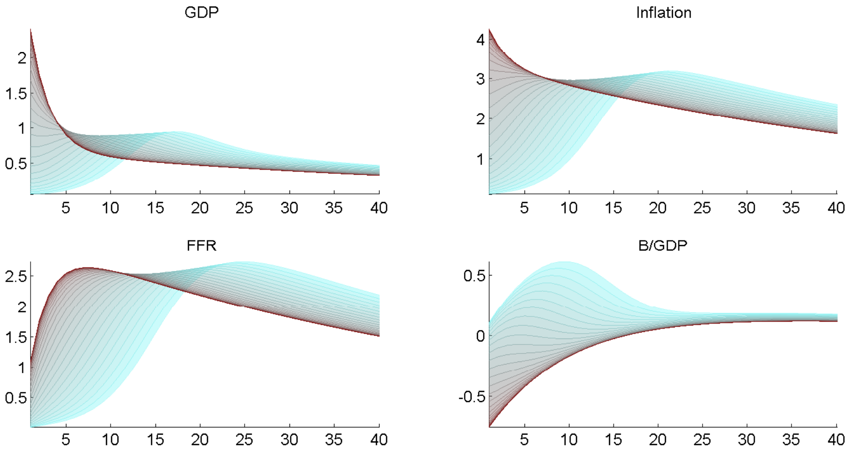
$$p_{33} - prob\left\{s_{t+1} \neq 1 | \tau = \tau^*\right\} < \varepsilon$$

  $\Longrightarrow$ Model approximated using $\tau^* + 1$ regimes

Solving the model with learning

- Agents fully understand the model and *they know that they do not know*
  $\Longrightarrow$ They take into account the impact of future policy makers' behavior on their future beliefs
- Different from anticipated utility/adaptive learning

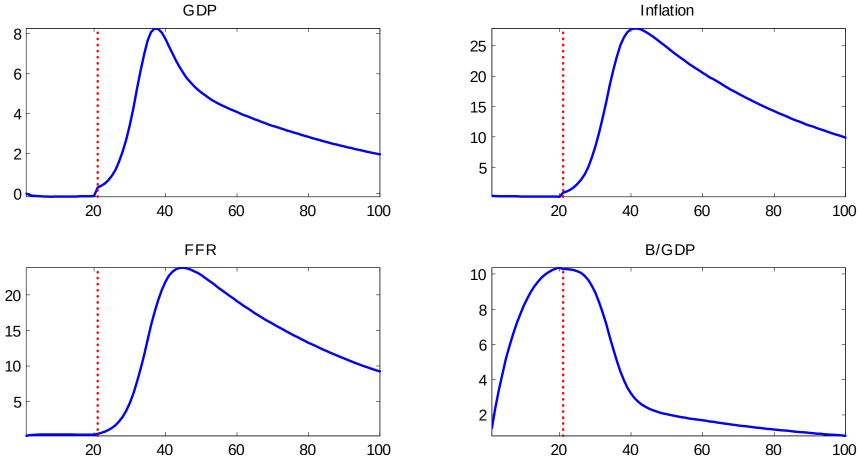
Impulse responses: Primary deficit ▸ MP



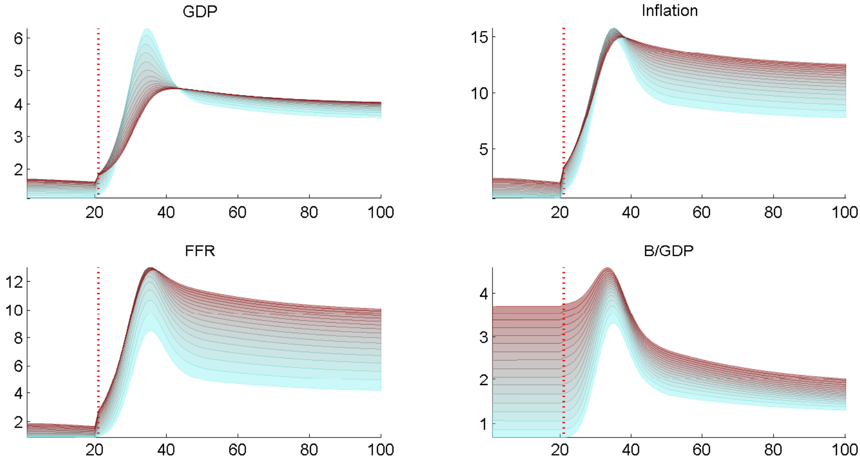
Dormant Shocks

- Consider the following scenario:
  1. An initial shock under the Virtuous regime
  2. After 5 years policy makers start deviating
- What are the consequences for inflation and the level of uncertainty in the economy?

