

# Monetary independence and rollover crises

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NBER Summer Institute

- 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...

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*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

# Eurozone Debt Crisis

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

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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

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**Key insight:** Investors pessimism triggers demand driven recession  $\Rightarrow$  sovereign default more attractive  $\Rightarrow$  investors more prone to run

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**Key insight:** Investors pessimism triggers demand driven recession  $\Rightarrow$  sovereign default more attractive  $\Rightarrow$  investors more prone to run

New perspective on rollover crisis in a monetary union

## Quantitative Results

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## 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

## Related Literature

**Classic papers on rollover crises:** Sachs (1984); Alesina, Pratti and Tabellini (1989); Cole and Kehoe (2000)

**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)

**Sovereign default model with nominal rigidities:** Na, Schmitt-Grohe, Uribe and Yue (2018); Bianchi, Ottonello and Presno (2016), Arellano, Bai and Mihalache (2018), Bianchi and Sosa-Padilla (2018)

## 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  $y^T \Rightarrow$  source of fundamental shocks
- Non-tradable goods:
  - Produced with labor  $y^N = F(h)$ , subject to DNWR  $W \geq \bar{W}$
  - Market must clear *domestically*
- Government borrows without commitment
  - Cole-Kehoe timing: default is decided at the end of the period
- Risk neutral competitive foreign lenders

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

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

- 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  $\bar{h}$



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

$$\phi_t^N = \max_{h_t} \left\{ P_t^N F(h_t) - W_t h_t \right\}$$

## Prelude: Equilibrium real wage

- Nontradable market clearing implies  $c_t^N = F(h_t)$
- Households' and firms' optimality conditions

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

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Increasing in tradable consumption  $c^T$  and decreasing in labor  $h$

## Downward wage rigidity

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  - Employment is demand determined:  $h_t = F'^{-1}\left(\frac{\bar{w}}{p_t^N}\right)$ ,  
where  $\bar{w} = \frac{\bar{W}}{e}$



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- Abstract here from gains of fixing exchange rate
  - See appendix

- **Crisis zone:** zone in which repayment/default depends on investors' beliefs
  - Characterize value function of repayment when investors are optimistic and pessimistic
- Examine how wage rigidity and monetary policy affects size of crisis zone

# Markov equilibrium

- States:  $(b, \mathbf{s})$   $\mathbf{s} = (y^T, \zeta)$ 
  - $\zeta$  is a sunspot, assumed to be iid
- Government problem in good credit standing

$$V(b, \mathbf{s}) = \max \left\{ V_D(y^T), V_R(b, \mathbf{s}) \right\}$$

## Value of repayment for the Govt.

Govt. maximizes utility s.t. resource constraint and DNWR

- Implementability constraints summarized in  $\mathcal{W}$

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

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

$$\mathcal{W}(c^T, h) \bar{e} \geq \bar{W}$$

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Optimal exchange rate eliminates wage rigidity  $c^T = y^T$

## Value of repayment for the Govt. if investors are optimistic

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

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

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## Value of repayment for the Govt. if investors are pessimistic

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$$\text{s.t. } c^T = y^T - \delta b$$

$$\mathcal{W} \left( \begin{matrix} c^T \\ + \\ - \\ h \end{matrix} \right) \bar{e} \geq \bar{W}$$

Inability to issue debt makes rigidity more binding  $\downarrow c^T \Rightarrow \downarrow h$

## Multiplicity of equilibria

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## Multiplicity of equilibria: crisis zone

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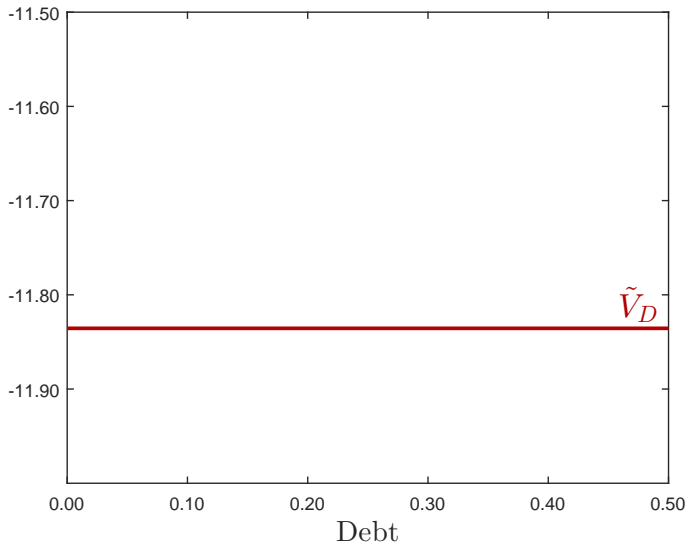
No indeterminacy if:

