Monetary independence and rollover crises

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Jorge Mondragon (University of Minnesota)

NBER Summer Institute
• Concerns about **rollover crises** and sovereign defaults
  
  • Lenders refuse to rollover ⇒ Liquidity problem for govt....
  
  • Liquidity problem ⇒ Govt. default ⇒ Lenders don’t rollover...
Eurozone Debt Crisis

- Concerns about **rollover crises** and sovereign defaults
  - Lenders refuse to rollover ⇒ Liquidity problem for govt....
  - Liquidity problem ⇒ Govt. default ⇒ Lenders don’t rollover...

*You have large parts of the euro area in what we call a “bad equilibrium”, namely an equilibrium where you may have self-fulfilling expectations that feed upon themselves and generate very adverse scenarios.*

Mario Draghi, President of the ECB, 2012 Speech
Concerns about **rollover crises** and sovereign defaults

- Lenders refuse to rollover ⇒ Liquidity problem for govt....
- Liquidity problem ⇒ Govt. default ⇒ Lenders don’t rollover...

Members of the Eurozone unable to conduct independent monetary policy

- Argument that this was exacerbating recession and debt crisis
- Fears of potential break-up of monetary union
Eurozone Debt Crisis

- Concerns about **rollover crises** and sovereign defaults
  - Lenders refuse to rollover $\Rightarrow$ Liquidity problem for govt.
  - Liquidity problem $\Rightarrow$ Govt. default $\Rightarrow$ Lenders don’t rollover...

- Members of the Eurozone unable to conduct independent monetary policy
  - Argument that this was exacerbating recession and debt crisis
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How does the lack of monetary autonomy affect the vulnerability of a government to a rollover crisis?
Inability to use monetary policy for macroeconomic stabilization leaves a government more vulnerable to a rollover crisis.
This Paper

Inability to use monetary policy for macroeconomic stabilization leaves a government more vulnerable to a rollover crisis

- Theory: Model of sovereign default and rollover crisis with:
  - Downward nominal wage rigidity ⇐ Macro-stabilization
  - Foreign currency debt ⇐ No role for inflating away

Key insight: Investors' pessimism can trigger a demand-driven recession ⇒ default more attractive ⇒ investors more prone to run
Inability to use monetary policy for macroeconomic stabilization leaves a government more vulnerable to a rollover crisis

- Theory: Model of sovereign default and rollover crisis with:
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**Key insight:** Investors pessimism can trigger a demand driven recession $\Rightarrow$ default more attractive $\Rightarrow$ investors more prone to run
This Paper (ctd): Quantitative Results

- Flexible exchange rate: govt. almost immune to rollover crises
  - Defaults mostly due to fundamentals
- In a monetary union, large fraction of defaults explained by rollover crises

Welfare implications:
- Large costs from joining a monetary union, mostly coming from default exposure, not output losses
- Lender-of-last resort can substantially decrease these costs
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Recent quantitative models on rollover crises: Chatterjee and Eygunoor (2012); Bocola and Dovis (2016); Aguiar, Chatterjee, Cole and Stangebye (2016); Roch and Uhlig (2018); Conesa and Kehoe (2015)

Other types of multiplicity in sovereign debt: Calvo (1988); Lorenzoni and Werning (2013); Ayres, Navarro, Nicolini and Teles (2015), Aguiar and Amador (2018)

Monetary models with domestic currency debt: Calvo (1988); Da Rocha, Gimenez and Lores (2013); Araujo, Leon and Santos (2016); Aguiar, Amador, Farhi and Gopinath (2013; 2016); Corsetti and Dedola (2016); Camous and Cooper (2014); Bacchetta, Perazzi and van Wincoop (2015)

Elements of the model

Small open economy (SOE) populated by households, firms and a government

- Tradable goods:
  - Law of one price holds: $P^T_t = P^*_t e_t$
    - Foreign price $P^*_t$ assumed to be constant, normalized to one
  - Stochastic endowment $y^T$

- Non-tradable goods:
  - Market must clear domestically
  - Produced with labor $y^N = F(h)$, subject to wage rigidity

- Government borrows without commitment
Households

$$\max \{c_t^T, c_t^N\} \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t U(c_t) \right]$$

$$c = [\omega(c^T)^{-\mu} + (1 - \omega)(c^N)^{-\mu}]^{-1/\mu}$$

- Budget constraint in domestic currency

$$e_t c_t^T + P_t^N c_t^N = e_t y_t^T + \phi_t^N + W_t h_t - T_t e_t$$

- $\phi^N$ firms’ profits, $T_t$ taxes. No direct access to external credit.

