Monetary Independence and Rollover Crises

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Eurozone Crisis

Concerns about the risk of a rollover crisis and "bad equilibrium":

- Investors refuse to rollover $\Rightarrow$ liquidity problems for govt....
- Liq. problems $\Rightarrow$ govt. default $\Rightarrow$ investors don't rollover...

  $\Rightarrow$ **self-fulfilling rollover crisis**

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- **Missing: aggregate demand channel and monetary policy**

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Central to Eurozone crisis: countries lack of monetary autonomy

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This paper: Theory linking monetary autonomy and rollover crisis based on aggregate demand channel

What we do

Canonical sovereign default model with foreign currency debt featuring rollover crisis & downward wage rigidity

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Quantitatively (preliminary):

- With flexible exchange rate, economy remains relatively immune to rollover crisis.
- With fixed exchange rate, much higher exposure

Rollover Crises and Downward Wage Rigidity

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$\Rightarrow$ Additional cost from losing monetary independence

Related Literature

Classic papers on rollover crises: Alesina, Tabellini and Pratti; Giavazzi and Pagano; Cole and Kehoe

Recent quantitative models on rollover crises: Chatterjee and Eygunoor; Bocola and Dovis; Aguiar, Chatterjee, Cole and Stangebye; Roch and Uhlig; Conesa and Kehoe

Other types of multiplicity in sovereign debt: Calvo , Lorenzoni and Werning, Ayres, Navarro, Nicolini and Teles, Aguiar and Amador

Monetary models with multiple equilibria in sovereign debt: Da Rocha, Gimenez and Lores; Araujo, Leun and Santos; Aguiar, Amador, Farhi and Gopinath, Corsetti; Camous and Cooper; Bacchetta, Perazzi and van Wincoop;

Sovereign default model with nominal rigidities: Na, Schmitt-Grohe, Uribe and Yue, Bianchi, Ottonello and Presno

Main elements of the model

- Small open economy with tradable and non-tradable goods
  - Stochastic endowment of tradable goods y^T
  - Non-tradable goods produced with labor $y^N = F(h)$
- Law of one price for tradable goods $P_t^T = P_t^* e_t$.
  - Assume $P_t^* = 1 \Rightarrow P_t^T = e_t$
- Wages are downward rigid in domestic currency $W_t \geq \overline{W}$
  - With fixed exchange rate regime $\Rightarrow$ *real* wage rigidity
- Government issues defaultable long-term debt, b, in foreign currency

- Preferences

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

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

- c^T, c^N: consumption of tradables and non-tradables
- Budget constraint (in domestic currency)

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

- ϕ^N firms' profits, T_t lump sum taxes
- Total endowment of hours $\bar{h}$

Households

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Households (ctd)

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

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

- Optimality

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

Downward wage rigidity

Wages in domestic currency cannot fall below $\overline{W}$

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

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If $\overline{W}$ is *higher* than market clearing wage $\Rightarrow$ unemployment

If $\overline{W}$ is *lower* than market clearing wage $\Rightarrow$ $h = \bar{h}$

$$\left(W_t - \overline{W}\right)\left(\bar{h} - h_t\right) = 0$$

Government

- Government issues long-term bonds at price q_t
- Bond payoff structure: $\delta\left[1,(1-\delta),(1-\delta)^2,....(1-\delta)^t\right]$
- Law of motion for bonds $b_{t+1}=b_t(1-\delta)+i_t$

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- Budget constraint in good credit standing:

$$\delta e_t b_t(1-d_t)=e_t q_t i_t+T_t$$

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- Focus on fixed exchange rate regime $e_t = e\ \forall t$

International Investors

- International investors are risk-neutral and competitive.
- Besides the defaultable bonds, they can invest in real risk-free security at rate r
- Bond prices satisfy no-arbitrage condition

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

when government repays

Equilibrium conditions

- Recall households' and firm optimality

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

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- *Real* equilibrium wage given by

$$\mathcal{W}_t\left(c_t^T, h\right) \equiv \frac{1-\omega}{\omega}\left(\frac{c_t^T}{F(h_t)}\right)^{1+\mu} F'(h_t)$$

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$$\mathcal{W}_t\left(c_t^T, h\right) \;\equiv\; \frac{1-\omega}{\omega}\left(\frac{c_t^T}{F(h_t)}\right)^{1+\mu} F'(h_t) \;\; \geq \frac{\overline{W}_t}{e_t}$$

where $\frac{\partial \mathcal{W}}{\partial c^T} > 0$, and $\frac{\partial \mathcal{W}}{\partial h} < 0$

- If wage rigidity binds: $\downarrow c^T \Rightarrow \downarrow h$

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

Where are going?