- If  $V_R^- > V_D$ , safe zone  $\Rightarrow$  always repay
- If  $V_R^+ < V_D$ , default zone  $\Rightarrow$  always defaults

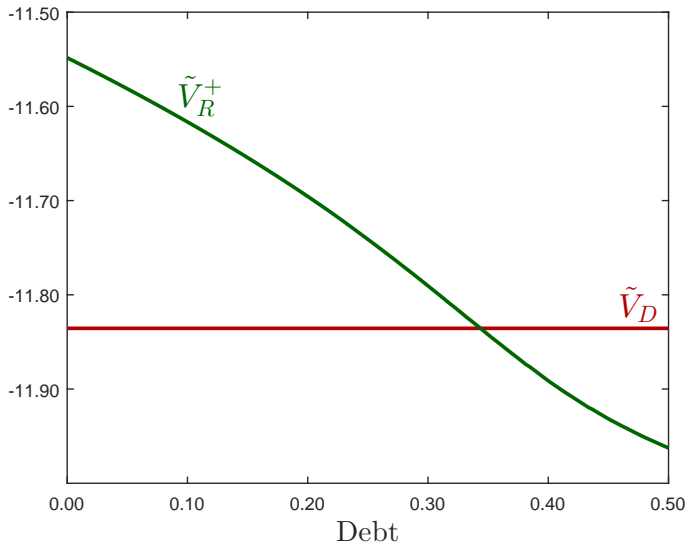
## Crisis Region under Flexible Wages

(fix a value of  $y^T$ )

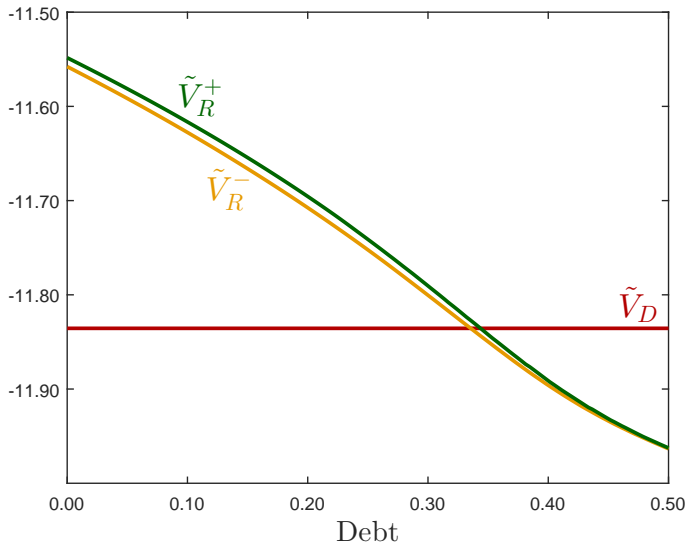
## Value Functions: Flexible Wages



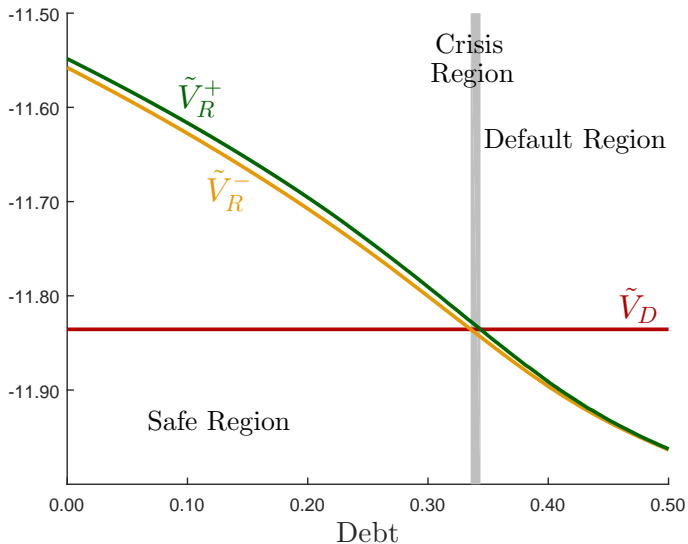
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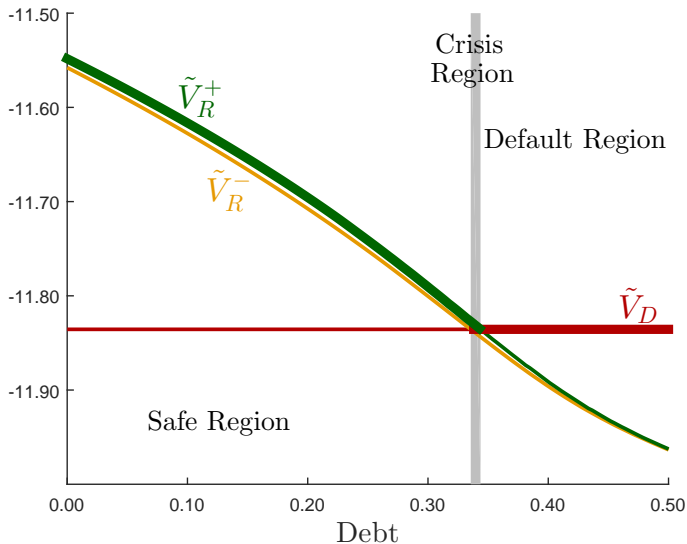
# Value Functions: Flexible Wages



