Monetary independence and rollover crises

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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...

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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?

This Paper

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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New perspective on rollover crisis in a monetary union

This Paper (ctd): Quantitative Results

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Welfare implications:

- Large costs from joining a monetary union, mostly coming from higher default exposure
- Lender-of-last resort can substantially decreases 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 downward nominal wage rigidity (DWNR)
  - Market must clear *domestically*
- Government borrows without commitment
  - Cole-Kehoe timing: default is decided at the end of the period

Households

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

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

- Budget constraint in domestic currency

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

- ϕ^N firms' profits, T_t taxes. No direct access to external credit.
- Endowment of hours $\bar{h}$

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- Endowment of hours $\bar{h}$
- Optimality:

$$\frac{P_t^N}{e_t} = \frac{1-\omega}{\omega} \left(\frac{c_t^T}{c_t^N} \right)^{1+\mu}$$

Firms

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

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

- Optimality

$$W_t = P_t^N F'(h_t)$$

Prelude: Equilibrium real wage

- Nontradable market clearing implies $c_t^N = F(h_t)$
- Recall household's and firm's optimality conditions

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- Real equilibrium wage function (in tradable units)

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

Downward wage rigidity

Wages in *domestic currency*:

$$W_t \geq \overline{W}$$

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  - Employment is demand determined: $h_t = F'^{-1}\left(\frac{\overline{W}}{P_t^N}\right)$

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Inside a monetary union, $w_t \geq \overline{w}$

Government

- Long maturity bond denominated in foreign currency
  - Coupon payments decrease at rate $1 - \delta$
- Budget constraint in repayment:

$$\delta b_t = q_t[b_{t+1} - b_t(1-\delta)] + T_t$$

q is a bond price schedule

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- If default:
  - Government suffers utility loss and temporary exclusion
  - Investors get zero

Government (ctd)

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  - Flexible: optimal choice of e_t
    - Depreciate currency to relax $\mathcal{W}(c^T, \overline{h})e_t \geq W$
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- Abstract here from gains of fixing exchange rate
  - See appendix

International Lenders

- Unit mass of atomistic risk-neutral investors
- No-arbitrage condition between long-term government bond and a one-period risk-free asset with interest rate r

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

Road map

- 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: $(b, \mathbf{s}) \quad \mathbf{s} = \left(y^T, \zeta\right)$
  - ζ 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 default ▸ Definition: Markov Perfect Equilibrium

▸ Definition of competitive equilibrium

Value of repayment for the Govt.

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

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

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

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

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

$\downarrow c^T \Rightarrow \downarrow h$

Value of repayment for the Govt.

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Optimal exchange rate eliminates wage rigidity $\downarrow c^T \Rightarrow \downarrow h$

Value of repayment for the Govt. if investors are optimistic

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

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Value of repayment for the Govt. if investors are pessimistic

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

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

Multiplicity of equilibria: crisis zone

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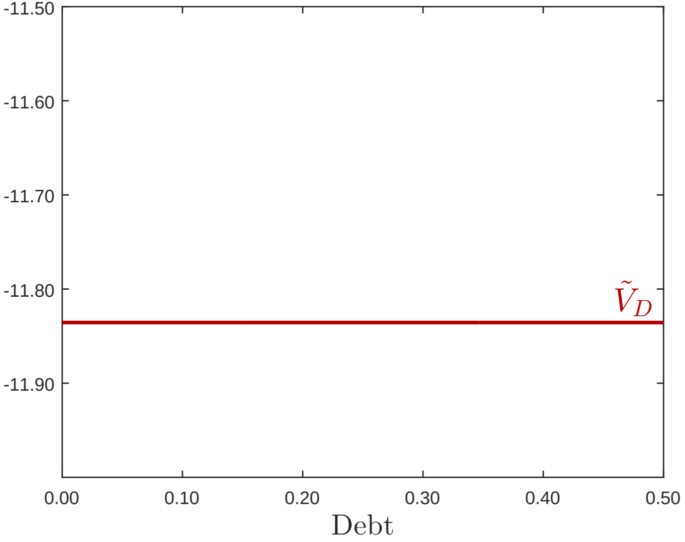
Two other zones are not subject to indeterminacy:

- 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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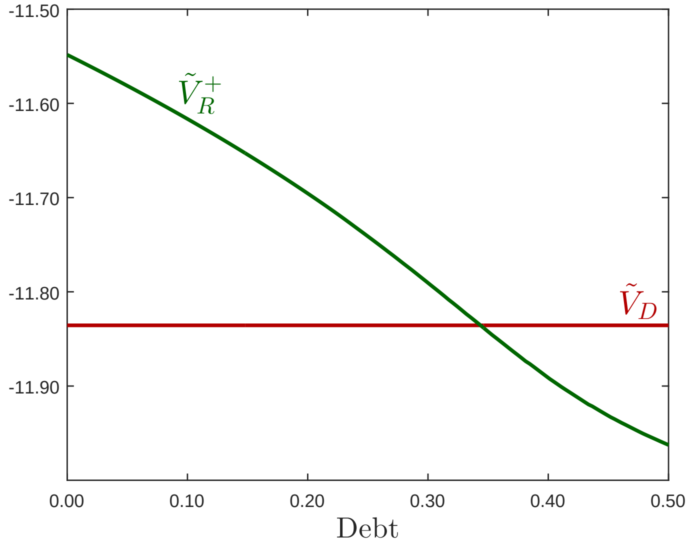

