Monetary Policy and Sovereign Debt Vulnerability

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1These slides represent the authors’ views and does not necessarily represent those of Banco de España
Motivation: European debt crisis

- Legacy of 2007-9 financial crisis: large fiscal deficits and soaring government debt
- Before summer 2012, sovereign yields rose sharply in EMU periphery (GR, IR, IT, PT, SP) ...  
  ... but not in other highly indebted countries (US, UK, etc.)
- Many argue a key difference is: US-UK can deflate debt away, EMU periphery countries cannot
Motivation: role of monetary policy

- What role, if any, should monetary policy play in guaranteeing sovereign debt sustainability?

- Arguments for and against monetary policy involvement:
  - provide 'monetary backstop' against default fears
  - creating inflation also entails costs
  - effect on inflation expectations (and yields) if low monetary credibility

- **This paper**: analyze trade-offs between price stability and sovereign debt sustainability...
  - ... when gov't cannot make credible commitments
Framework of analysis

- Small open-economy, continuous-time model
- Benevolent government issues *nominal* defaultable debt to foreign investors
- Gov’t may default on debt at any time
  - costs of default: exclusion from capital markets + output loss
- Government chooses fiscal (primary deficit) and monetary policy (inflation) under discretion
- Benefits and costs of inflation:
  - debt can be deflated away
  - direct welfare losses
Calibrate to average peripheral EMU economy

Analyze two monetary regimes:

1. *inflationary regime*: benevolent gov't chooses inflation discretionarily
2. *no inflation regime*: zero inflation at all times

In (2), government *gives up* option to deflate debt away
- issue foreign currency debt
- join monetary union with strong anti-inflation mandate

**Main result:** Welfare is higher in *no inflation regime*, for any debt ratio and on average
Literature review

- Links between sovereign debt vulnerability and monetary policy

- Optimal fundamental sovereign default in quantitative models
  - Aguiar and Gopinath (2006), Arellano (2008), etc.

- Extend literature on continuous-time models of default to the pricing of defaultable nominal sovereign debt
The model: output, prices and debt

- Single consumption good with int’l price = 1. Exogenous output endowment,

\[ dY_t = \mu Y_t dt + \sigma Y_t dW_t. \]
The model: output, prices and debt

- Single consumption good with int’l price = 1. Exogenous output endowment,
  \[ dY_t = \mu Y_t dt + \sigma Y_t dW_t. \]
- Local currency price,
  \[ dP_t = \pi_t P_t dt. \]

\( \mu, \sigma, \pi_t \): parameters

\( \lambda \): amortization rate

\( \delta \): coupon rate

\( \lambda \): amortization rate; fully held by foreign investors

\( Q_t \): Government’s flow of funds

\( B_{new} \): new sovereign debt

\( C_t \): consumption

\( Y_t \): output

\( W_t \): stochastic process

\( P_t \): price

\( \pi_t \): inflation rate

\( \mu, \sigma, \pi_t \): parameters
The model: output, prices and debt

- Single consumption good with int’l price = 1. Exogenous output endowment,

\[ dY_t = \mu Y_t dt + \sigma Y_t dW_t. \]

- Local currency price,

\[ dP_t = \pi_t P_t dt. \]

- Sovereign debt,

\[ dB_t = B_t^{\text{new}} dt - \lambda dtB_t. \]

\( \lambda \): amortization rate; fully held by foreign investors
The model: output, prices and debt

- Single consumption good with int’l price = 1. Exogenous output endowment,
  \[ dY_t = \mu Y_t dt + \sigma Y_t dW_t. \]

- Local currency price,
  \[ dP_t = \pi_t P_t dt. \]

- Sovereign debt,
  \[ dB_t = B_{t}^{new} dt - \lambda dtB_t. \]

  \( \lambda \): amortization rate; fully held by foreign investors

- Government’s flow of funds
  \[ Q_t B_{t}^{new} = (\lambda + \delta) B_t + P_t (C_t - Y_t). \]

  \( \delta \): coupon rate
The state variable: debt-to-GDP ratio

- Debt-to-GDP ratio

\[ b_t \equiv \frac{B_t}{P_t Y_t} \]
Debt-to-GDP ratio

\[ b_t \equiv B_t / (P_t Y_t) \]