- Endowment of hours $\bar{h}$
Households

\[ \max \{ c^T_t, c^N_t \} \quad \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t U(c_t) \right] \]

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- \( \phi^N \) firms’ profits, \( T_t \) taxes. No direct access to external credit.

- Endowment of hours \( \bar{h} \)
Firms

- Produce using labor: \( y^N = F(h) \)
- Profit maximization

\[
\phi^N_t = \max_{h_t} \left\{ P^N_t F(h_t) - W_t h_t \right\}
\]
Prelude: Equilibrium real wage

- Household’s and firms’s optimality conditions

\[
\frac{P_t^N}{e_t} = \frac{1 - \omega}{\omega} \left( \frac{c_t^T}{c_t^N} \right)^{1+\mu} \quad \& \quad \frac{W_t}{e_t} = \frac{P_t^N}{e_t} F'(h_t)
\]

- Nontradable market clearing implies \( c_t^N = F(h_t) \)

- For any equilibrium \((c_t^T, h_t)\), wages (in tradable units) are

\[
W(c_t^T, h_t) \equiv \frac{1 - \omega}{\omega} \left( \frac{c_t^T}{F(h_t)} \right)^{1+\mu} F'(h_t)
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and

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- Nontradable market clearing implies $c^N_t = F(h_t)$

- For any equilibrium $(c^T, h_t)$, wages (in tradable units) are

$$\mathcal{W} \left( c^T_t, h_t \right) \equiv \frac{1 - \omega}{\omega} \left( \frac{c^T_t}{F(h_t)} \right)^{1+\mu} F'(h_t)$$

Increasing in tradable consumption $c^T$ and decreasing in labor $h$
Wages in *domestic currency* cannot fall below $\bar{W}$:

$$W_t \geq \bar{W}$$
Wages in *domestic currency* cannot fall below \( \bar{W} \):

\[
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- If market clearing wage is *lower* than \( \bar{W} \) \( \Rightarrow \) unemployment
- Employment is demand determined: \( h_t = F'\left( \frac{W}{P_t^N} \right) \)
Wages in *domestic currency* cannot fall below $\bar{W}$:

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- If market clearing wage is *lower* than $\bar{W}$ ⇒ unemployment
- Employment is demand determined: $h_t = F' \left( \frac{W}{P_t} \right)$

Inside a monetary union, wages in foreign currency $w_t$ must satisfy

$$w_t \geq \bar{w}$$
Government

- Long maturity bond denominated in foreign currency
  - Coupon payments decrease at rate \( 1 - \delta \)
- Budget constraint in repayment (in units of \( T \)):
  \[
  \delta b_t = q_t[b_{t+1} - b_t(1 - \delta)] + T_t
  \]
  \( q \) is a bond price schedule
- If default:
  - Government suffers utility loss and temporary exclusion
  - Investors get zero
Focus on two exchange rate regimes

- **Flexible**: optimal choice of $e_t$
  - Depreciate currency to achieve $\mathcal{W}(c^T, \bar{h})e \geq W$

- **Fixed**: $e_t = \bar{e}$ for all $t$
  - Equivalent to a single (small) economy within a currency union
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Abstract here from gains of fixing exchange rate

- See appendix
• Unit mass of atomistic risk-neutral lenders

• No-arbitrage condition between long-term government bond and a one-period risk-free asset with interest rate $r$

$$q_t(1 + r) = \mathbb{E}_t[(1 - d_{t+1})(\delta + (1 - \delta)q_{t+1})]$$
Where are we going?