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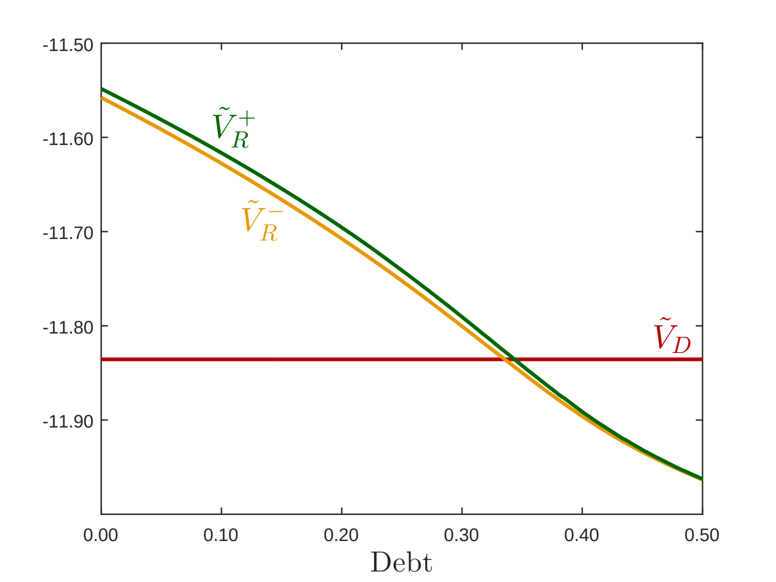

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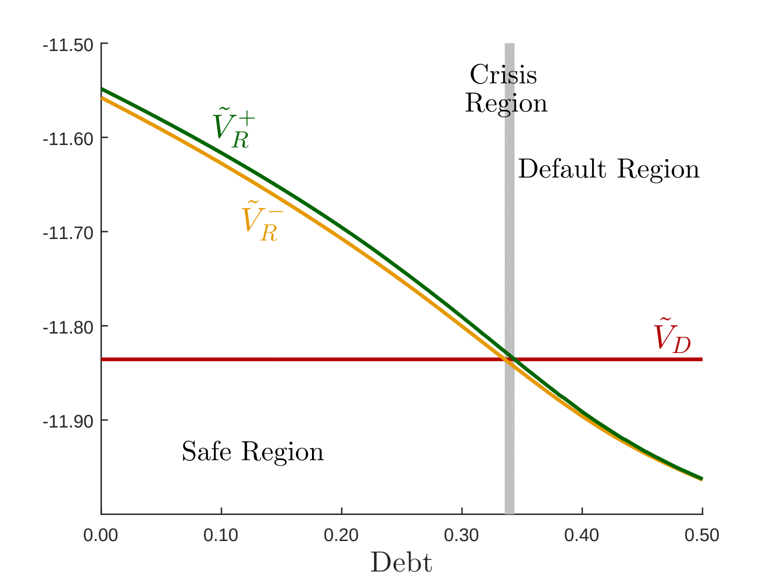
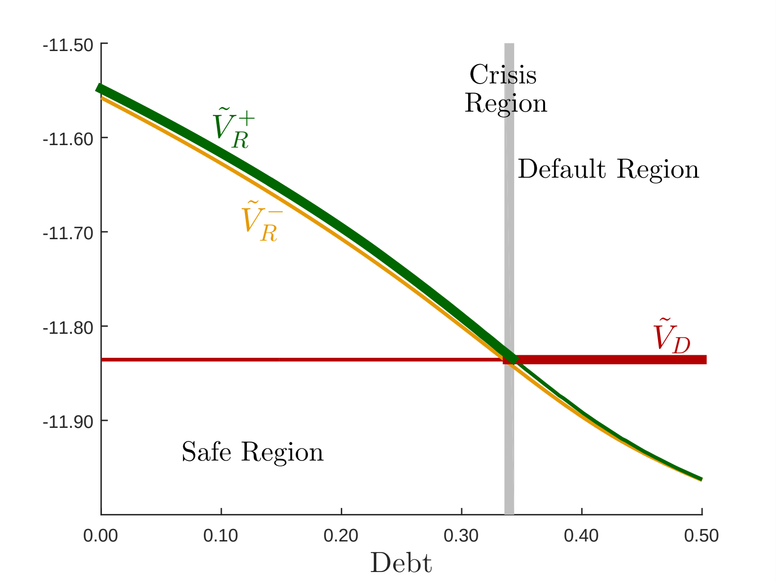