Applying Itô’s lemma

\[
\begin{align*}
    db_t &= \left[ \left( \frac{r_t \text{ (yield)}}{Q_t} - \lambda + \sigma^2 - \mu - \pi_t \right) b_t + \frac{c_t}{Q_t} \right] \ dt - \sigma b_t dW_t, \\
    \text{where} \\
    c_t &\equiv (C_t - Y_t) / Y_t
\end{align*}
\]

is primary deficit ratio
Household preferences,

\[ U_0 = \mathbb{E}^0 \left[ \int_0^\infty e^{-\rho t} \left( \log(C_t) - \frac{\psi}{2} \pi_t^2 \right) dt \right]. \]

\( \psi > 0 \): distaste for inflation, reduced-form \( \pi \)-disutility following Aguiar et al. (2013)
Preferences

- Household preferences,

\[ U_0 = \mathbb{E}_0 \left[ \int_0^\infty e^{-\rho t} \left( \log(C_t) - \frac{\psi}{2} \pi_t^2 \right) dt \right]. \]

\( \psi > 0 \) : distaste for inflation, reduced-form \( \pi \)-disutility following Aguiar et al. (2013)

- Using \( C_t = (1 + c_t) Y_t \),

\[ U_0 = \mathbb{E}_0 \left[ \int_0^\infty e^{-\rho t} \left( \log(1 + c_t) - \frac{\psi}{2} \pi_t^2 \right) dt \right] + V_{0}^{aut}, \]

where \( V_{0}^{aut} = \mathbb{E}_0 \left[ \int_0^\infty e^{-\rho t} \log(Y_t) dt \right] \) is the (exogenous) autarky value
At each point in time, choose
- default or continue repaying debt ⇔ optimal default threshold \( b^* \)
- primary deficit ratio \( (c_t) \), inflation rate \( (\pi_t) \)

under discretion (take investor’s pricing scheme \( Q(b) \) as given)

First analyze default scenario

Then lay out general optimization problem
The default scenario

- Default (at a debt ratio $b$) implies
  - exclusion from capital markets (reenter at rate $\chi$)
  - and contraction in output endowment (in logs, $\epsilon \max\{0, b - \hat{b}\}$)
- At end of exclusion period, gov’t reenters markets with debt ratio $\theta b$
- Value of defaulting (net of autarky value),

$$V^{def}(b) = -\frac{\epsilon \max\{0, b - \hat{b}\}}{\rho + \chi} + \frac{\chi}{\rho + \chi} V(\theta b).$$
The general problem

Let $T(b^*)$ be *time-to-default*. Government value function,

$$V(b) = \max_{b^*, \{c_t, \pi_t\}} \mathbb{E} \left\{ \int_0^{T(b^*)} e^{-\rho t} \left( \log(1 + c_t) - \frac{\psi}{2} \pi_t^2 \right) dt \right\} + e^{-\rho T(b^*)} V_{\text{def}}(b^*) | b_0 = b$$

subject to $b$’s law of motion, and

$$V(b^*) = V_{\text{def}}(b^*),$$

$$V'(b^*) = V'_{\text{def}}(b^*),$$

i.e. *value matching & smooth pasting* conditions
The 'no inflation' regime

Consider an alternative scenario where

$$\pi (b) = 0$$

for all $b$.

Government *renounces* the ability to deflate debt away

Possible interpretations:

- Issue foreign currency debt
- Join a monetary union with a strong anti-inflationary stance
- (Appoint extremely conservative central banker)
International investors (bond pricing)

- Risk-neutral investors can invest elsewhere at riskless real rate $\bar{r}$
- Unit price of the nominal non-contingent bond

$$Q(b) = \mathbb{E} \left[ e^{-\bar{r} \tau} \theta \frac{Y_\tau}{Y_0} Q(\theta b^*) \right] = \frac{\chi}{\bar{r} + \chi - \mu} \theta Q(\theta b^*).$$
Calibration