We defined equilibrium for given government policies

Next, we will study markov equilibria: government chooses repayment and borrowing without commitment

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Three distinct **"zones"** (Cole-Kehoe)

- Safe zone: government always repays
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Recursive Government Problem

- States: $(b, \mathbf{s}) \quad \mathbf{s} = \left(y^T, \zeta\right)$ where ζ is a sunspot
- Government problem in good credit standing

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

Values of repayment and default

$$
\begin{aligned}
V_R \;\; (b, \mathbf{s}) = \underset{c^T\ h, b'}{\text{Max}} & \left\{ u(c^T, F(h)) + \beta \mathbb{E} \left[V\left(b', \mathbf{s}'\right) \right] \right\} \\
s.t. \quad & c^T = y^T - \delta b + q(b', b, \mathbf{s}) \left[b' - (1-\delta) b \right] \\
& \mathcal{W}(c^T, h) \bar{e} \geq \overline{W}, \\
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V_D(y^T) = & u(y^T, F(h)) - \kappa(y^T) + \beta\mathbb{E}[\psi V(0, s') + (1-\psi)V_D(y^{T'})] \\
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Optimal exchange rate eliminates wage rigidity

Values of repayment and default good sunspot

$$
\begin{aligned}
{V_R}^{+}(b, y^T) = & \underset{c^T\ h, b'}{\text{Max}} \left\{ u(c^T, F(h)) + \beta \mathbb{E}\left[V\left(b', \mathbf{s}'\right)\right] \right\} \\
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s.t. \quad & \mathcal{W}(y^T, h)\bar{e} \geq \overline{W}, \\
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If government is not issuing debt $\hat{b}_R^+ < (1-\delta) b \ \Rightarrow V_R^+ = V_R^-$

Values of repayment and default bad sunspot

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V_R{}^{-}(b, y^T) = &\underset{c^T\ h, b'}{\text{Max}} \left\{ u(c^T, F(h)) + \beta \mathbb{E} \left[V\left(b', \mathbf{s}'\right)\right] \right\} \\
s.t. \quad & c^T = y^T - \delta b \\
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& h \leq \bar{h} \\
& b' = b(1-\delta) \\
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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

Multiplicity of Equilibria as in Cole-Kehoe

Consider a state (b, y^T) in which government wants to issue debt:

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   - Government can rollover debt and obtains value V_R
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2. If each lender expects other lenders to **refuse** to extend credit
    - Government cannot rollover debt and obtains value V_R
    - If ${V_R}^- < V_D$, government **defaults**

In second case, default is entirely due to self-fulfilling beliefs: if lenders refuse to lend, government is unwilling/unable to cut down consumption and defaults

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)

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

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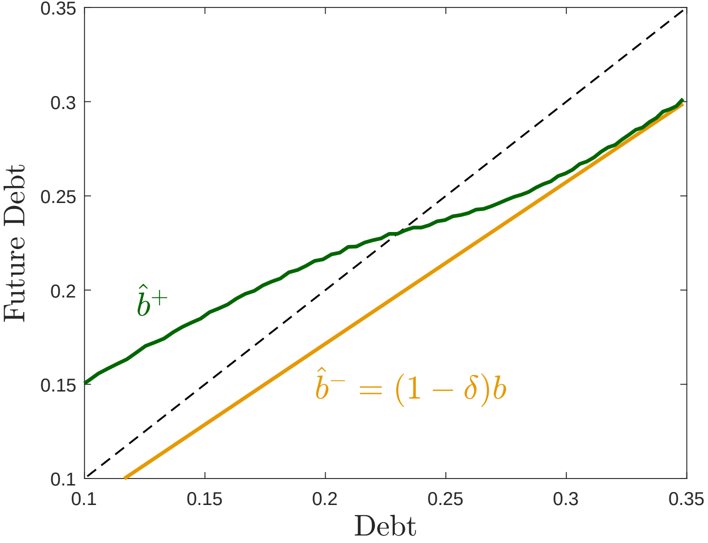
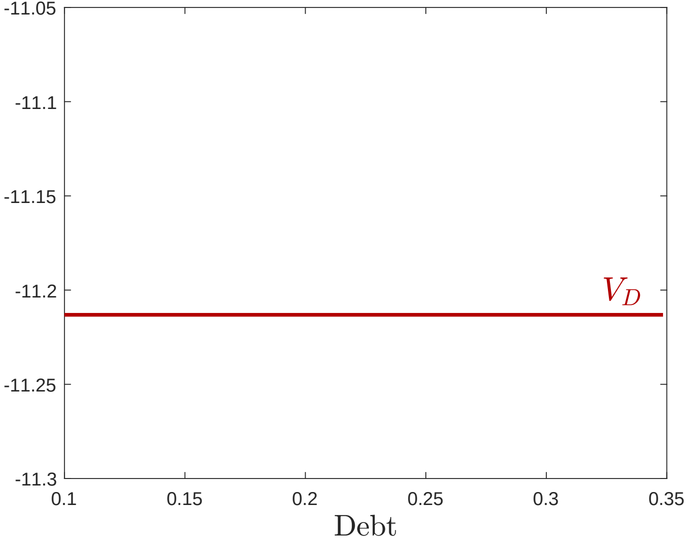
Will show how wage rigidity enlarges "crisis zone"