Value Functions: Flexible Wages - Equilibrium



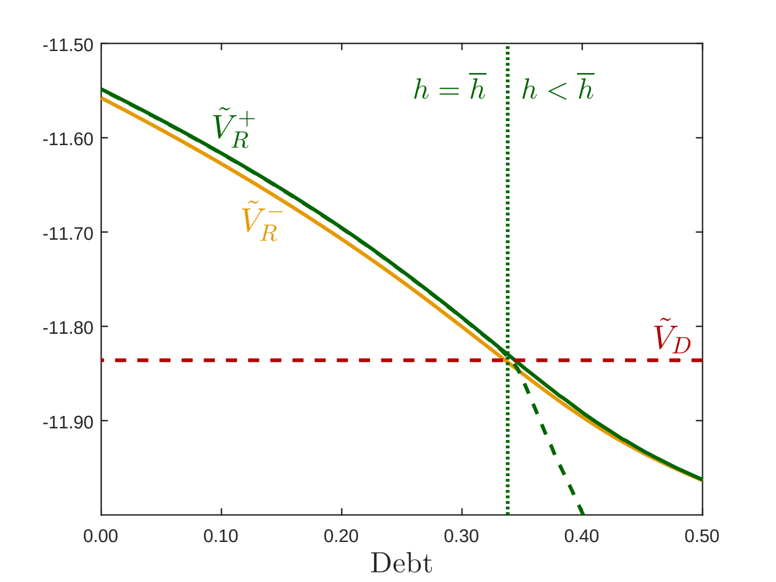
“Comparative Statics”: Flexible vs. Sticky Wages

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

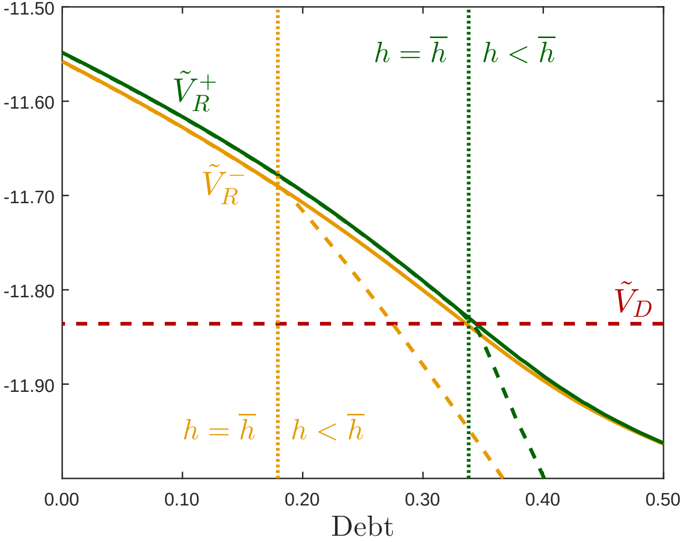
“Comparative Statics”: Flexible vs. Sticky Wages