- Find **“crisis zone”**: zone in which repayment/default depends on investors’ beliefs
  - Characterize value function of repayment in optimistic/pessimistic cases
- Examine how wage rigidity and monetary policy affects size of crisis zone
Markov equilibrium: Recursive Government Problem

- States: \((b, s)\) \(s = (y^T, \zeta)\)
  - \(\zeta\) is a sunspot, assumed to be iid
- Government problem in good credit standing
  \[
  V(b, s) = \max \left\{ V_D(y^T), V_R(b, s) \right\}
  \]
- Repayment/default decision is made at the end of the period
  - Cole-Kehoe timing
Multiplicity of Equilibria

Notation for value functions:

- Optimistic: If lenders are willing to rollover, government obtains value $V_R^+$ under repayment
- Pessimistic: If lenders refuse to rollover, government obtains value $V_R^-$ under repayment

If $V_R^- < V_D < V_R^+$, equilibrium depends on beliefs (Cole-Kehoe):
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If $V_R^- < V_D < V_R^+$, equilibrium depends on beliefs (Cole-Kehoe):

- If each investor expects others to lend to the government, s/he also lends & govt. repays
- If each investor expects others not to lend to the government, s/he doesn’t lend & govt. defaults
Value of repayment for the Govt.

\[ V_R(b, s) = \max_{b', c^T, h \leq \bar{h}} \left\{ u\left(c^T, F(h)\right) + \beta \mathbb{E} \left[ V(b', s') \right] \right\} \]

s.t. \[ c^T = y^T - \delta b + q(b', b, s) \left[ b' - (1 - \delta)b \right] \]

\[ \mathcal{W} \left( c^T, h \right) \bar{e} \geq \bar{\mathcal{W}} \]

\[ \downarrow c^T \Rightarrow \downarrow h \]
Value of repayment for the Govt.

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s.t. \[ c^T = y^T - \delta b + q(b', b, s) [b' - (1 - \delta) b] \]

\[ \mathcal{V} \left( c^T, h \right) \bar{e} \geq \bar{W} \]

Optimal exchange rate eliminates wage rigidity, \( c^T \Rightarrow \downarrow h \)
Value of repayment for the Govt. if investors lend

\[ V_R^+(b, y^T) = \max_{b', c^T, h \leq \bar{h}} \left\{ u(c^T, F(h)) + \beta \mathbb{E} \left[ V(b', s') \right] \right\} \]

s.t.  \[ c^T = y^T - \delta b + \bar{q}(b', y^T) \left[ b' - (1 - \delta)b \right] \]

\[ \mathcal{W} \left( c^T, h \right) \bar{e} \geq \overline{W} \]
Value of repayment for the Govt. if investors do not lend

\[ V_R^-(b, y^T) = \max_{c^T, h \leq \bar{h}} \left\{ u\left(c^T, F(h)\right) + \beta \mathbb{E}\left[V\left((1 - \delta)b, s'\right)\right] \right\} \]

s.t. \[ c^T = y^T - \delta b + \bar{q}(b', y^T)[b' - (1 - \delta)b] \]

\[ \mathcal{W}\left(c^T, h\right) \geq \bar{W} \]
Value of repayment for the Govt. if investors do not lend

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s.t. \( c^T = y^T - \delta b \)

\[ \mathcal{W} \left( c^T, h \right) \bar{e} \geq \overline{W} \]

Inability to issue debt makes rigidity more binding ↓ \( c^T \) ⇒↓ \( h \)
Crisis Region under Flexible Wages

(fix a value of $y^T$)
Value Functions: Flexible Wages

\[ \tilde{V}_D \]
Value Functions: Flexible Wages

\[ \tilde{V}_D \]

\[ \tilde{V}_R^+ \]
Value Functions: Flexible Wages

\[
\tilde{V}_D - \tilde{V}_R^+ + \tilde{V}_R^-
\]

Debt

-11.50
-11.60
-11.70
-11.80
-11.90

\[
\tilde{V}_D
\]

\[
\tilde{V}_R^+
\]

\[
\tilde{V}_R^-
\]

\[
\text{Debt}
\]
Value Functions: Flexible Wages

![Graph showing value functions and debt levels](image)

- **Safe Region**: Indicates stable financial states.
- **Crisis Region**: Represents critical or defaulting states.
- **Default Region**: Highlighted area where debt exceeds a certain threshold.