Policy functions and value functions & zones with flexible wages

Policy for Borrowing: good and bad sunspot



Value Functions



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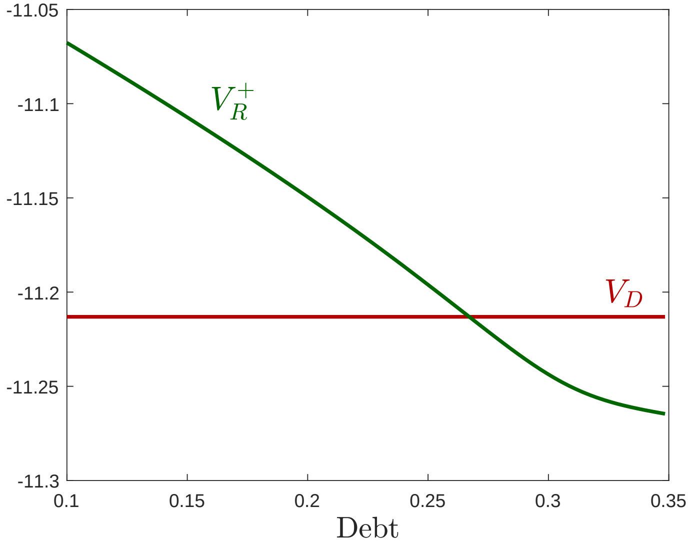

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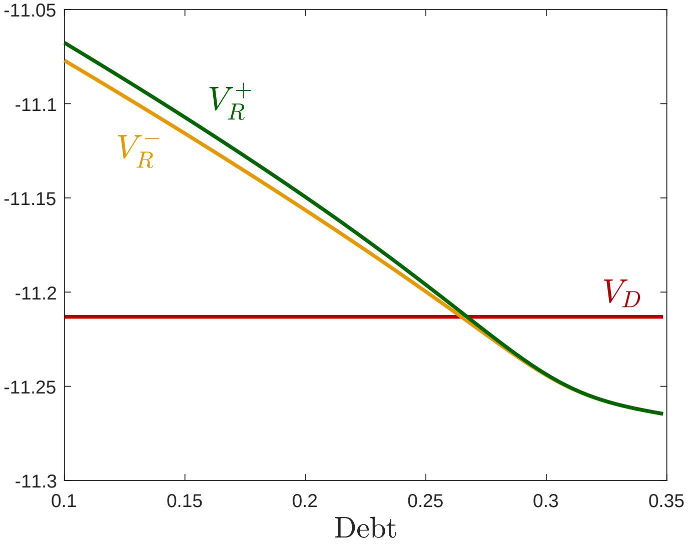
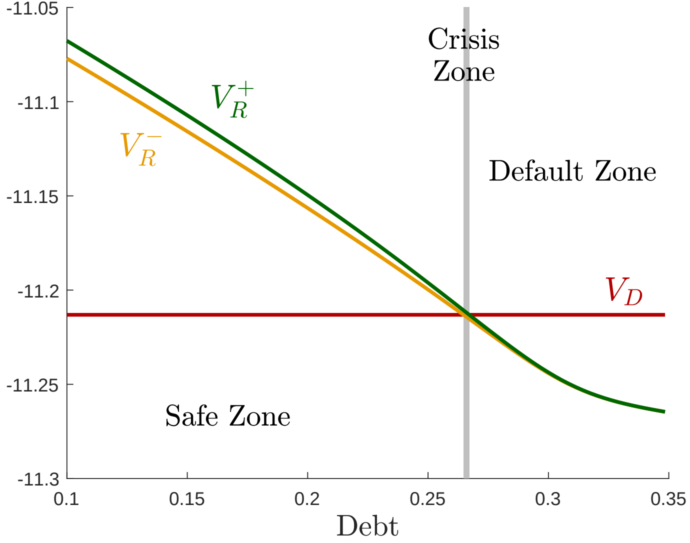
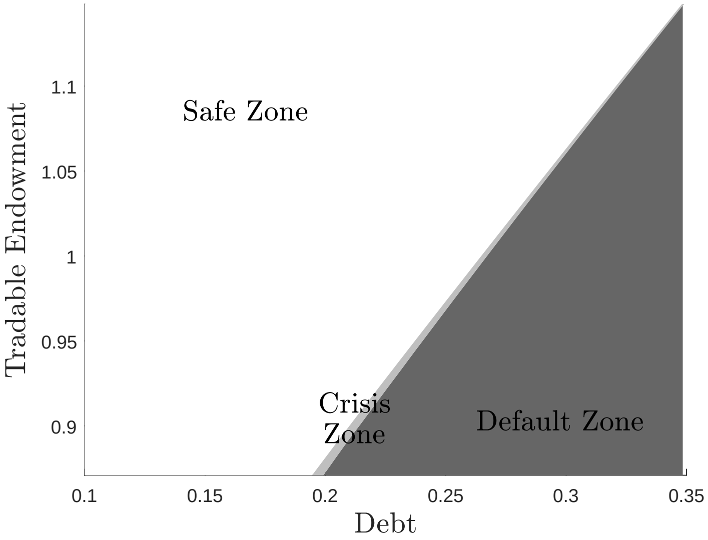