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

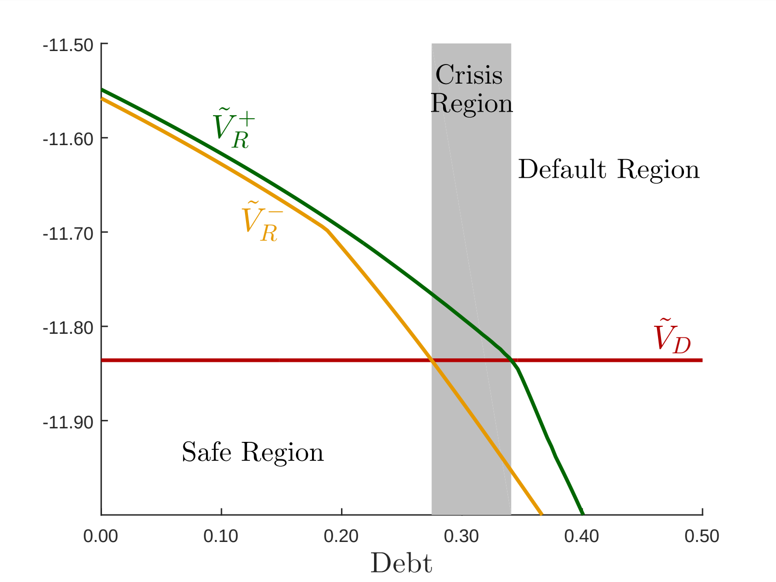
V^+ is reduced for high levels of debt



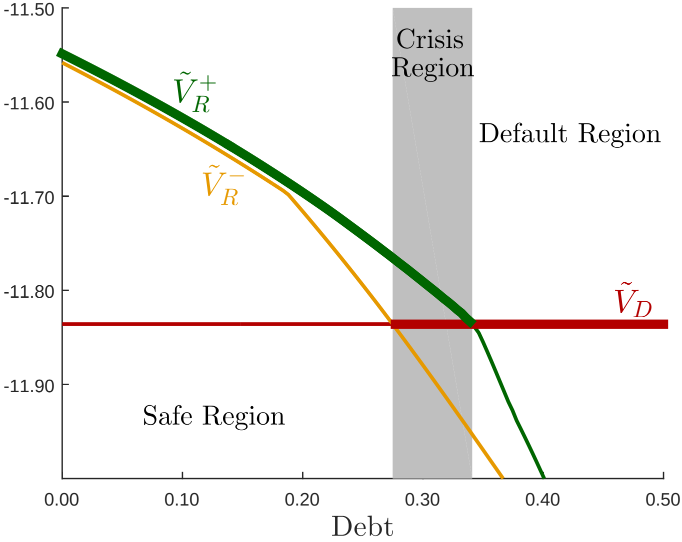
V^- is reduced by more than V^+



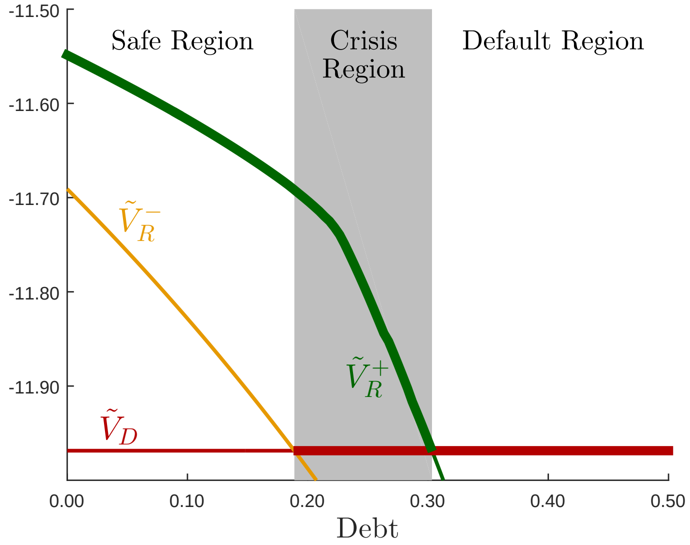
Increase in Crisis Region



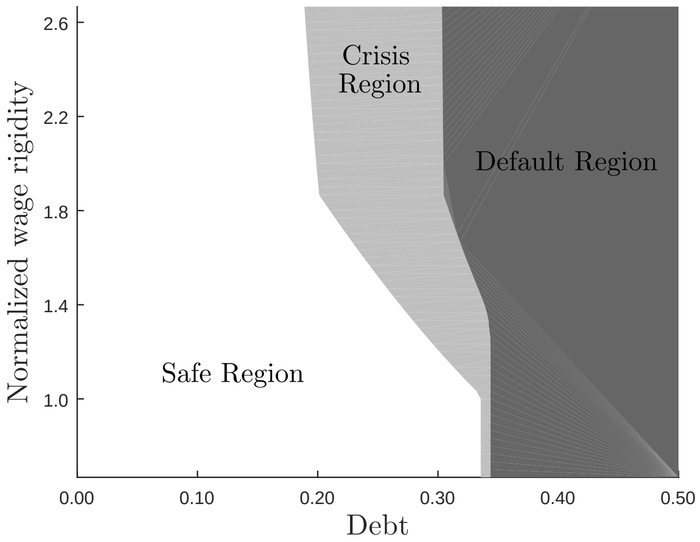
Increase in Crisis Region (Default Region Unaffected)



Increase in Crisis Region and Default Region



Safe region, crisis region, and default regions



Theoretical characterization of tighter wage rigidity

Paper characterizes thresholds that separates three regions

Main results:

- Safe region contracts and crisis region expands

  $\Rightarrow$ 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

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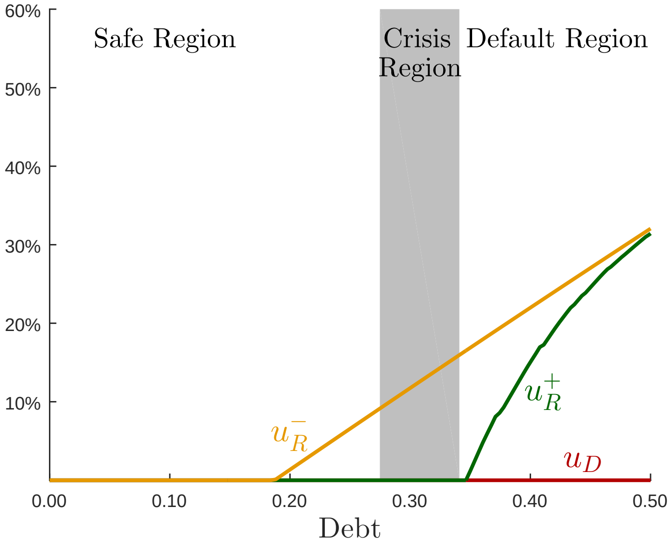
Key mechanism: larger $V_R^+ - V_R^-$ under wage rigidity