- Calibrate to the average peripheral EMU economy, time unit = 1 year

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{r}$</td>
<td>0.04</td>
<td>world real interest rate</td>
<td>standard</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.20</td>
<td>subjective discount rate</td>
<td>standard</td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.022</td>
<td>drift output growth</td>
<td>average growth EMU periphery</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>0.032</td>
<td>diffusion output growth</td>
<td>growth volatility EMU periphery</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.16</td>
<td>bond amortization rate</td>
<td>Macaulay duration = 5 years</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.04</td>
<td>bond coupon rate</td>
<td>price of riskless real bond = 1</td>
</tr>
<tr>
<td>$\chi$</td>
<td>0.33</td>
<td>reentry rate</td>
<td>mean duration of exclusion = 3 years</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.56</td>
<td>recovery rate parameter</td>
<td>mean recovery rate = 60%</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>1.50</td>
<td>default cost parameter</td>
<td>output loss during exclusion = 6%</td>
</tr>
<tr>
<td>$\hat{b}$</td>
<td>0.332</td>
<td>default cost parameter</td>
<td>average external debt/GDP ratio (35.6%)</td>
</tr>
<tr>
<td>$\psi$</td>
<td>9.15</td>
<td>inflation disutility parameter</td>
<td>mean inflation rate (1987-1997) = 3.2%</td>
</tr>
</tbody>
</table>
Equilibrium: inflationary regime

Value function, $V$

Bond price, $Q$

Primary deficit to gdp, $c$

Inflation, $\pi$

Expected time to default, $T^e$

Nominal interest rate, $r$
Equilibrium: inflationary vs no-inflation regime

Value function, $V$

- No inflation
- Inflationary

Primary deficit to gdp, $c$

Expected time to default, $T^e$

Bond price, $Q$

Inflation, $\pi$

Nominal interest rate, $r$
Nominal bond yield $r(b)$ can be decomposed as *risk premium* + *inflation premium*.
Average performance

- Inflationary regime yields lower value function $V(b)$ at any debt ratio, but...

- If it delivers sufficiently lower debt ratio most of the time, average welfare could be higher

- Compute stationary debt distribution so as to calculate unconditional average values
Stationary debt distribution

- Inflationary regime shifts distribution to the left (debt deflation)...

![Graph showing distribution of debt-to-gdp ratio](image-url)
Average performance (cont’d)

- but not enough to make inflationary policy better on average

<table>
<thead>
<tr>
<th></th>
<th>Data 1995-2012</th>
<th>No inflation</th>
<th>Inflationary</th>
</tr>
</thead>
<tbody>
<tr>
<td>debt-to-GDP, $b$ (%)</td>
<td>35.6</td>
<td>35.6</td>
<td>35.6</td>
</tr>
<tr>
<td>primary deficit ratio, $c$ (%)</td>
<td>-4.1</td>
<td>-0.01</td>
<td>-0.12</td>
</tr>
<tr>
<td>inflation, $\pi$ (%)</td>
<td>0.4</td>
<td>0</td>
<td>3.20</td>
</tr>
<tr>
<td>bond yields (net of $\bar{r}$), $r - \bar{r}$ (bp)</td>
<td>187</td>
<td>154</td>
<td>448</td>
</tr>
<tr>
<td>risk premium, $r - \tilde{r}$ (bp)</td>
<td>154</td>
<td>154</td>
<td>139</td>
</tr>
<tr>
<td>inflation premium, $\tilde{r} - \bar{r}$ (bp)</td>
<td>33</td>
<td>0</td>
<td>309</td>
</tr>
<tr>
<td>Exp. time to default, $T^e$ (years)</td>
<td>-</td>
<td>29.4</td>
<td>37.1</td>
</tr>
<tr>
<td>Welfare loss, $V - V_{\pi=0}$ (% cons.)</td>
<td>-</td>
<td>0</td>
<td>-0.25</td>
</tr>
</tbody>
</table>

- Again, ↑ in mean risk premia dominated by ↓ in mean inflation premia & direct utility costs
Robustness

- Investigate robustness to alternative calibrations of:
  - bond amortization rate ($\lambda$)
  - bond recovery parameter ($\theta$)
  - output loss from default ($\hat{b}$)

- For all parameter values, we continue to find higher average welfare in no-inflation regime
'No inflation' regime equivalent to appointing an extremely conservative central banker

Consider intermediate arrangement: appoint a central banker...
  - who dislikes inflation more than society...
  - ... but not so much as to set $\pi = 0$ at all times

Given government’s $c(b)$ and $b^*$, central banker chooses $\pi$ ...

to maximize its value function $\tilde{V}$, defined similarly to $V$, but with $\tilde{\psi} \geq \psi$
Monetary policy delegation: results

- Average welfare increases monotonically with $\tilde{\psi}/\psi$ but *never* reaches $\mathbb{E}(V_{\pi=0})$.

