The Dynamics of Sovereign Debt Crises and Bailouts: Theory and Implications for Policy-Making

ESM Workshop on “Debt Sustainability: Current Practice and Future Perspectives”

The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.

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Luxembourg, December 11th, 2018
Outline

1. Introduction
2. A single country: the model
3. Private markets only
4. With a Bailout Agency
5. Numerical example
6. Policy Discussion
7. Conclusions
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Default premia in Europe: 2006 - 2011

10yr yield spread to Germany. Source: Bloomberg.
Default premia in Europe: 2006 - 2011, rescaled

10yr yield spread to Germany. Source: Bloomberg.
Who owns Greece’s debt? In 2015: EU bailout loans!

Source: Open Europe, BIS, IMF, ECB

Source:
https://www.globalresearch.ca/who-owns-greeces-debt/5460265
The ECB, OMT, and “Whatever it takes”

- 2012, July 26th, Draghi: “... the euro is irreversible. ... Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough.”

- 2012, September 6th: outright monetary transactions (OMT) program: intended to reduce country-specific distress yields per potentially unlimited purchases of the short-term government bonds of that country.

- 2013, June 6th, Draghi: “OMT has been probably the most successful monetary policy measure undertaken in recent time.”

- 2013, June 11th, 12th. Germany’s constitutional court (BVerfG) hearings on Bundesbank participation in OMT. “Ultra vires”?

- 2016, June 21st: BVerfG decides to let the Bundesbank and ECB proceed, “provided the volume of purchases is restricted ex ante.”
The ESM (“European Stability Mechanism”)

- Replaced two temporary programs: EFSF and EFSM.
- EMU reform plan: betw July 2017 and 2025, ESM should become fully integrated into EU law framework.

Tools:
2. Bank recap programme.
3. Precautionary financial assistance (credit lines).

- Total capital subscription of ESM: 700 billion Euro.
- Two current programs: 100 billion Euro/9 billion Euro for Spanish/Cypriot bank recaps.
Bond Spreads: Italy vs Germany, 10yr bonds

Italy 10 Year vs Germany 10 Year Spread Bond Yield Overview

Italy 10 Year vs Germany 10 Year Spread • 284.8 -3.2 (-1.11%)
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Goal

- Modelling financial crises for a single country ...
  - random income shocks, Arellano (2008)
  - short-sighted politicians, Beetsma-Uhlig (1999)

- ... and the role of a bailout agency.

- Benchmark intervention: actuarially fair, i.e., bailout agency earns market return, in expectation.

- **Question**: how much intervention is necessary to avoid self-fulfilling defaults?
The government

Arellano (2008).

- Government objective: given $q_t(\cdot)$, choose $c_t, B_{t+1}, \delta_t$ to max.

$$U = E \left[ \sum_{t=0}^{\infty} \beta^t (u(c_t) - \chi_t \delta_t) \right]$$

- $c_t$: gov. spending, choice.
- $y_t$: tax receipts, iid $\sim$ dens. $f(y)$ on $y \in [y_L, y_H]$, exog.
- $\delta_t = 1$: default in $t$, choice. $\chi_t$: pain of defaulting, exog.

- Budget constraint:

$$c_t + (1 - \theta) B_t = y_t + q_t (B_{t+1})(B_{t+1} - \theta B_t)$$

- $0 \leq \theta \leq 1$: maturity, parameter. $\theta = 0$: one-period debt.
- Once defaulted: autarky. Then, $c_t = y_t$. Return to debt market with probability $\alpha$. 

Debt pricing and Timing

- State: $s = (B, d, z)$, where $z = (y, \chi, \zeta)$.
- $\zeta \sim U([0, 1])$: “sunspot”.
- Debt pricing schedule: $q(B'; s)$, per probability of future defaults.
- Example: one-period debt, $\theta = 1$. Then $q(B'; s) = \text{Prob(“no default in } t + 1”) / R.$
A single country: the model

Time line

Assume: there is some bailout agency: a large, infinitely-lived lender.

