Dormant Shocks and Fiscal Virtue

Francesco Bianchi  Leonardo Melosi
Duke University    London Business School

ESSIM - 2012
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
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

  ➔ 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
As agents observe more and more deviations, they grow increasingly pessimistic about a prompt return to the Virtuous regime.

Drift in beliefs $\rightarrow$ 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)
- 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)
Two models

- To inspect the mechanism
  → Basic three equations new-Keynesian model augmented with a fiscal rule

- Quantitative analysis
  → Richer model based on Bianchi and Ilut (2012)
The representative household maximizes:

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

subject to the budget constraint:

$$P_tC_t + B_t + P_tE_t = P_tW_th_t + R_{t-1}B_{t-1}$$

We assume $d_t = \rho_d d_{t-1} + \sigma_d \epsilon_{d,t}$
Each of the monopolistically competitive firms faces a downward-sloping demand curve:

\[ Y_t(j) = \left( \frac{P_t(j)}{P_t} \right)^{-1/v} Y_t \]

where \(1/v\) 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:

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

\[
\ln A_t = \ln \bar{A} + z_t \\
z_t = \rho_z z_{t-1} + \sigma_z \epsilon_{z,t}
\]
The Central Bank moves the FFR according to the rule:

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

where \( R \) is the steady-state gross nominal interest rate, \( Y^n_t \) is natural output, \( \Pi \) is the target level for gross inflation, and \( \xi_t \) is a hidden variable that determines the regime in place at time \( t \).
The government budget constraint is given by:

\[ b_t = b_{t-1} \left( \frac{Y_t \Pi_t}{Y_{t-1}} \right)^{-1} R_{t-1} - s_t \]

where \( b_t = B_t / (P_t Y_t) \) and \( s_t = S_t / (P_t Y_t) \).

The government moves primary surpluses according to the rule:

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

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

- **Linearized Euler Equation:**

\[ y_t = E_t(y_{t+1}) - (R_t - E_t(\pi_{t+1})) + (1 - \rho_d) d_t \]  

(1)

- **Expectation augmented Phillips curve:**

\[ \pi_t = \beta E_t(\pi_{t+1}) + \kappa (y_t - z_t) \]  

(2)

- **Stochastic processes of the shocks:**

\[ d_t = \rho_d d_{t-1} + \sigma_d \epsilon_{d,t} \]  

(3)

\[ z_t = \rho_z z_{t-1} + \sigma_z \epsilon_{z,t} \]  

(4)

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

- Linearized government budget constraint:
  \[ b_t = \beta^{-1} b_{t-1} + b\beta^{-1} (R_{t-1} - \pi_t - \Delta y_t) - s_t \]  
  \[ s_t = \rho_s s_{t-1} + (1 - \rho_s) \delta_{b,\xi_t} b_{t-1} + \sigma_s \epsilon_{s,t} \]  
- Monetary rule:
  \[ R_t = (1 - \rho_{R,\xi_t}) \left( \psi_{\pi,\xi_t} \pi_t + \psi_{y,\xi_t} [y_t - z_t] \right) + \rho_{R,\xi_t} R_{t-1} + \sigma_R \epsilon_{R,t} \]  

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

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

\[ s_t = \rho_s s_{t-1} + (1 - \rho_s) \delta_{b,\xi_t} b_{t-1} + ... \]

\[ b_t = \beta^{-1} b_{t-1} + ... - s_t \]

\[ \rightarrow b_t = (\beta^{-1} - \delta_{b,\xi_t}) b_{t-1} + ... \]
Leeper (1991) shows that two determinacy regions exist:

<table>
<thead>
<tr>
<th></th>
<th>$\psi_{\pi,\xi_t}$</th>
<th>$\delta_{b,\xi_t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Monetary, Passive Fiscal</td>
<td>$&gt; 1$</td>
<td>$&gt; \beta^{-1} - 1$</td>
</tr>
<tr>
<td>Passive Monetary, Active Fiscal</td>
<td>$&lt; 1$</td>
<td>$&lt; \beta^{-1} - 1$</td>
</tr>
</tbody>
</table>

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

- We assume that the policy mix is generally \textit{virtuous}:

\[ AM/\text{PF} \rightarrow \psi_{\pi}(\xi_t = 1) = \psi^A_{\pi} > 1, \ \delta_b(\xi_t = 1) = \delta^P_b > \beta^{-1} - 1 \]