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# Value Functions: Flexible Wages - Equilibrium



## “Comparative Statics”: Flexible vs. Sticky Wages

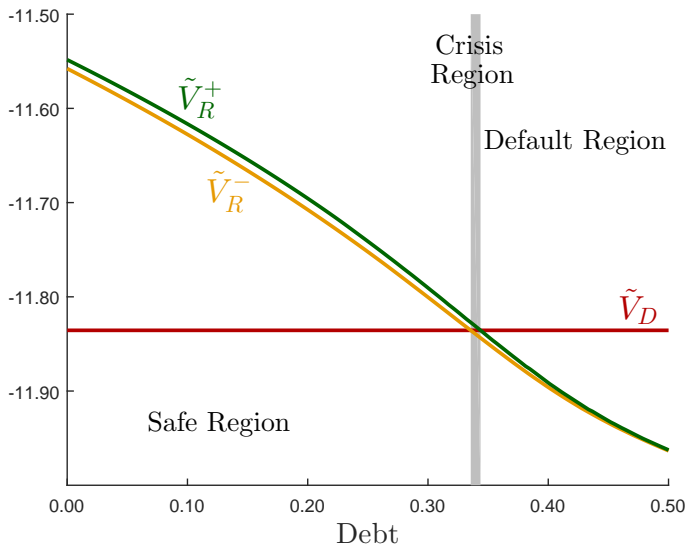
- Start by assuming that rigidity is in place for *only one period*
  - Same continuation values and bond price schedule
- How do three zones change with  $\bar{w}_t \equiv \bar{W}/\bar{e}_t$ ?



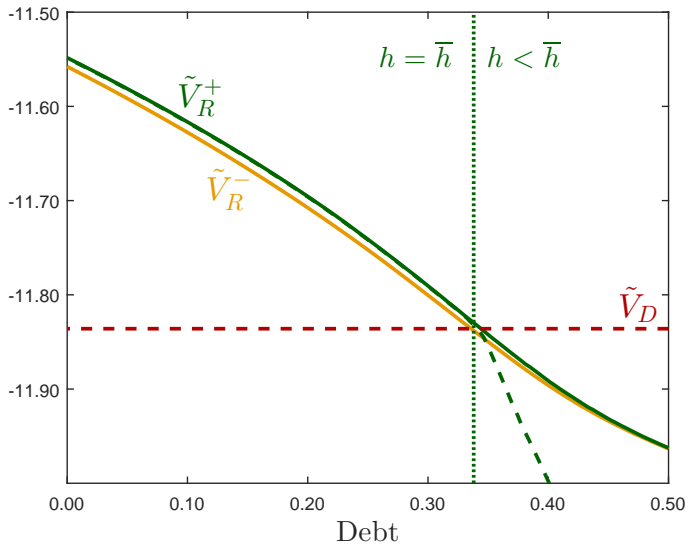
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- Start by assuming that rigidity is in place for *only one period*
  - Same continuation values and bond price schedule
- How do three zones change with  $\bar{w}_t \equiv \bar{W}/\bar{e}_t$ ?
- Denote by  $\tilde{V}(b, s; \bar{w})$  current values

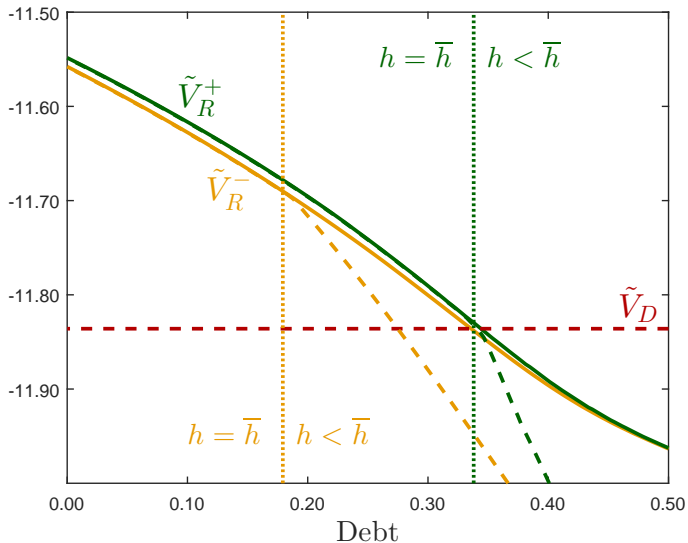
## Recall crisis zone with flexible wages