Time line:
1. Fundamental shocks \((y, \chi)\) are realized.
2. Government picks desired \(B' \in \mathbb{R}\).
3. The bailout agency picks \((B'_a, q_a) \in \mathbb{R}^2, 0 \leq B'_a \leq B', 0 \leq q_a\).
4. Sunspot shock \(\zeta\) is realized.
5. Private market price \(q\) for new debt is established.
6. Government decides:
   - default or
   - pay and issue new debt \(B' - \theta B\) at price \(q\) or
   - pay and issue new debt \(B'_a - \theta B'\) at price \(q_a\).
Time line without bailout agency:

1. Fundamental shocks \((y, \chi)\) are realized.
2. Government picks desired \(B' \in \mathbb{R}\).
3. Sunspot shock \(\zeta\) is realized.
4. Private market price \(q\) for new debt is established.
5. Government decides:
   - default or
   - pay and issue new debt \(B' - \theta B\) at price \(q\)
6. government consumes.
Cole-Kehoe sunspots

- If current debt is too large $B > \bar{B}(z)$: default, even if traders were willing to buy new debt, $q(B') > 0$.
- If current debt is small, $B < \underline{B}(z)$: do not default, even if traders are not willing to buy new debt $q(B') = 0$.
- Crisis zone: sunspots

$$\underline{B}(z) \leq B \leq \bar{B}(z)$$

- for $\zeta \leq \pi$, i.e. with prob. $\pi$: $q(B') = 0$, default.
- for $\zeta > \pi$, i.e. with prob. $1 - \pi$: $q(B') > 0$, no default.

$\pi$: exogenous parameter

- Arellano (2008): default more likely with $y$ low. For given $B$, country is in crisis zone, if

$$\bar{y}(B) \leq y \leq \underline{y}(B)$$
Default decision

- Default if $q > 0$
- No Default
Sunspot

\[ B(y) \]

\[ \bar{B}(y) \]

Crisis zone

Default if \( q > 0 \)

No Default

Default if \( q = 0 \)

No Default
Debt pricing

\[ q(B') \]

\[ \frac{1}{R} \]

\[ \min B(z) \quad \max B(z) \]

Crisis zone
Debt pricing with and without sunspots

\[ q(B') \]

\[ q_{\pi=0}(B') \]

\[ \min B(z) \quad \min \bar{B}(z) \quad \max \bar{B}(z) \]

Crisis zone
Debt pricing: small income fluctuations

\[ q = \frac{1}{R} \]

\[ q(B') \]

Crisis zone
Debt pricing: no income fluctuations, Cole-Kehoe

\[
\frac{1}{R} \quad \frac{(1 - \pi)}{R} \quad q(B')
\]

Crisis zone
Debt dynamics, $\beta R = 1$, small income fluct.
Debt dynamics, $\beta R < 1$, small income fluct.
Debt dynamics, $\beta R << 1$, small income fluct.
The game with a bailout agency

Assume: there is some bailout agency: a large, infinitely-lived lender.

Time line:
1. Fundamental shocks \((y, \chi)\) are realized.
2. Government picks desired \(B' \in \mathbb{R}\).
3. The bailout agency picks \((B'_a, q_a) \in \mathbb{R}^2, 0 \leq B'_a \leq B', 0 \leq q_a\).
4. Sunspot shock \(\zeta\) is realized.
5. Private market price \(q\) for new debt is established.
6. Government decides:
   - default or
   - pay and issue new debt \(B' - \theta B\) at price \(q\) or
   - pay and issue new debt \(B'_a - \theta B'\) at price \(q_a\).
7. government consumes.
Game Details: payoffs

If the government defaults, then we are in the "default" situation (details as usual). If the government does not default, two cases:

1. **Case A.** private sector buys at positive prices $q > 0$:
   - the government reaches the new debt level $B'$, receiving a revenue $q(B' - \theta B)$, or paying this amount, if negative (i.e. if the government buys back debt).
   - the bailout agency receives and pays nothing.
   - the private sector pays $q(B' - \theta B)$, or receives it, if negative.

2. **Case B.** buyers’ strike $q = 0$:
   - the government reaches the new debt level $B_a'$, receiving a revenue $q_a(B_a' - \theta B)$, or paying this amount, if negative.
   - the bailout agency pays $q_a(B_a' - \theta B)$, or receives it, if negative.
   - the private sector receives and pays nothing.