Dormant Shocks: Expenditure on levels



Dormant Shocks: Expenditure on volatilities

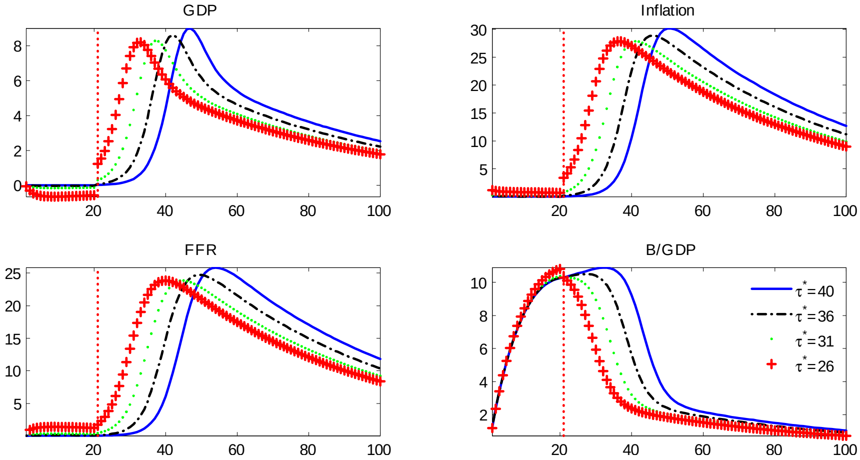


Fiscal Virtue: Conditional priors

- $p_{13}/(p_{12}+p_{13})$ controls the relative probability of a long lasting deviation in the aftermath of a first deviation
- When the ratio is high, agents' beliefs experience a larger jump following the first deviation

$100p_{13}/(p_{12}+p_{13})$	p_{22}	τ^*
.04	0.70	40
.20	0.70	36
1.00	**0.70**	**31**
5.00	0.70	26

Fiscal Virtue: Conditional priors

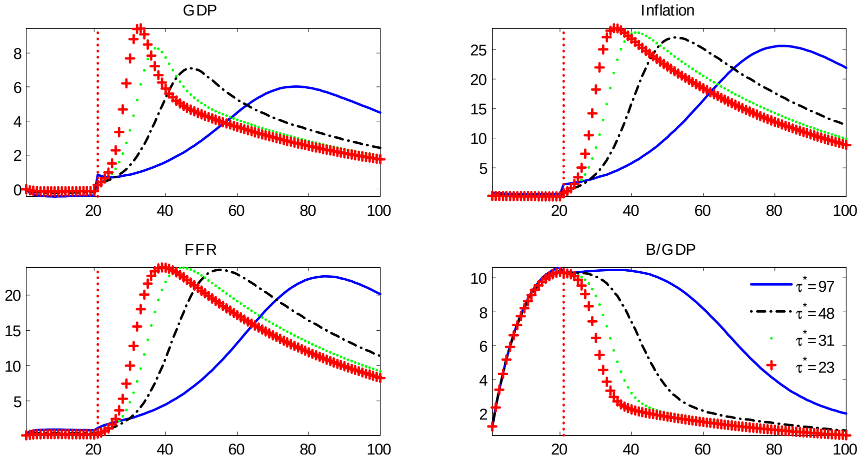


Fiscal Virtue: Conditional priors

- p_{22}/p_{33} controls the relative persistence of a short lasting versus a long lasting deviation
- When the ratio is high, agents are "tolerant"

$100p_{13}/(p_{12}+p_{13})$	p_{22}	τ^*
1.00	.90	97
1.00	.80	48
1.00	**.70**	**31**
1.00	.60	23

Fiscal Virtue: Relative persistences



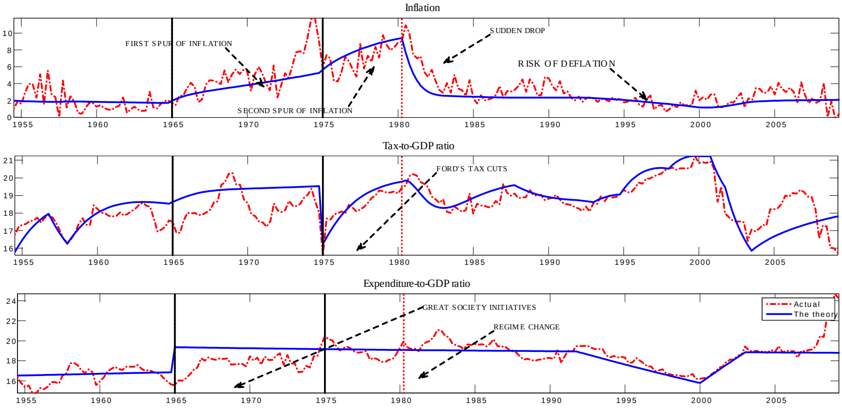
A look at the Past...