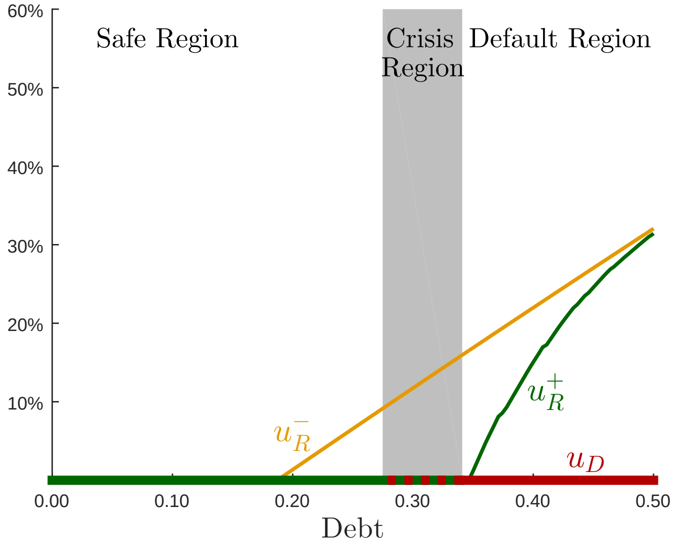
The role of unemployment

▸ Zones

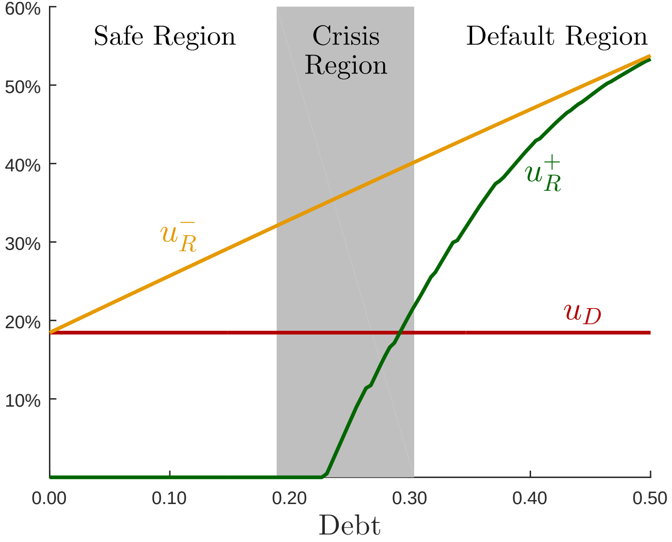
Unemployment with $\overline{w}_{low}$



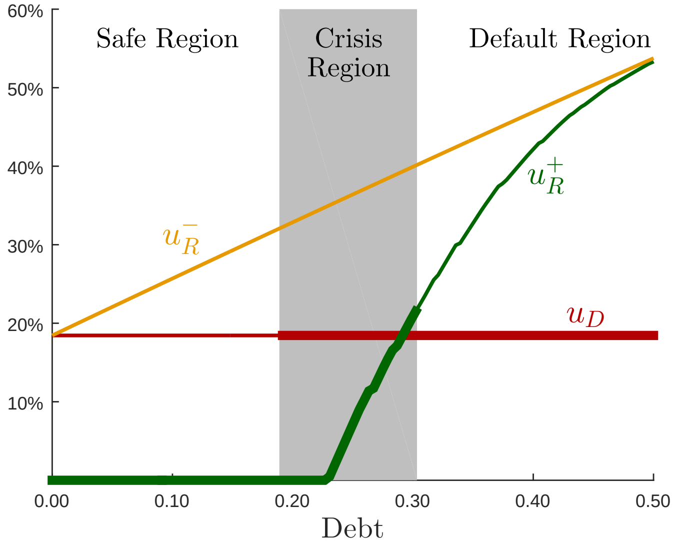
Unemployment with $\overline{w}_{low}$ - Equilibrium



Unemployment with $\overline{w}_{high}$



Unemployment with $\overline{w}_{high}$ - Equilibrium

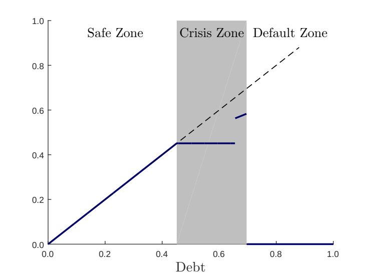


Simple Example: Gambling for redemption

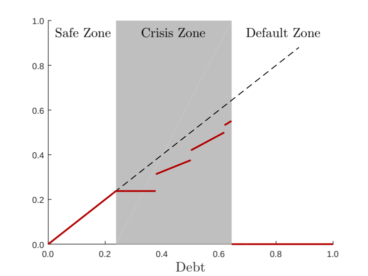
- Constant income, $\overline{w}$ one-period debt $\beta R = 1$

  $\rightarrow$ Government eventually leaves crisis zone

Flexible exchange rate: b'



Fixed exchange rate: b'



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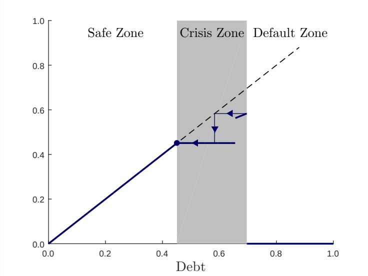

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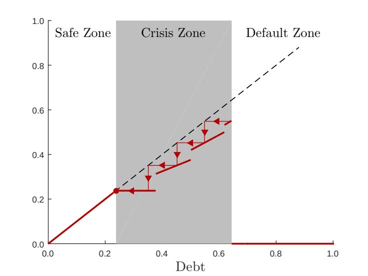

Government stays longer in crisis zone under fixed exchange rate

Taking stock: Larger vulnerability under fixed

- Two key ingredients:
  - Pessimism triggers capital outflows (if government repays)
  - Costs of outflows are more severe under fixed
    - Demand-driven recession avoided under flex

$\Rightarrow$ Government is more tempted to default & investors more prone to run

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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