We examine equilibria, so that the government chooses “no default” in the crisis zone, even if followed by “Case B”. Subsequent play is “Case A”, and bailout agency never buys.
Actuarily fair interventions, ruling out sunspots

- Assume **actuarily fair intervention**: the bailout agency picks $q_a$ so as to earn the market return $R$, in expectation.
- Assume bailout agency seeks to rule out the sunspot default equilibrium, per (forever) guaranteeing some debt purchase $B_a(s)$ at “good” ($\pi = 0$) equilibrium price: $q_a = q_{\pi=0}$.
- Goal: find the **minimal** intervention $B'_a(s)$ to do so.
- Note: with the guarantee and restoration of the “good” ($\pi = 0$) equilibrium, country might as well only borrow from all other lenders and not use the agency.
- Theory: $B_a$, compare to $B'$. Plots:

$$B_{a,\text{net}} = \max\{B_a - \theta B; 0\}$$

i.e. the amount that needs to be guaranteed for sales of new debt.
Characterizing $B_a$

- $\bar{B}(z)$: maximum level of current debt consistent with no default in the good $\pi = 0$ equilibrium.
- Value from non-defaulting, with assistance:

$$v_{ND}(s) = \max_{c, B' \leq B_a(s)} \{ u(c) + \beta E \left[ v(s') \mid z \right] \mid$$

$$c + (1 - \theta)B(s) = y(s) + q_{(\pi=0)}(B'; s)(B' - \theta B(s))$$

$$s' = (B', d(s), z')$$

- For $0 \leq B \leq \bar{B}(z)$, find $B'_a(s) \geq 0$ so that

$$v_{ND}(s = (B, 0, z)) = v_D(z(s)) - \chi(s = (B, 0, z)) \quad (1)$$

- For $B > \bar{B}(z)$, define $B'_a(s) = 0$. 
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Calibration

- (Arbitrary) benchmark: $\pi = 5\%$.
- Target:
  - Debt/Tax (i.e.: $B/Y$): between 2 and 3.
  - Default rates: around 5% to 8% p.a.

Normally: hard! Here, "easy", per two-state Markov process for $\chi$:
  - Utility: CRRA with $\sigma < 1$, low $\beta$ ("impatient").
  - Set $\chi_L = 0$.
  - Calibrate $\chi_H$ and trans.prob. $\chi_H \rightarrow \chi_L$ to match target.

\[
\begin{bmatrix}
0 & 1 \\
0.04 & 0.96
\end{bmatrix}
\]
### Parameters ($t$ counts years):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government’s risk aversion</td>
<td>$\sigma$</td>
</tr>
<tr>
<td>Interest rate</td>
<td>$r$ 3.0%</td>
</tr>
<tr>
<td>Income autocorrelation coefficient</td>
<td>$\rho$ 0.945</td>
</tr>
<tr>
<td>Standard deviation of innovations</td>
<td>$\sigma_\varepsilon$ 3.4%</td>
</tr>
<tr>
<td>Mean log income</td>
<td>$\mu (-1/2)\sigma_\varepsilon^2$</td>
</tr>
<tr>
<td>Exclusion</td>
<td>$\alpha$ 0.2</td>
</tr>
<tr>
<td>Maturity structure</td>
<td>$\theta$ 0.8</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$ 0.4</td>
</tr>
<tr>
<td>Cost</td>
<td>$\chi_L$ 0</td>
</tr>
<tr>
<td>Cost</td>
<td>$\chi_H$ 0.5</td>
</tr>
<tr>
<td>SFC sunspot probability</td>
<td>$\pi$ 0.05</td>
</tr>
<tr>
<td>Income grid</td>
<td>$y_1, \ldots, y_{20}$ [0.73, \ldots, 1.37]</td>
</tr>
<tr>
<td>Debt grid</td>
<td>$B_1, \ldots, B_{1000}$</td>
</tr>
</tbody>
</table>
## Results

### Targets

<table>
<thead>
<tr>
<th></th>
<th>Target</th>
<th>( \theta = 0.8 )</th>
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<tbody>
<tr>
<td>Debt/Tax ratio</td>
<td>2 .. 3</td>
<td>2.4</td>
</tr>
<tr>
<td>Default rate</td>
<td>5% .. 8%</td>
<td>6.6%</td>
</tr>
</tbody>
</table>