Mathematical expressions:

\[ \tilde{V}_D \]

\[ \tilde{V}_R^+ \]

\[ \tilde{V}_R^- \]

The graph illustrates the relationship between debt levels and value functions, demonstrating how flexible wages affect decision-making in different financial scenarios.
• Start by assuming that rigidity in place for *only one period*
  
  • Same continuation values and bond price schedule

• How do three zones change with $\bar{w}_t \equiv \overline{W}/\bar{e}_t$?
“Comparative Statics”: Flexible vs. Sticky Wages

• Start by assuming that rigidity in place for only one period
  • Same continuation values and bond price schedule

• How do three zones change with $\bar{w}_t \equiv \bar{W}/\bar{e}_t$?

• Denote by $\tilde{V}(b, s; \bar{w})$ current values
Recall crisis zone with flexible wages

![Graph showing the relationship between debt and default risk]

Note that default region does not change in this example.
$V^+$ is reduced with $\bar{W}_{low}$
$V^-$ is reduced by more than $V^+$
Increase in Crisis Region (Default Region Unaffected)

Note that default region does not change in this example.
Increase in Crisis Region (Default Region Unaffected)

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Increase in Crisis Region and Default Region

The graph illustrates the relationship between debt and the region of default. The x-axis represents debt, while the y-axis shows the value of the functions $\tilde{V}_D$, $\tilde{V}_R^-$, and $\tilde{V}_R^+$. The graph is divided into three regions:

- **Safe Region**: Represented by the green line $\tilde{V}_D$.
- **Crisis Region**: Represented by the yellow line $\tilde{V}_R^-$.
- **Default Region**: Represented by the red line $\tilde{V}_R^+$.

The graph shows how the value of these functions changes as debt increases, with the crisis region transitioning to the default region at certain thresholds.
The role of unemployment
Unemployment with $\bar{W}_{low}$

![Diagram showing Unemployment with $\bar{W}_{low}$](image)

- Safe Region
- Crisis Region
- Default Region

- $u_R^-$
- $u_R^+$
- $u_D$
Unemployment with $\bar{w}_{\text{low}}$ - Equilibrium
Unemployment with $\bar{w}_{\text{high}}$

![Diagram showing the relationship between unemployment and debt, with regions for safe, crisis, and default.](image)
Unemployment with $\bar{w}_{\text{high}}$ - Equilibrium

The diagram illustrates the relationship between unemployment rates and debt levels under different economic conditions. The x-axis represents debt levels, while the y-axis shows unemployment rates. The diagram is divided into three regions:

- **Safe Region**: Where both unemployment rates are low, indicating stable economic conditions.
- **Crisis Region**: The shaded area indicating potential economic crises.
- **Default Region**: Where high unemployment rates and high debt levels are observed, indicating economic default risk.

The graphs $u_R^-$ and $u_R^+$ represent the labor market equilibrium curves, while $u_D$ represents the default threshold. The diagram helps to visualize how changes in debt levels affect unemployment rates and the likelihood of entering a crisis or default region.
Theoretical Characterization

Paper characterizes thresholds that separates three regions and how they depend on rigidities

Main result:

- When wage rigidity increases, safe region contracts
  \[\Rightarrow\] Government vulnerable with lower levels of debt
Theoretical Characterization

Paper characterizes thresholds that separate three regions and how they depend on rigidities.

**Main result:**
- When wage rigidity increases, safe region contracts.
  \[ \Rightarrow \text{Government vulnerable with lower levels of debt} \]

Results can be generalized substantially:
- Price rigidity, costs of depreciating exchange rate, nominal debt, maturity structure, and other monetary policy regimes.
Simple Example: Gambling for redemption

- Constant income, one-period debt $\beta R = 1$

  → Government eventually leaves crisis zone

Government stays longer in crisis zone under fixed exchange rate
Simple Example: Gambling for redemption

- Constant income, one-period debt $\beta R = 1$
  - Government eventually leaves crisis zone

Flexible exchange rate: $b'$

Fixed exchange rate: $b'$

Government stays longer in crisis zone under fixed exchange rate
Taking stock

- Under fixed, crisis zone is larger and government stays longer
  - Investors anticipate that government is more prone to default so they are more likely to run
  - Saving away can trigger recession today, take longer to exit

Next, quantitative simulations calibrated to Spain:
- How important are rollover crises and how does this depend on the exchange rate regime?
- How large are the welfare costs from lack of monetary independence?
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# Benchmark Calibration: Spain 1995-2015