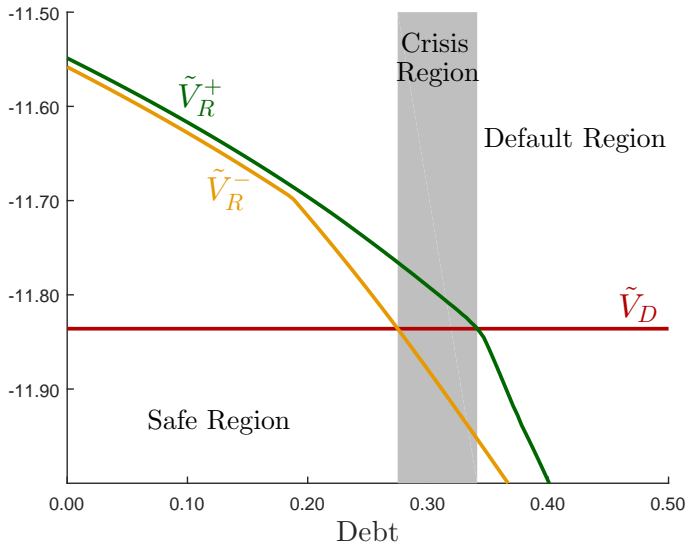
$V^+$  is reduced with  $\bar{w}_{low}$



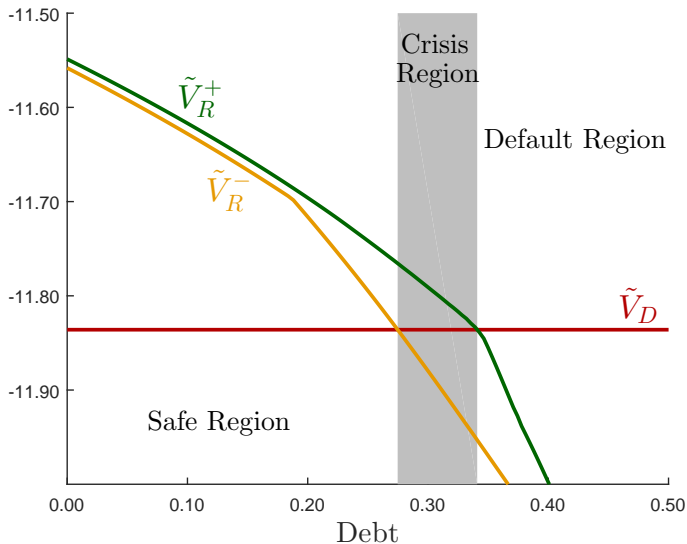
$V^-$  is reduced by more than  $V^+$



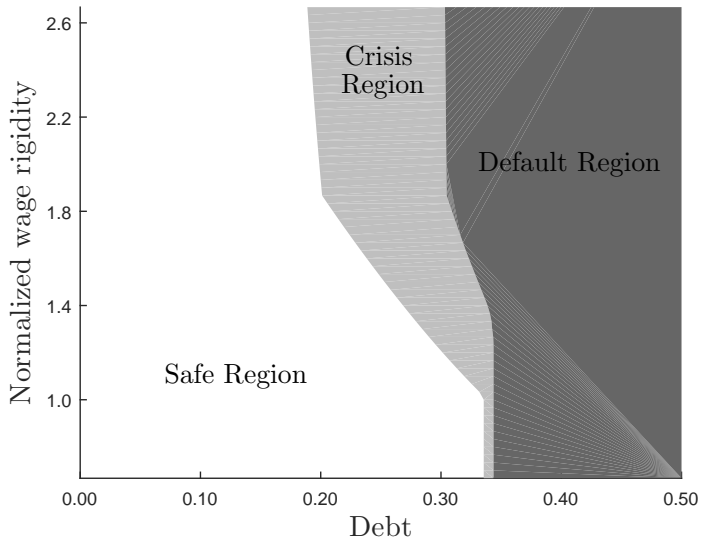
# Increase in Crisis Region



# Increase in Crisis Region (Default Region Unaffected)



## Safe region, crisis region, and default regions



# Theoretical Characterization

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

## Main result of tighter wage rigidity:

- Safe region contracts and crisis region expands  
⇒ Government vulnerable with lower levels of debt
- Fundamental default region expands iff  $TB^{flex} > 0$