### Defaults

<table>
<thead>
<tr>
<th></th>
<th>Buyers present</th>
<th>Buyers’ strike</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi_L )</td>
<td>38%</td>
<td>2%</td>
</tr>
<tr>
<td>( \chi_H )</td>
<td>12%</td>
<td>48%</td>
</tr>
</tbody>
</table>
Crisis Zones

![Graph showing the relationship between Debt / Mean Income and Income, illustrating various zones of crisis.](image-url)
Bailout facility purchase guarantees ($\chi_H$)
Numerical example

Income and bailout agency purchase guarantees

![Graph showing Net Ba / New issued debt against Debt / Mean Income for Low y and High y.](image-url)
Numerical example

... at market values

![Graph showing the relationship between debt and mean income with two lines representing Low y and High y scenarios. The y-axis represents \( q(B')^*\text{Net Ba} \), and the x-axis represents Debt / Mean Income. The graph shows two peaks at different x-values for both scenarios.]
# Maturity and debt levels

## Targets:

<table>
<thead>
<tr>
<th></th>
<th>Target</th>
<th>$\theta = 0.9$</th>
<th>$\theta = 0.8$</th>
<th>$\theta = 0.5$</th>
<th>$\theta = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt/Tax ratio</td>
<td>2 .. 3</td>
<td>3.3</td>
<td>2.4</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Default rate</td>
<td>5% .. 8%</td>
<td>6.6%</td>
<td>6.6%</td>
<td>6.2%</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

### Defaults: $\theta = 0.9$

<table>
<thead>
<tr>
<th></th>
<th>Buyers present</th>
<th>Buyers’ strike</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_L$</td>
<td>38%</td>
<td>2%</td>
</tr>
<tr>
<td>$\chi_H$</td>
<td>16%</td>
<td>44%</td>
</tr>
</tbody>
</table>

### Defaults: $\theta = 0$

<table>
<thead>
<tr>
<th></th>
<th>Buyers present</th>
<th>Buyers’ strike</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_L$</td>
<td>42%</td>
<td>2%</td>
</tr>
<tr>
<td>$\chi_H$</td>
<td>2%</td>
<td>54%</td>
</tr>
</tbody>
</table>
Debt and $\theta$
Default and $\theta$
Maturity and Crisis Zones

\[ \theta = 0.9 \]

\[ \theta = 0 \]

Debt / Mean Income

Income

Income

Debt / Mean Income

Debt / Mean Income
Maturity and Bailout facility purchase guarantees

Debt / Mean Income

Net Ba / New issued debt

Theta = 0.9
Theta = 0.8
Theta = 0.5
Theta = 0

Roch-Uhlig
Sovereign Debt Crises
2018-Dec-11 44 / 65
# Sunspot probabilities and debt levels

<table>
<thead>
<tr>
<th>Target</th>
<th>$\pi = 0.2$</th>
<th>$\pi = 0.1$</th>
<th>$\pi = 0.05$</th>
<th>$\pi = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt/Tax ratio</td>
<td>2 .. 3</td>
<td>1.8</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Default rate</td>
<td>5% .. 8%</td>
<td>5%</td>
<td>8%</td>
<td>6.6%</td>
</tr>
</tbody>
</table>
Sunspot probabilities and default details

Defaults for $\pi = 0.1$: total prob = 8%.

<table>
<thead>
<tr>
<th></th>
<th>Buyers present</th>
<th>Buyers’ strike</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_L$</td>
<td>27%</td>
<td>3%</td>
</tr>
<tr>
<td>$\chi_H$</td>
<td>8%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Defaults for $\pi = 0.05$ (Benchmark): total prob = 6.6%.

<table>
<thead>
<tr>
<th></th>
<th>Buyers present</th>
<th>Buyers’ strike</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_L$</td>
<td>38%</td>
<td>2%</td>
</tr>
<tr>
<td>$\chi_H$</td>
<td>12%</td>
<td>48%</td>
</tr>
</tbody>
</table>

Defaults for $\pi = 0$: total prob = 4%.

<table>
<thead>
<tr>
<th></th>
<th>Buyers present</th>
<th>Buyers’ strike</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_L$</td>
<td>81%</td>
<td>0%</td>
</tr>
<tr>
<td>$\chi_H$</td>
<td>19%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Debt and $\pi$

![Graph showing the relationship between Debt-to-income ratio and $\pi$]
Default and $\pi$
Debt pricing function, $\pi = 0.05$ vs $\pi = 0$. 