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Quantitative Simulations: Exposure to Rollover Crises

Defaults due to Rollover

Time in Crisis Zone

Same parameter values for fixed and flex
Quantitative Simulations: Exposure to Rollover Crises

Defaults due to Rollover

Time in Crisis Zone

Average Debt
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<td>Average spread (%)</td>
<td>2.01</td>
<td>2.46</td>
<td>1.43</td>
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<tr>
<td>Average debt-income (%)</td>
<td>29.05</td>
<td>29.73</td>
<td>31.33</td>
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<tr>
<td>Spread volatility (%)</td>
<td>1.42</td>
<td>1.33</td>
<td>1.60</td>
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<tr>
<td>Unemployment Increase (%)</td>
<td>2.00</td>
<td>0.00</td>
<td>1.83</td>
</tr>
<tr>
<td>$\rho(y, c)$</td>
<td>0.98</td>
<td>0.97</td>
<td>0.94</td>
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<tr>
<td>$\rho(y, spread)$</td>
<td>0.38</td>
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<td>Fraction of defaults due to rollover crisis (%)</td>
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<td>0.92</td>
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</tbody>
</table>

Sunspot probability

30/35
Welfare Cost of a Monetary Union

Benefits from a one-period devaluation for different $b$

\[ \zeta = 0 \]
\[ \zeta = 1 \]
Simulation of Spain 2000-2010

- Start economy with 2000’s external debt
- Feed income shocks through 2000-2012
- Feed sunspot shocks
Simulation of Spain 2000-2010

- Start economy with 2000’s external debt
- Feed income shocks through 2000-2012
- Feed sunspot shocks

Predictions of the model:

1. Spain falls in crisis region in 2012
2. Exiting the Euro, would take Spain to safe zone
3. About 60% of welfare losses from lack of monetary independence can be eliminated by a lender of last resort

Abstract from gains of monetary union
The Path to Spain’s Rollover Crisis

**Spread**

![Graph showing the spread over years from 2000 to 2012 with data and model lines.]

**Debt**

![Graph showing the debt over years from 2000 to 2012 with data and model lines.]

**Income process**

![Graph showing the income process over years from 2000 to 2012 with data and model lines.]

Year-wise data and model comparison.
The Path to Spain’s Rollover Crisis

Probability Crisis Zone

Welfare (one-period)
Inability to use monetary policy for macroeconomic stabilization increases the vulnerability to a rollover crisis

- Uncover new cost from monetary unions

Lender of last resort critical for monetary unions and economies with limited exchange rate flexibility

- For economies with flexible exchange rate, moral hazard likely to outweigh benefits
Conclusion

- Inability to use monetary policy for macroeconomic stabilization increases the vulnerability to a rollover crisis
  - Uncover new cost from monetary unions

- Lender of last resort critical for monetary unions and economies with limited exchange rate flexibility
  - For economies with flexible exchange rate, moral hazard likely to outweigh benefits
EXTRAS
Three Zones: Flexible Wages

- Safe Zone
- Crisis Zone
- Default Zone

Debt

Tradable Endowment
Three Zones: Low Wage Rigidity

- **Safe Zone**
- **Default Zone**
- **Crisis Zone**

Graph showing the relationship between debt and tradable endowment.
Three Zones: High Wage Rigidity

![Graph showing three zones: Safe Zone, Crisis Zone, and Default Zone. The x-axis represents Debt, ranging from 0.00 to 0.50, and the y-axis represents Tradable Endowment, ranging from 0.90 to 1.10. The zones are shaded differently to visually distinguish them.]
Safe region, crisis region, and default regions
A Markov perfect equilibrium is defined by value functions 
\{V(b, s), V_R(b, s), V_D(y^T)\}, policy functions 
\{d(b, s), c_T(b, s), b'(b, s), h(b, s)\}, and a bond price schedule 
q(b', b, s) such that 

i. Given the bond price schedule, the policy functions solve the 
government problem 

ii. The bond price schedule satisfies no arbitrage given future 
government policies
### Sensitivity to Sunspot Probability