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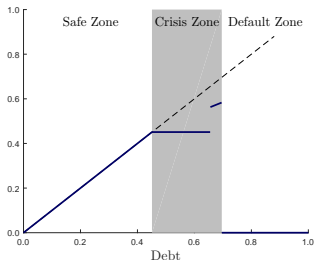
Results can be generalized substantially:

- Price rigidity, costs of depreciating exchange rate, nominal debt, maturity structure, and other monetary policy regimes

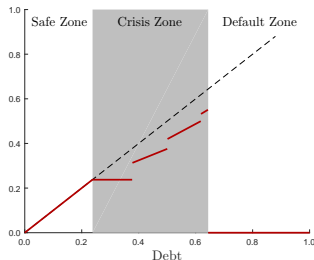
# Simple Example: Gambling for redemption

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

Flexible exchange rate:  $b'$



Fixed exchange rate:  $b'$

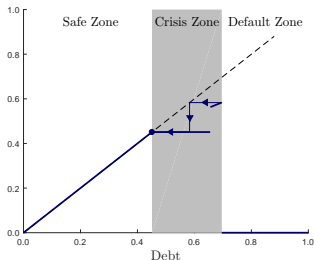


Government stays longer in crisis zone under fixed exchange rate

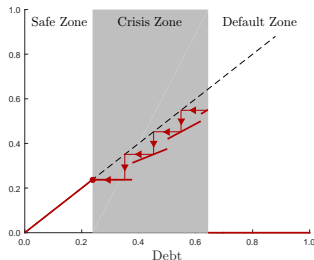
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# Taking stock

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  - Investors anticipate that government is more prone to default so they are more likely to run
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  - 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?

# Benchmark Calibration: Spain 1995-2015

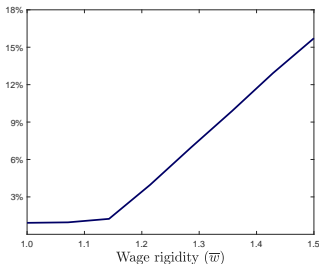
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$\sigma$	2.000	Standard risk aversion	
$\omega$	0.197	Share of tradable GDP	
$\mu$	1.000	Elasticity of substitution between T-NT= 1/2	
$\rho$	0.777	Persistence of tradable income	
$\sigma_y$	0.029	Std. of tradable output	
$\alpha$	0.750	Labor share in nontradable sector	
$r$	0.020	German 6-year government bond yield	
$\delta$	0.141	Spanish bond maturity 6 years	
$\psi$	0.240	Re-entry to financial markets probability	
$\pi$	0.030	Sunspot probability	
Calibration	Flexible	Fixed	Target
$\beta$	0.914	0.908	Average external debt-GDP ratio 29.05%
$\kappa_0$	0.101	0.315	Average spread 2.01%
$\kappa_1$	0.759	3.273	Standard deviation interest rate spread 1.42%
$\bar{w}$	-	2.493	$\Delta$ unemployment rate 2.00%

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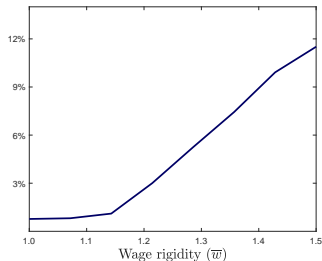
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# Quantitative Simulations: Defaults due to Rollover Crises

## Defaults due to Rollover



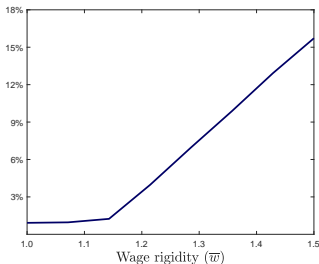
## Time in Crisis Zone



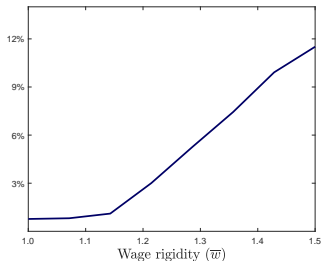


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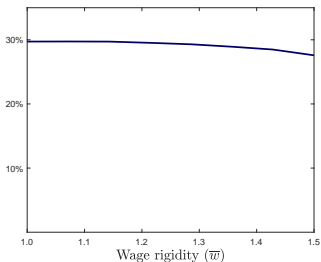
## Defaults due to Rollover