![Graph showing debt pricing function, $\pi = 0.05$ vs $\pi = 0$.](image)
Debt pricing function, $\pi = 0.05$ vs $\pi = 0$, when $\theta = 0$. 

![Graph showing debt pricing function with $\pi = 0.05$ and $\pi = 0$, indicating different dynamics with respect to debt to mean income ratio.](image-url)
Numerical example

Risk Yield Spreads, $\pi = 0.05$ vs $\pi = 0$. 

![Graph of Risk Yield Spreads showing annual spread (%) against Debt / Mean Income. The graph compares the spread if $\pi = 0.05$ (blue line) and the spread if $\pi = 0$ (red line). The x-axis represents Debt / Mean Income ranging from 0 to 3.5, while the y-axis represents Annual Spread (%) ranging from 0 to 0.8. The graph illustrates the difference in spread between the two scenarios.](image-url)
Risk Yield Spreads, $\pi = 0.05$ vs $\pi = 0$, when $\theta = 0$. 

![Graph showing annual spread vs debt to mean income](image-url)
Debt dynamics after bailout agency launch

Starting point: $\pi = 0.05$, mean income, mean debt/gdp ratio

Years after the bailout facility is introduced

Debt-to-income ratio

With assistance
Default frequency after bailout agency launch

Starting point: \( \pi = 0.05 \), mean income, mean debt/gdp ratio
Bond prices after bailout agency launch

Starting point: $\pi = 0.05$, mean income, mean debt/gdp ratio.
Debt Distribution with sunspots: $\pi = 0.1$
Debt Distribution with sunspots: $\pi = 0.05$
Debt Distribution without sunspots / with assistance
Stationary debt dynamics, permanent assistance

\[ B' \]

Case 1 \( << \beta R \)

\[ B'_a(B; y) \]

\[ B'(B; y) \]

\[ B^* \quad B'_a^* \]

Crisis zone
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Summary of the paper: main messages (Aitor Erce).

1. Interventions can successfully eliminate non-fundamental crises
   - If distinction between illiquid and insolvent is unclear, losses can be large
   - Program size can be substantial

2. Such interventions can be designed to imply no transfers:
   - Actuarially fair

3. Presence of bailout agency has consequences:
   - Increased debt level (a form of moral hazard?)
   - Default probabilities may remain unchanged

4. Bailouts are fickle:
   - Small changes in fundamentals may lead the bailout agency to remove its support

5. Maturity of debt matters:
   - Longer maturities reduce the crisis zone
Policy issues

1. Conditionality:
   - **Hope**: enforces fiscal discipline.
   - **Danger**: some “bad equilibria” remain, increasing bond premia and default risk.

2. ESM lending capacity smaller than ECB.
   - **Hope**: limit to putting tax payer money at risk.
   - **Danger**: limit to stopping bad equilibria.

3. ESM is senior lender.
   - **Hope**: tax payers get repaid first.
   - **Danger**: private money flees, increasing buyer strike potential.

4. Contagion and spill-overs.
   - **Hope**: stopping the crisis in Greece stops the crisis in Italy.
   - **Danger**: stopping the crisis in Greece empties the coffers, increasing fears of those buying Italian debt.

5. Is Italy too large, in any case?

6. Should we have a fiscal union in Europe? The U.S. example.
Bond Spreads: Italy vs Germany, 10yr bonds

Italy 10 Year vs Germany 10 Year Spread Bond
Yield Overview

Italy 10 Year vs Germany 10 Year Spread • 284.8 -3.2 (-1.11%)
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- The Roch-Uhlig paper offers a framework to think about potential roles of a bailout agency such as the IMF, the ECB or the ESM.
- One role: ruling out “buyer-strike” equilibria. This can be done in an actuarially fair way, but may involve substantial resources and running the risk of bailing out insolvent countries, at a potentially huge cost.
- Other roles worthy of investigation.
- Issues such as conditionality, lending seniority, contagion, banking unions or fiscal unions are still in need of deeper clarification and research. The tradeoffs are intricate.