<table>
<thead>
<tr>
<th>Sunspot probability (percentage %)</th>
<th>$\pi = 3%$</th>
<th>$\pi = 10%$</th>
<th>$\pi = 20%$</th>
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<tbody>
<tr>
<td></td>
<td>Flexible</td>
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<td>Flexible</td>
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<tr>
<td>Average spread</td>
<td>2.46</td>
<td>1.43</td>
<td>2.45</td>
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<tr>
<td>Average debt-income</td>
<td>29.73</td>
<td>31.33</td>
<td>29.58</td>
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<tr>
<td>Spread volatility</td>
<td>1.33</td>
<td>1.60</td>
<td>1.30</td>
</tr>
<tr>
<td>Unemployment Increase</td>
<td>0.00</td>
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<tr>
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<td>3.70</td>
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Long-Run Simulation Statistics: Fixed vs. Flexible

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Data</th>
<th>Flexible</th>
<th>Fixed</th>
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<td>Average spread (%)</td>
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<td>1.43</td>
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</tr>
<tr>
<td>$\rho(y, c)$</td>
<td>0.98</td>
<td>0.97</td>
<td>0.94</td>
</tr>
<tr>
<td>$\rho(y, spread)$</td>
<td>0.38</td>
<td>0.87</td>
<td>0.77</td>
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Three Zones

- Safe zone (govt. always repays)
  \[ S \equiv \{(b, y^T) : \quad V_D(y^T) \leq V_R^-(b, y^T)\} \]

- Default zone (govt. always defaults)
  \[ D \equiv \{(b, y^T) : \quad V_D(y^T) > V_R^+(b, y^T)\} \]

- Crisis zone (govt. repayment depends on beliefs)
  \[ C \equiv \{(b, y^T) : \quad V_D(y^T) > V_R^-(b, y^T) \quad \& \quad V_D(y^T) \leq V_R^+(b, y^T)\} \]
Debt-GDP ratio: Data vs Model

<table>
<thead>
<tr>
<th>Year</th>
<th>Data</th>
<th>Model</th>
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<tbody>
<tr>
<td>2000</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interest rate spreads: Data vs Model

Year


-2% 0% 2% 4% 6% 8% 10% 12%

Data

Model

counter 47/35
Definition: Competitive eq. given govt. policies

Given $b_0$, and govt. policy $\{e_t, b_{t+1}, d_t\}_{t=0}^\infty$, a **competitive equilibrium** is given by households and firms’ allocations $\{c^T_t, c^N_t, h_t\}_{t=0}^\infty$, and prices $\{P^N_t, W_t, q_t\}_{t=0}^\infty$, such that

i. Households and firms solve their optimization problems

ii. Government budget constraint holds

iii. Bond pricing schedule satisfies investors’ optimality

iv. NT market clears $c^N_t = y^N_t$ and resource constraint for $T$

\[
c^T_t - q_t (b_{t+1} - (1 - \delta) b_t) = y^T_t - \delta (1 - d_t) b_t
\]

v. Labor market equilibrium conditions hold
A Markov perfect equilibrium is defined by value functions \( \{ V(b, s), V_R(b, s), V_D(y^T) \} \), policy functions \( \{ d(b, s), c^T(b, s), b'(b, s), h(b, s) \} \), and a bond price schedule \( q(b', b, s) \) such that

i. Given the bond price schedule, the policy functions solve the government problem

ii. The bond price schedule satisfies no arbitrage given future government policies
Proposition.  (*Safe zone shrinks with \( \bar{w} \))

There exist a \( \bar{w}^* \) such that for every \( \bar{w}_1, \bar{w}_2 \in [0, \bar{w}^*] \), if \( \bar{w}_2 > \bar{w}_1 \), the safe zone compresses \( S(\bar{w}_2) \subset S(\bar{w}_1) \).
Proposition. *(Safe zone shrinks with $\bar{w}$)*
There exist a $\bar{w}^*$ such that for every $\bar{w}_1, \bar{w}_2 \in [0, \bar{w}^*]$, if $\bar{w}_2 > \bar{w}_1$, the safe zone compresses $S(\bar{w}_2) \subset S(\bar{w}_1)$.

Proposition. *(Default zone expands with $\bar{w}$)*
There exist a $\bar{w}^*$ such that for every $\bar{w}_1, \bar{w}_2 \in [0, \bar{w}^*]$, if $\bar{w}_2 > \bar{w}_1$, the default zone expands $D(\bar{w}_1) \subset D(\bar{w}_2)$. 