- Richer model calibrated using estimates of Bianchi and Ilut (2012) and the following transition matrix:

$$H = \begin{bmatrix} .9200 & .0720 & .0080 \\ .0600 & .9400 & \\ .0050 & & .9950 \end{bmatrix}$$

- It takes a long time for agents to get convinced that they entered a long lasting deviation: p_{22} and p_{33} relatively close
- Even when under the Virtuous regime, agents are concerned about a long lasting deviation: $p_{13} = .8\%$

A look at the Past...

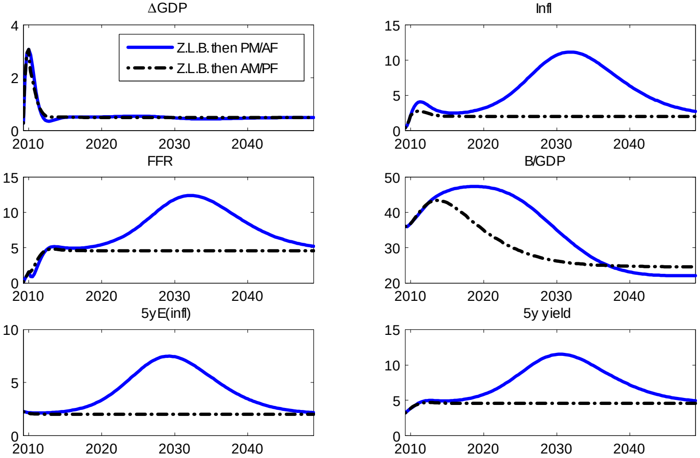


...to understand the Future

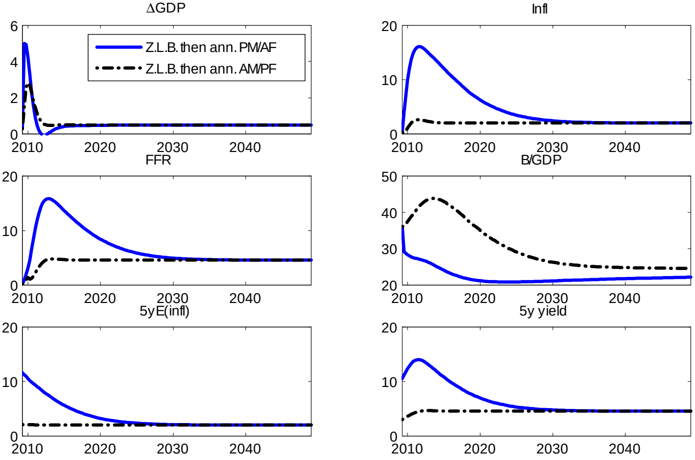
- What is the risk of high inflation for the US?
- Do low long term interest rates imply that agents attach little probability to a spur of high inflation?
- To answer this question we simulate the economy for 40 years
- Whenever agents regard a regime change as possible, we assume that it occurs after 5 years
- We assume:

$$H = \begin{bmatrix} .9750 & .0249 & .0001 \\ .0800 & .9200 & \\ .0100 & & .9900 \end{bmatrix}$$

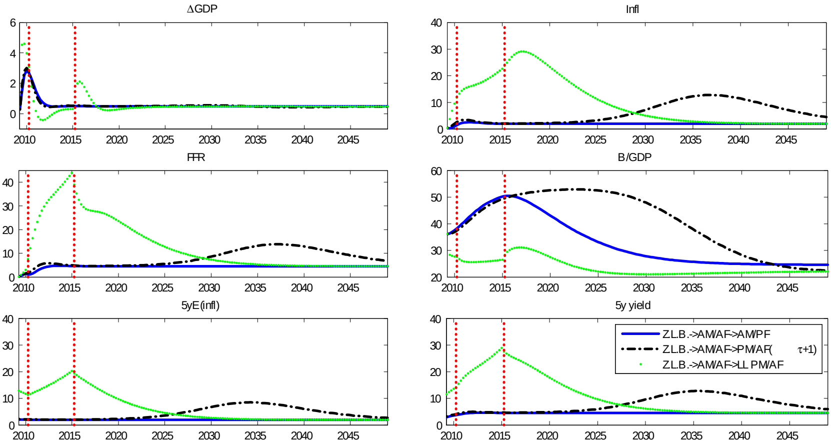
Risk of inflation?