## Time in Crisis Zone



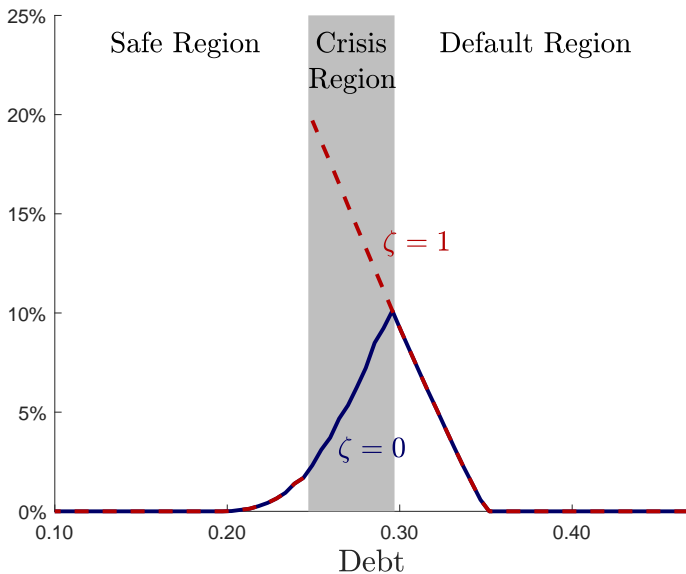
## Average Debt



## Simulations: Fixed vs. Flexible (recalibrated)

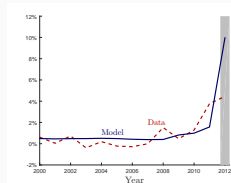
Statistic	Data	Flexible	Fixed
Average spread (%)	2.01	2.46	1.43
Average debt-income (%)	29.05	29.73	31.33
Spread volatility (%)	1.42	1.33	1.60
Unemployment Increase (%)	2.00	0.00	1.83
$\rho(y, c)$	0.98	0.97	0.94
$\rho(y, spread)$	0.38	0.87	0.77
$\sigma(\hat{c})/\sigma(\hat{y})$	1.10	1.55	1.33
Fraction of time in crisis region (%)	-	0.77	2.59
Fraction of defaults due to rollover crisis (%)	-	0.92	6.53

# High Welfare Cost of a Monetary Union in Crisis Zone

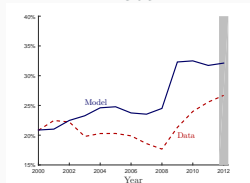


# The Path to Spain's Rollover Crisis

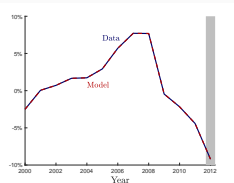
## Spread



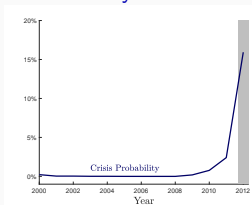
## Debt



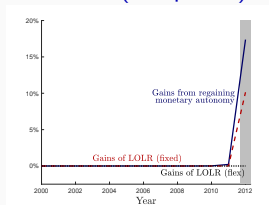
## Income process



## Probability Crisis Zone



## Welfare (one-period)



1. Spain falls in crisis region in 2012
2. Exiting the Euro, would take Spain to safe zone
3. LOLR reduces by 60% benefits from exit

# Conclusion

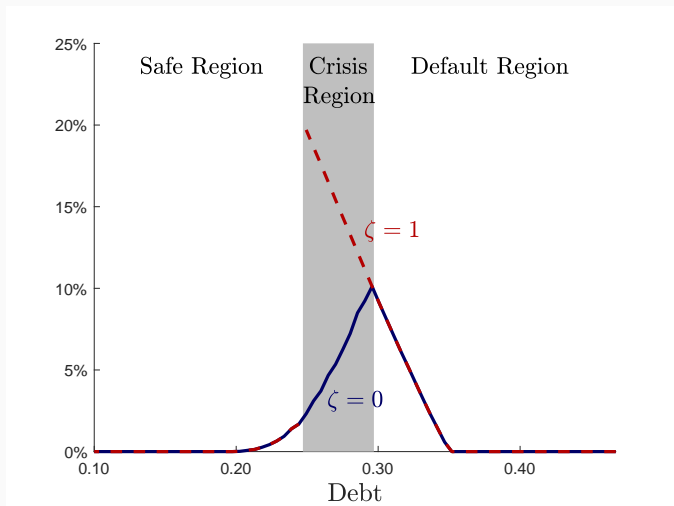
- Inability to use monetary policy for macroeconomic stabilization increases the vulnerability to a rollover crisis
  - Uncover new cost from monetary unions
- Theory suggests that lender of last resort is critical for monetary unions
  - For economies with flexible exchange rate, moral hazard likely to outweigh benefits
- Higher vulnerability to rollover crises likely to apply to economies with limited exchange rate flexib. or subject to ZLB

# Conclusion

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  - Uncover new cost from monetary unions
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# Welfare Cost of a Monetary Union