Next, results on crisis zone
Safe and Default Zones and $\bar{w}$

**Proposition.** *(Safe zone shrinks with $\bar{w}$)*
There exist a $\bar{w}^*$ such that for every $\bar{w}_1, \bar{w}_2 \in [0, \bar{w}^*]$, if $\bar{w}_2 > \bar{w}_1$, the safe zone compresses $S(\bar{w}_2) \subset S(\bar{w}_1)$.

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Next, results on **crisis zone**
Crisis zone expands with \( \bar{w} \)

- For every \( y^T \), there is an interval of debt in crisis region

\[
C_{yT} \equiv \left( \bar{B}^S_{yT}, \bar{B}^D_{yT} \right) \quad \& \quad \Delta C_{yT} \equiv \bar{B}^D_{yT} - \bar{B}^S_{yT}
\]

\( \bar{B}^S_{yT}, \bar{B}^D_{yT} \) are the thresholds for the default and safe zones

**Assumption.** Autarchy after default, i.i.d. shock for \( y^T \), and one-period wage rigidity shock \( \bar{w} > 0 \)

**Proposition.** There exists a \( \bar{w}^* \) such that for every \( \bar{w}_1, \bar{w}_2 \in [0, \bar{w}^*] \), if \( \bar{w}_2 > \bar{w}_1 \), then, for all \( y_T \), \( \Delta C_{yT} \) increases and \( \frac{d \bar{B}^S_{yT}}{d \bar{w}} \leq 0 \)
Crisis zone expands with $\bar{w}$

- For every $y^T$, there is an interval of debt in crisis region

$$C_{y^T} \equiv \left( \bar{B}^S_{y^T}, \bar{B}^D_{y^T} \right) \quad \& \quad \Delta C_{y^T} \equiv \bar{B}^D_{y^T} - \bar{B}^S_{y^T}$$

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**Proposition.** There exists a $\bar{w}^*$ such that for every $\bar{w}_1, \bar{w}_2 \in [0, \bar{w}^*]$, if $\bar{w}_2 > \bar{w}_1$, then, for all $y^T$, $\Delta C_{y^T}$ increases and $\frac{d \bar{B}^S_{y^T}}{d \bar{w}} \leq 0$

Starting from $w^{FLEX}$, crisis region expands with higher $\bar{w}$
Why crisis region expands with $\bar{w}$?

$$V^R(S) = \max_{c^T h, b'} \left\{ u(c) + \beta \mathbb{E} \left[ V(b', s') \right] \right\}$$

subject to

$$c = \left( \omega \left( c^T \right)^{-\mu} + (1 - \omega) (F(h))^{-\mu} \right)^{-\frac{1}{\mu}}$$

$$c^T = y^T - \delta b + q(b', S) \left[ b' - (1 - \delta) b \right]$$

$$\bar{w} \leq \mathcal{W}_t \left( c^T, F(h), h \right)$$

$$h \leq \bar{h}$$
Why crisis region expands with $\bar{w}$?

Value of repayment during rollover crisis, $V^C$, is reduced considerably more than $V^F$ and $V^D$

$$V^R(S) = \max_{c^T h, b'} \left\{ u(c) + \beta \mathbb{E} \left[ V(b', s') \right] \right\}$$

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$$c^T = y^T - \delta b$$

$$\bar{w} \leq W_t \left( c^T, F(h), h \right)$$

$$h \leq \bar{h}$$
Why crisis region expands with $\bar{w}$?

Value of repayment during rollover crisis, $V^C$, is reduced considerably more than $V^F$ and $V^D$

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$$c^T = y^T - \delta b$$

$$\bar{w} \leq \mathcal{W}_t \left( c^T, F(h), h \right)$$

$$h \leq \bar{h}$$

Even if unemployment not “observed”, rigidity can trigger crisis
“The assessment of the Governing Council is that we are in a situation now where you have large parts of the euro area in what we call a “bad equilibrium”, namely an equilibrium where you may have self-fulfilling expectations that feed upon themselves and generate very adverse scenarios. So, there is a case for intervening, in a sense, to “break” these expectations”

Mario Draghi, 2012 Speech