Parameter	Value		Description
$\overline{h}$	1.000		Normalization
σ	2.000		Standard risk aversion
ω	0.197		Share of tradable GDP
μ	1.000		Elasticity of substitution between T-NT$= 1/2$
ρ	0.777		Persistence of tradable income
σ_y	0.029		Std. of tradable output
α	0.750		Labor share in nontradable sector
r	0.020		German 6-year government bond yield
δ	0.141		Spanish bond maturity 6 years
ψ	0.240		Re-entry to financial markets probability
π	0.030		Sunspot probability
Calibration	**Flexible**	**Fixed**	**Target**
β	0.914	0.908	Average external debt-GDP ratio 29.05%
κ_0	0.101	0.315	Average spread 2.01%
κ_1	0.759	3.273	Standard deviation interest rate spread 1.42%
$\overline{w}$	-	2.493	Δ unemployment rate 2.00%

Benchmark Calibration: Spain 1995-2015

Parameter	Value		Description
$\overline{h}$	1.000		Normalization
σ	2.000		Standard risk aversion
ω	0.197		Share of tradable GDP
μ	1.000		Elasticity of substitution between T-NT$= 1/2$
ρ	0.777		Persistence of tradable income
σ_y	0.029		Std. of tradable output
α	0.750		Labor share in nontradable sector
r	0.020		German 6-year government bond yield
δ	0.141		Spanish bond maturity 6 years
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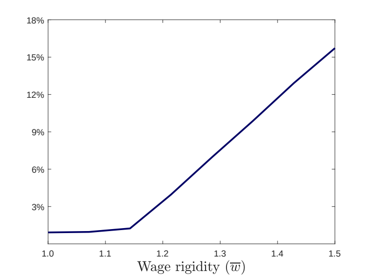
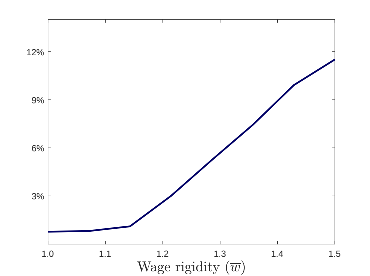
Quantitative Simulations: Defaults due to Rollover Crises

Defaults due to Rollover



Time in Crisis Zone



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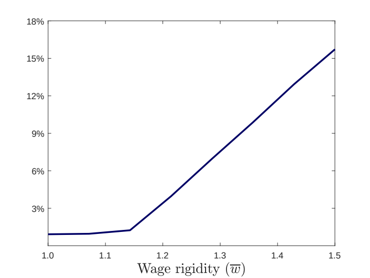

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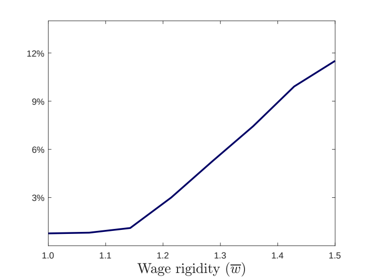
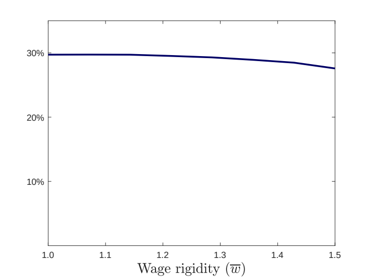


Average Debt

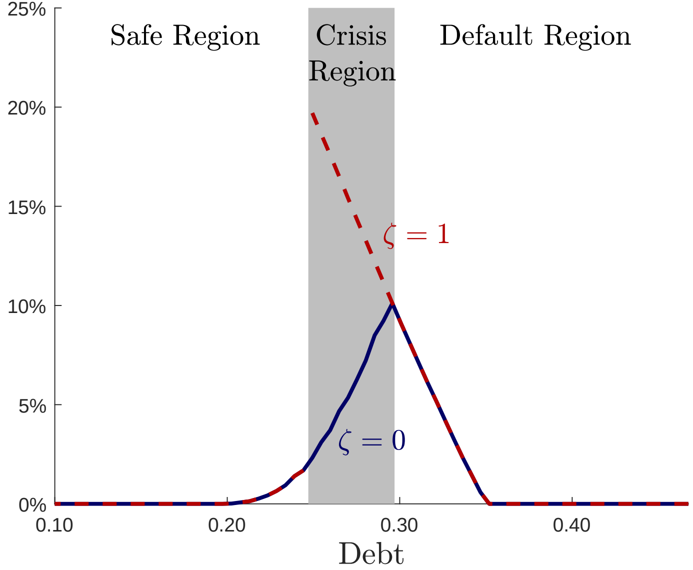


Simulations: Fixed vs. Flexible (recalibrated)