![Welfare, V](image1.png)

![Default threshold, $b^*$](image2.png)

![Average time in exclusion](image3.png)

![Inflation, $\pi$](image4.png)

![Primary deficit, $c$](image5.png)

![Nominal interest rate, $r$](image6.png)
Conclusions

- Analyzed trade-offs between price stability and sovereign debt sustainability...
  - ... in an open-economy model with nominal debt and optimal default

- Welfare is higher if gov’t renounces the option to deflate debt away, e.g. by
  - issuing foreign currency debt
  - joining an anti-inflationary monetary union

- Intuition: benefits (lower inflation premia, no direct welfare costs) outweigh costs (higher risk premia)
## Appendix: Robustness

<table>
<thead>
<tr>
<th></th>
<th>Welfare % cons.</th>
<th>Time to default years</th>
<th>Inflation %</th>
<th>Risk premium bp</th>
<th>Inflation premium bp</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benchmark</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No inflation</td>
<td>0</td>
<td>29.4</td>
<td>0</td>
<td>317</td>
<td>0</td>
</tr>
<tr>
<td>Inflationary</td>
<td>-0.25</td>
<td>37.1</td>
<td>2.97</td>
<td>298</td>
<td>299</td>
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<tr>
<td>Difference</td>
<td>0.25</td>
<td>-7.7</td>
<td>-2.97</td>
<td>19</td>
<td>-299</td>
</tr>
<tr>
<td><strong>Duration = 3</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>No inflation</td>
<td>0.1</td>
<td>40.4</td>
<td>0</td>
<td>311</td>
<td>0</td>
</tr>
<tr>
<td>Inflationary</td>
<td>-0.36</td>
<td>47.4</td>
<td>3.28</td>
<td>304</td>
<td>331</td>
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<tr>
<td>Difference</td>
<td>0.55</td>
<td>-7.0</td>
<td>3.28</td>
<td>7</td>
<td>-331</td>
</tr>
<tr>
<td><strong>Duration = 7</strong></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>No inflation</td>
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<td>26.0</td>
<td>0</td>
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<tr>
<td>Inflationary</td>
<td>-0.17</td>
<td>34.7</td>
<td>2.75</td>
<td>278</td>
<td>278</td>
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<td>Difference</td>
<td>0.17</td>
<td>-8.7</td>
<td>-2.75</td>
<td>81</td>
<td>-278</td>
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<td><strong>Recovery rate = 50%</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No inflation</td>
<td>-0.08</td>
<td>30.7</td>
<td>0</td>
<td>401</td>
<td>0</td>
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<tr>
<td>Inflationary</td>
<td>-0.33</td>
<td>38.5</td>
<td>3.00</td>
<td>373</td>
<td>302</td>
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<tr>
<td>Difference</td>
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<td>-7.8</td>
<td>-3.00</td>
<td>28</td>
<td>-302</td>
</tr>
<tr>
<td><strong>Recovery rate = 70%</strong></td>
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<tr>
<td>No inflation</td>
<td>0.09</td>
<td>28.3</td>
<td>0</td>
<td>246</td>
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<tr>
<td>Inflationary</td>
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<td>35.3</td>
<td>2.94</td>
<td>236</td>
<td>297</td>
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<tr>
<td>Difference</td>
<td>0.29</td>
<td>-7.5</td>
<td>-2.94</td>
<td>10</td>
<td>-297</td>
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<tr>
<td><strong>Default costs = 3.5%</strong></td>
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<tr>
<td>No inflation</td>
<td>0.43</td>
<td>29.7</td>
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<td>318</td>
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<tr>
<td>Inflationary</td>
<td>0.33</td>
<td>34.6</td>
<td>1.87</td>
<td>304</td>
<td>189</td>
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<tr>
<td>Difference</td>
<td>0.10</td>
<td>-4.9</td>
<td>-1.87</td>
<td>14</td>
<td>-189</td>
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<td><strong>Default costs = 7%</strong></td>
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<tr>
<td>No inflation</td>
<td>-0.22</td>
<td>29.6</td>
<td>0</td>
<td>314</td>
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<tr>
<td>Inflationary</td>
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<td>38.7</td>
<td>3.50</td>
<td>293</td>
<td>353</td>
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<tr>
<td>Difference</td>
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<td>-9.1</td>
<td>-3.50</td>
<td>21</td>
<td>-353</td>
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</table>