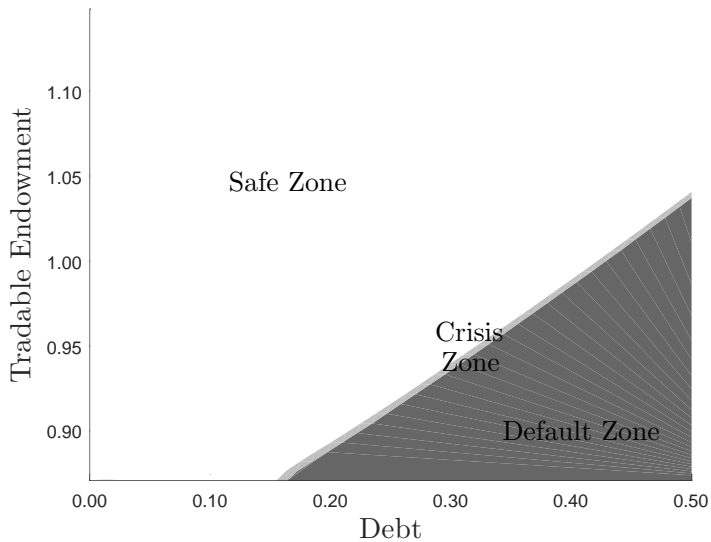
Benefits from a one-period devaluation for different  $b$



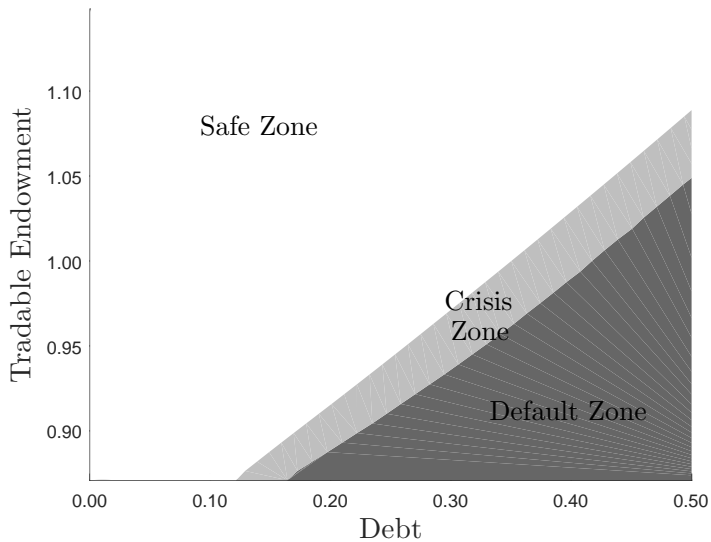
EXTRAS



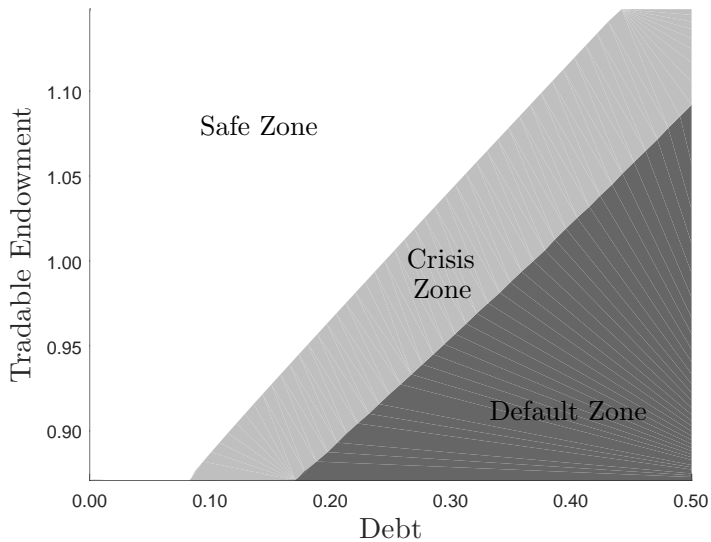
## Three Zones: Flexible Wages



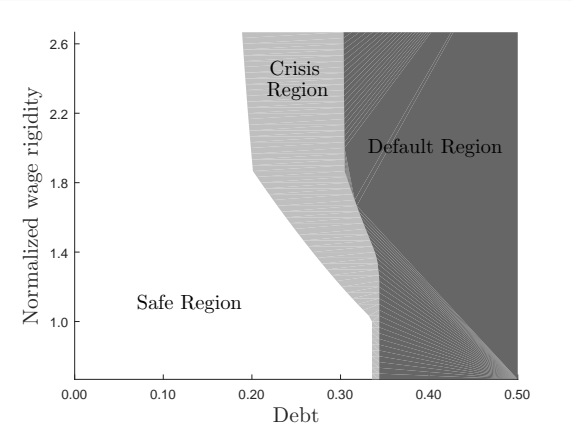
## Three Zones: Low Wage Rigidity



## Three Zones: High Wage Rigidity



# Safe region, crisis region, and default regions



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# Markov Perfect Equilibrium