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

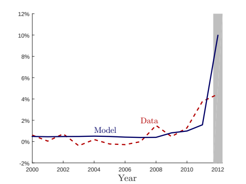
▸ Sunspot probability

High Welfare Cost of a Monetary Union in Crisis Zone

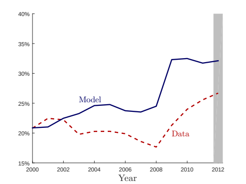


The Path to Spain’s Rollover Crisis

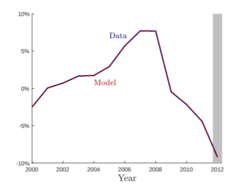
Spread



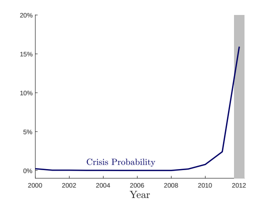
Debt



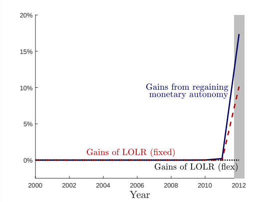
Income process



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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  - For economies with flexible exchange rate, moral hazard likely to outweigh benefits
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Value of Default

$$V_D(y^T,\chi) = \max_{h\le\bar{h}} u(y^T, F(h)) - \kappa(y^T) \\ + \beta\mathbb{E}\left[\psi V(0,s') + (1-\psi)V_D\left(y^{T\prime}\right)\right]$$

subject to

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

$$s.t. \quad \mathcal{W}(y^T,h)\bar{e} \ge \overline{W},$$

▸ back

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\begin{aligned}
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back

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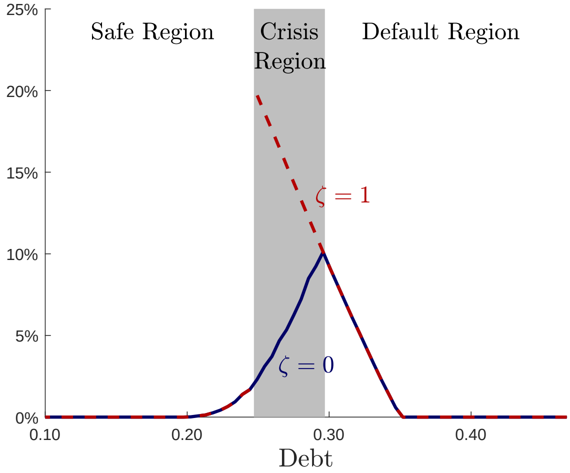
back