- However, policy makers can \textit{deviate} from the Virtuous regime:

\[ PM/\text{AF} \rightarrow \psi_{\pi}(\xi_t = 2) = \psi^P_{\pi} < 1, \ \delta_b(\xi_t = 2) = \delta^A_b < \beta^{-1} - 1 \]
\[ PM/\text{AF} \rightarrow \psi_{\pi}(\xi_t = 3) = \psi^P_{\pi} < 1, \ \delta_b(\xi_t = 3) = \delta^A_b < \beta^{-1} - 1 \]
Allowing for regime changes

- These deviations can be short or long lasting:

  \[ p_{22} \ll p_{33} \]

- Short lasting deviations are (conditionally) more frequent:

  \[ p_{12} > p_{13} \]

- Transition matrix:

\[
H = \begin{bmatrix}
p_{11} & p_{12} & p_{13} \\
1 - p_{22} & p_{22} \\
1 - p_{33} & p_{33}
\end{bmatrix}
\]
Agents are aware of the possibility of regime changes $\implies$ 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:

$$S_t = T(\zeta_t, \theta, H) S_{t-1} + R(\zeta_t, \theta, H) \varepsilon_t$$  \hspace{1cm} (9)
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_{\pi}^A$</td>
<td>2.00</td>
<td>$\rho_s$</td>
<td>0.90</td>
<td>$100\sigma_R$</td>
<td>0.20</td>
</tr>
<tr>
<td>$\psi_y^A$</td>
<td>0.10</td>
<td>$\rho_z$</td>
<td>0.90</td>
<td>$100\sigma_s$</td>
<td>0.50</td>
</tr>
<tr>
<td>$\rho_R^P$</td>
<td>0.75</td>
<td>$\rho_d$</td>
<td>0.90</td>
<td>$100\sigma_z$</td>
<td>0.70</td>
</tr>
<tr>
<td>$\delta_b^P$</td>
<td>0.03</td>
<td>$b$</td>
<td>1.00</td>
<td>$100\sigma_d$</td>
<td>0.40</td>
</tr>
<tr>
<td>$\psi_{\pi}^P$</td>
<td>0.80</td>
<td>$\kappa$</td>
<td>0.05</td>
<td>$p_{11}$</td>
<td>0.95</td>
</tr>
<tr>
<td>$\psi_y^P$</td>
<td>0.10</td>
<td>$\beta$</td>
<td>0.99</td>
<td>$p_{12}$</td>
<td>0.495</td>
</tr>
<tr>
<td>$\rho_R^P$</td>
<td>0.75</td>
<td></td>
<td></td>
<td>$p_{22}$</td>
<td>0.70</td>
</tr>
<tr>
<td>$\delta_b^A$</td>
<td>0</td>
<td></td>
<td></td>
<td>$p_{33}$</td>
<td>0.99</td>
</tr>
</tbody>
</table>
Impulse responses: Primary deficit shock • MP

- GDP
- Inflation
- FFR
- B/GDP

The graphs show the impulse responses of various economic indicators to a primary deficit shock. The x-axis represents time in years (5 to 40), and the y-axis represents the magnitude of the response. Different lines correspond to different scenarios or models.
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

Probability of PM/AF for the next period

Expected number of consecutive periods of PM/AF
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 \( \implies \) As policy makers keep deviating, agents grow more and more pessimistic about moving back to the Virtuous regime.
Evolution of Agents’ Beliefs

Details

Beliefs

Prob PM/AF for next period

E(n consecutive deviations)
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. $\theta^{AM/\text{PF}}, \tau = 0$
  2. $\theta^{PM/\text{AF}}, \tau = x + 1$

  $\Longrightarrow$ Transition matrix $H \rightarrow$ transition matrix $\tilde{H}$

- Upper bound to pessimism: For each $\varepsilon > 0$, $\exists$ integer $\tau^* > 0$ s.t.

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

  $\Longrightarrow$ Model approximated using $\tau^* + 1$ regimes
Solving the model with learning

- Agents **fully understand the model and they know that they do not know**
  - 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 $\delta^\text{MP}$
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

GDP

Inflation

FFR

B/GDP
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.