A *Markov perfect equilibrium* is defined by value functions  $\{V(b, \mathbf{s}), V_R(b, \mathbf{s}), V_D(y^T)\}$ , policy functions  $\{d(b, \mathbf{s}), c^T(b, \mathbf{s}), b'(b, \mathbf{s}), h(b, \mathbf{s})\}$ , and a bond price schedule  $q(b', b, \mathbf{s})$  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

Sunspot probability (percentage %)	$\pi = 3\%$		$\pi = 10\%$		$\pi = 20\%$	
	Flexible	Fixed	Flexible	Fixed	Flexible	Fixed
Average spread	2.46	1.43	2.45	1.47	2.46	1.53
Average debt-income	29.73	31.33	29.58	29.29	29.37	28.53
Spread volatility	1.33	1.60	1.30	1.72	1.31	1.75
Unemployment Increase	0.00	1.83	0.00	1.80	0.00	1.35
Fraction of time in crisis region	0.77	2.59	0.68	1.93	0.58	1.41
Fraction of defaults due to rollover crisis	0.92	<b>6.53</b>	3.70	<b>11.80</b>	6.20	<b>19.80</b>

▶ Back

## Long-Run Simulation Statistics: Fixed vs. Flexible

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# Three Zones

- Safe zone (govt. always repays)

$$\mathcal{S} \equiv \left\{ (b, y^T) : V_D(y^T) \leq V_R^-(b, y^T) \right\}$$

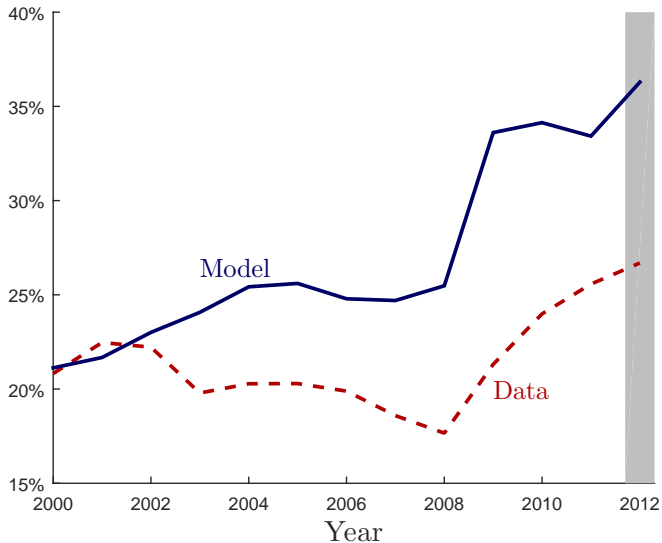
- Default zone (govt. always defaults)

$$\mathcal{D} \equiv \left\{ (b, y^T) : V_D(y^T) > V_R^+(b, y^T) \right\}$$

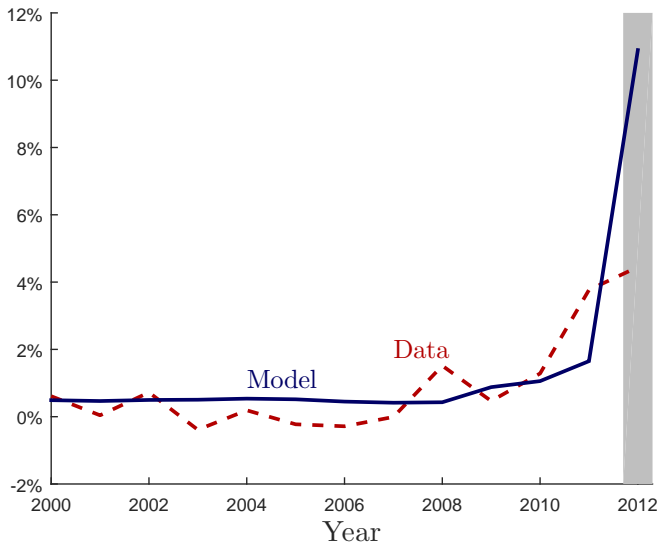
- Crisis zone (govt. repayment depends on beliefs )

$$\mathcal{C} \equiv \left\{ (b, y^T) : V_D(y^T) > V_R^-(b, y^T) \right. \\ \left. \& \quad V_D(y^T) \leq V_R^+(b, y^T) \right\}$$

# Debt-GDP ratio: Data vs Model



# Interest rate spreads: Data vs Model



## 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  $\{c_t^T, c_t^N, h_t\}_{t=0}^{\infty}$ , and prices  $\{P_t^N, W_t, q_t\}_{t=0}^{\infty}$ , 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  $c_t^N = y_t^N$  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

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