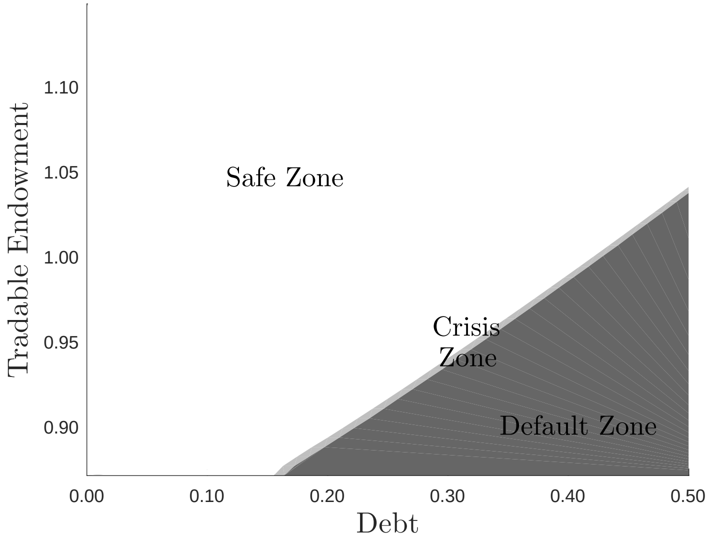
Welfare Cost of a Monetary Union

Benefits from a one-period devaluation for different b

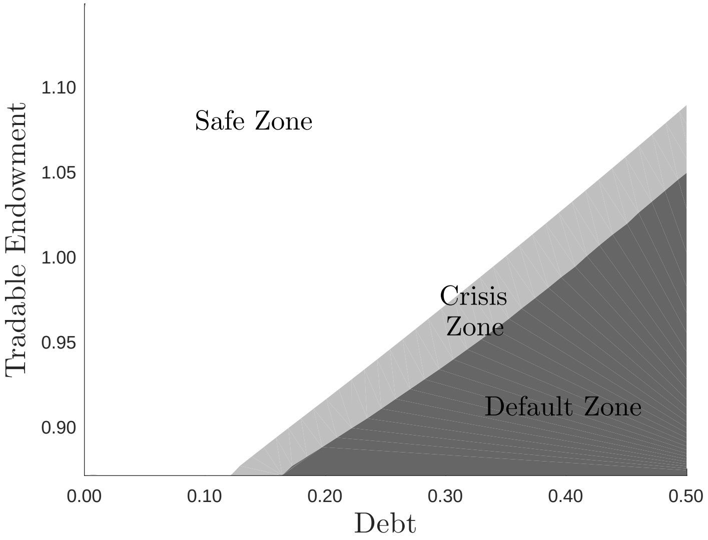


EXTRAS

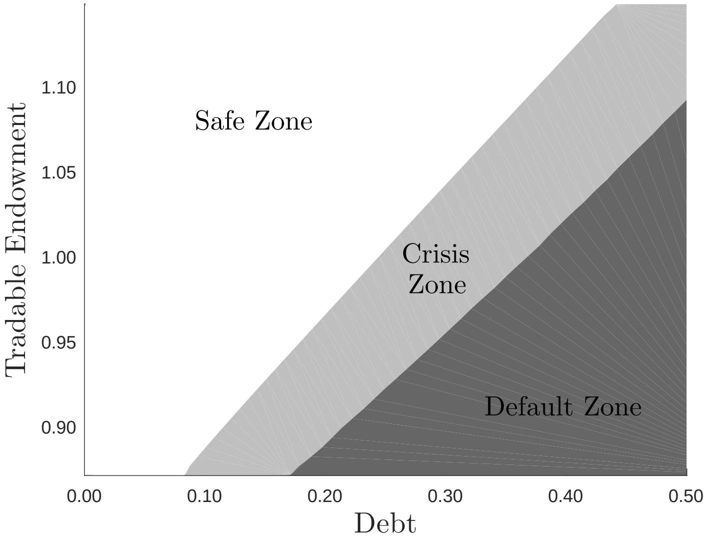
Three Zones: Flexible Wages



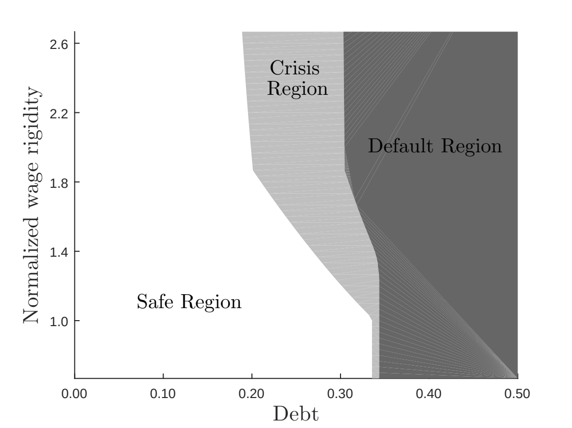
Three Zones: Low Wage Rigidity



Three Zones: High Wage Rigidity



Safe region, crisis region, and default regions



Back

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

Back

Sensitivity to Sunspot Probability

Sunspot probability	$\pi = 3\%$		$\pi = 10\%$		$\pi = 20\%$	
(percentage %)	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	6.53	3.70	11.80	6.20	19.80

Back

Long-Run Simulation Statistics: Fixed vs. Flexible

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Average spread (%)	2.01	2.46	1.43
Average debt-income (%)	29.05	29.73	31.33
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Three Zones

- Safe zone (govt. always repays)

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

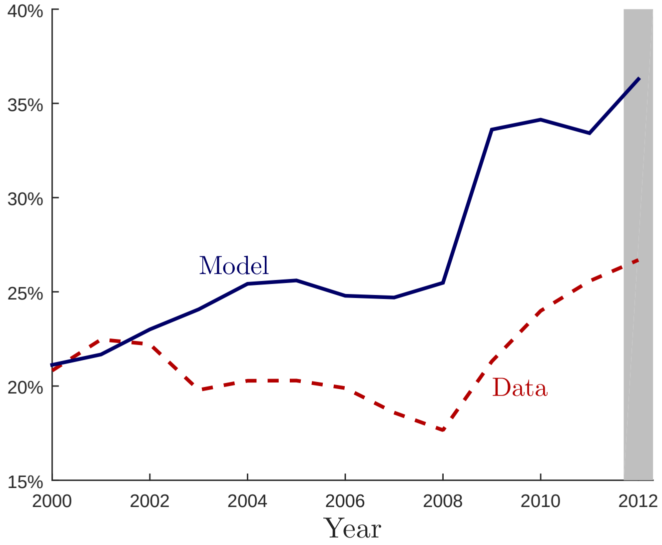
- Default zone (govt. always defaults)

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

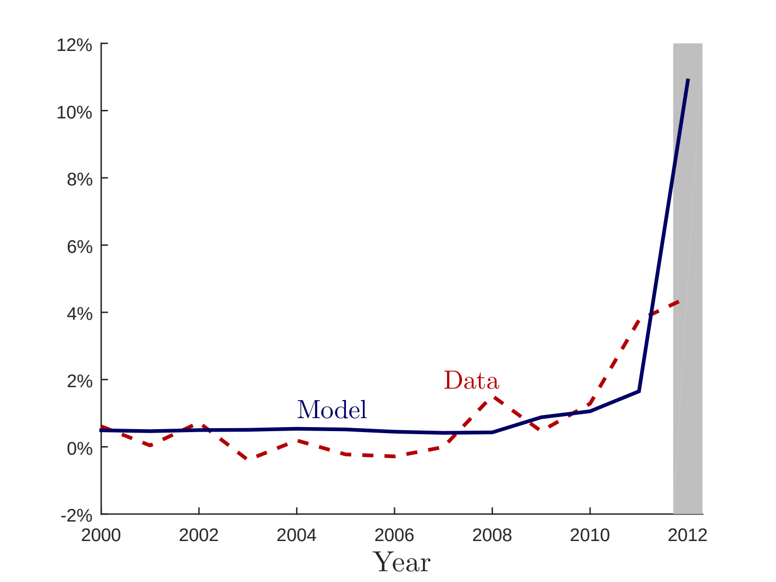
- Crisis zone (govt. repayment depends on beliefs)

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

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

$$c_t^T - q_t\left(b_{t+1} - (1-\delta)b_t\right) = y_t^T - \delta(1-d_t)b_t$$

v. Labor market equilibrium conditions hold

▸ Back

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