<table>
<thead>
<tr>
<th>$100p_{13}/(p_{12} + p_{13})$</th>
<th>$p_{22}$</th>
<th>$\tau^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>.04</td>
<td>0.70</td>
<td>40</td>
</tr>
<tr>
<td>.20</td>
<td>0.70</td>
<td>36</td>
</tr>
<tr>
<td><strong>1.00</strong></td>
<td><strong>0.70</strong></td>
<td><strong>31</strong></td>
</tr>
<tr>
<td>5.00</td>
<td>0.70</td>
<td>26</td>
</tr>
</tbody>
</table>
Fiscal Virtue: Conditional priors

- **GDP**: The blue line represents \( \tau^* = 40 \), the black dashed line \( \tau^* = 36 \), the green dotted line \( \tau^* = 31 \), and the red dot-dashed line \( \tau^* = 26 \).
- **Inflation**: Similar lines for GDP, but with different Y-axis values.
- **FFR**: The blue line is \( \tau^* = 40 \), the black dashed line \( \tau^* = 36 \), the green dotted line \( \tau^* = 31 \), and the red dot-dashed line \( \tau^* = 26 \).
- **B/GDP**: Again, similar lines but with different Y-axis values.

Note: The values \( \tau^* \) are constant across all plots, indicating a fixed parameter in the model.
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".

<table>
<thead>
<tr>
<th>$100p_{13}/(p_{12} + p_{13})$</th>
<th>$p_{22}$</th>
<th>$\tau^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>.90</td>
<td>97</td>
</tr>
<tr>
<td>1.00</td>
<td>.80</td>
<td>48</td>
</tr>
<tr>
<td><strong>1.00</strong></td>
<td><strong>.70</strong></td>
<td><strong>31</strong></td>
</tr>
<tr>
<td>1.00</td>
<td>.60</td>
<td>23</td>
</tr>
</tbody>
</table>
Fiscal Virtue: Relative persistences

GDP

Inflation

FFR

B/GDP

\( \tau^* = 97 \)

\( \tau^* = 48 \)

\( \tau^* = 31 \)

\( \tau^* = 23 \)
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...

**Inflation**

- **First Spur of Inflation**
- **Second Spur of Inflation**
- **Sudden Drop**
- **Risk of Deflation**

**Tax-to-GDP ratio**

- **Ford's Tax Cuts**

**Expenditure-to-GDP ratio**

- **Great Society Initiatives**
- **Regime Change**
Motivation

The Model

Perfect Information

Learning

Dormant Shocks

Conclusions

...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
- Infl
- FFR
- BGDP
- 5yE(infl)
- 5y yield

Z.L.B. then ann. PMAF
Z.L.B. then ann. AMPF
Motivation

The Model

Perfect Information

Learning

Dormant Shocks

Conclusions

Contradictory Announcements

\[ \text{ΔGDP} \]

\[ \text{Infl} \]

\[ \text{B/GDP} \]

\[ 5y \text{E(infl)} \]

\[ 5y \text{yield} \]

\[ Z.L.B. \rightarrow \text{AM/AF} \rightarrow \text{AM/PM} \]

\[ Z.L.B. \rightarrow \text{AM/AF} \rightarrow \text{LL} \rightarrow \text{PM/AF} (\tau + 1) \]

\[ Z.L.B. \rightarrow \text{AM/AF} \rightarrow \text{PM/AF} \]
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
Following Leeper (1991) we can distinguish four cases:

<table>
<thead>
<tr>
<th></th>
<th>Active Fiscal (AF)</th>
<th>Passive Fiscal (PF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Monetary (AM)</td>
<td>No Solution</td>
<td>Determinacy</td>
</tr>
<tr>
<td>Passive Monetary (PM)</td>
<td>Determinacy</td>
<td>Indeterminacy</td>
</tr>
</tbody>
</table>

- 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
After the first deviation \( \tau = 1 \):

\[
\text{prob} \{ s_t = 2 | \mathcal{F}_t \} = \frac{p_{12}}{p_{12} + p_{13}}
\]

This represents a lower bound for agents’ pessimism:

\[
\text{prob} \{ s_{t+1} \neq 1 | \mathcal{F}_t, \tau = 1 \} = \frac{p_{12}}{p_{12} + p_{13}} p_{22} + \frac{p_{13}}{p_{12} + p_{13}} p_{33}
\]

After \( \tau \geq 1 \) consecutive deviations:

\[
\text{prob} \{ s_{t+1} \neq 1 | \mathcal{F}_t \} = \frac{p_{22} \left( \frac{p_{12}}{p_{13}} \right) \left( \frac{p_{22}}{p_{33}} \right)^{\tau-1} + p_{33}}{\left( \frac{p_{12}}{p_{13}} \right) \left( \frac{p_{22}}{p_{33}} \right)^{\tau-1} + 1}
\]

Pessimism has then an upper bound:

\[
\lim_{\tau \to \infty} \text{prob} \{ s_{t+1} \neq 1 | \mathcal{F}_t \} = p_{33}
\]
Impulse responses: Monetary Policy shock