Stimulus?


ΔGDP
Z.L.B. then ann. PM/AF
Z.L.B. then ann. AM/PF
Infl
FFR
B/GDP
5y E(infl)
5y yield
2010
2020
2030
2040

Contradictory Announcements



Fiscal-Monetary Policy Coordination

1. The model can
   - replicate heterogeneity over time and across countries
   - generate persistent and accelerating increases in inflation
2. The strict distinction between non-Ricardian and Ricardian regimes typical of the Fiscal Theory of Price Level breaks down
3. When calibrated for US data:
   - The model can explain the run-up in inflation of the '70s with only two shocks and the risk of deflation in the early 2000s
   - Past Fiscal Virtue can hide the true risk of inflation
   - Contradictory statements can conduct to undesirable outcomes

Monetary/Fiscal Policy Mix ▸ Back

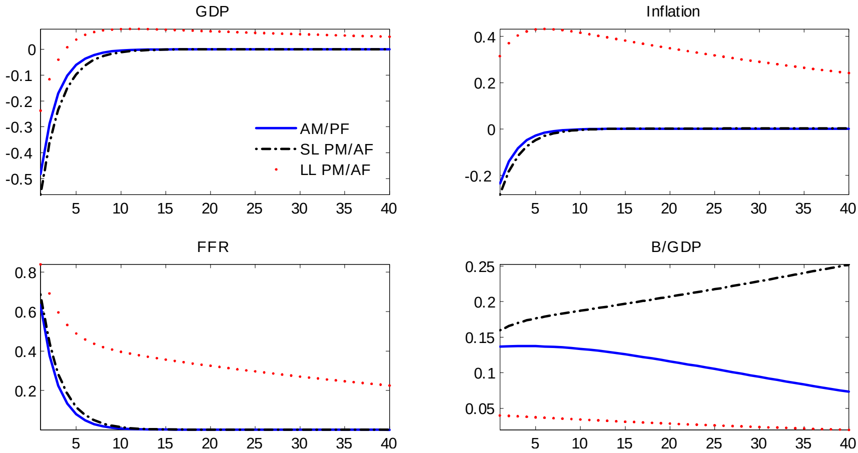
Following Leeper (1991) we can distinguish four cases:

	Active Fiscal (AF)	Passive Fiscal (PF)
Active Monetary (AM)	No Solution	**Determinacy**
Passive Monetary (PM)	**Determinacy**	Indeterminacy

- Active Monetary Policy: Taylor principle is satisfied ($\psi_{\pi,\xi_t} > 1$)
- Passive Fiscal Policy: Taxes react strongly to debt ($\delta_{b,\xi_t^{sp}} > \beta^{-1} - 1 \;\rightarrow\; \beta^{-1} - \delta_{b,\xi_t} < 1$)
- We focus on the two determinacy areas
  - Active Monetary/Passive Fiscal: Fiscal policy is Ricardian
  - Passive Monetary/Active Fiscal: Fiscal policy is non-Ricardian

Impulse responses: Monetary policy shock

Back



- After the first deviation $\tau = 1$:

$$prob\left\{s_t = 2|\mathcal{F}_t\right\} = \frac{p_{12}}{p_{12} + p_{13}}$$

- This represents a lower bound for agents' pessimism:

$$prob\left\{s_{t+1} \neq 1|\mathcal{F}_t, \tau = 1\right\} = \frac{p_{12}}{p_{12} + p_{13}} p_{22} + \frac{p_{13}}{p_{12} + p_{13}} p_{33}$$

- After $\tau \geq 1$ consecutive deviations:

$$prob\left\{s_{t+1} \neq 1|\mathcal{F}_t\right\} = \frac{p_{22}\left(p_{12}/p_{13}\right)\left(p_{22}/p_{33}\right)^{\tau-1} + p_{33}}{\left(p_{12}/p_{13}\right)\left(p_{22}/p_{33}\right)^{\tau-1} + 1} \tag{10}$$

- Pessimism has then an upper bound:

$$\lim_{\tau\to\infty} prob\left\{s_{t+1} \neq 1|\mathcal{F}_t\right\} = p_{33} \tag{11}$$

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Impulse responses: Monetary Policy shock

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