Value Functions and Zones



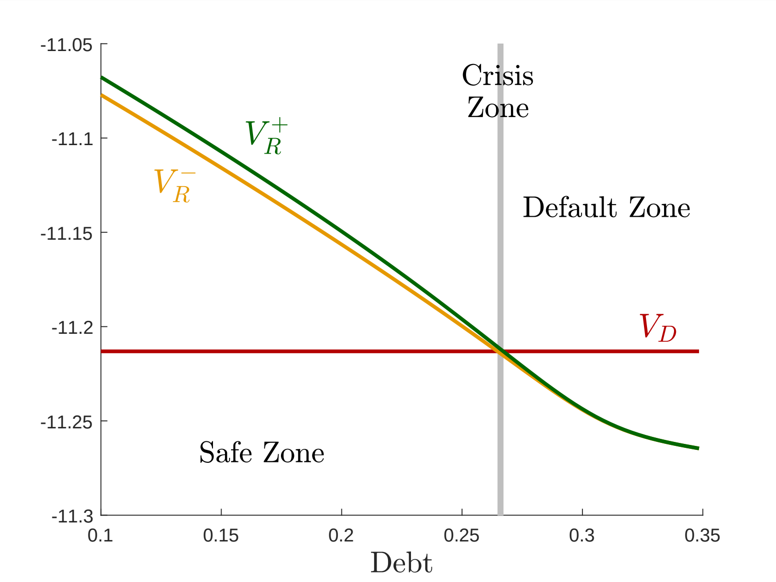
Zones: Flexible Wages



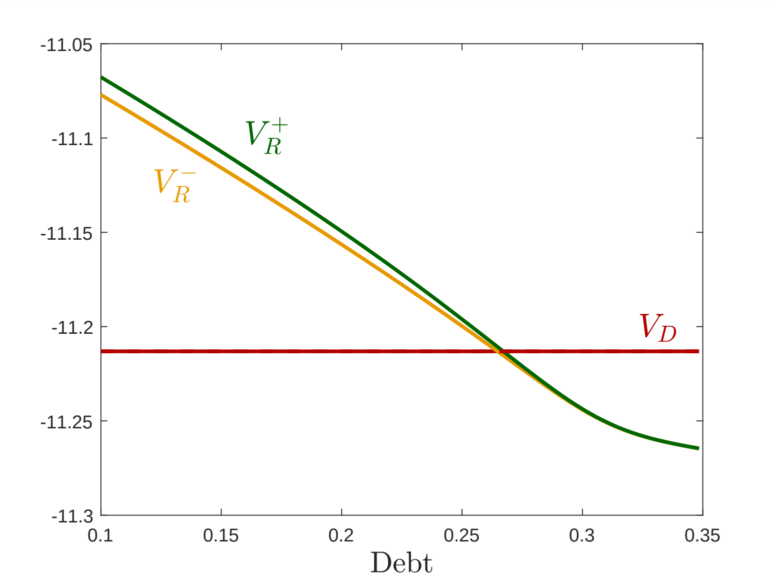
Comparison: flexible vs. sticky wages

- Assume wage rigidity is introduced for *only one period*
  - Same continuation values and bond price schedule
- How do three zones change?
  - High and low wage rigidities, $\overline{w}_{high} > \overline{w}_{low}$
- Later, will study permanent changes in wage rigidity

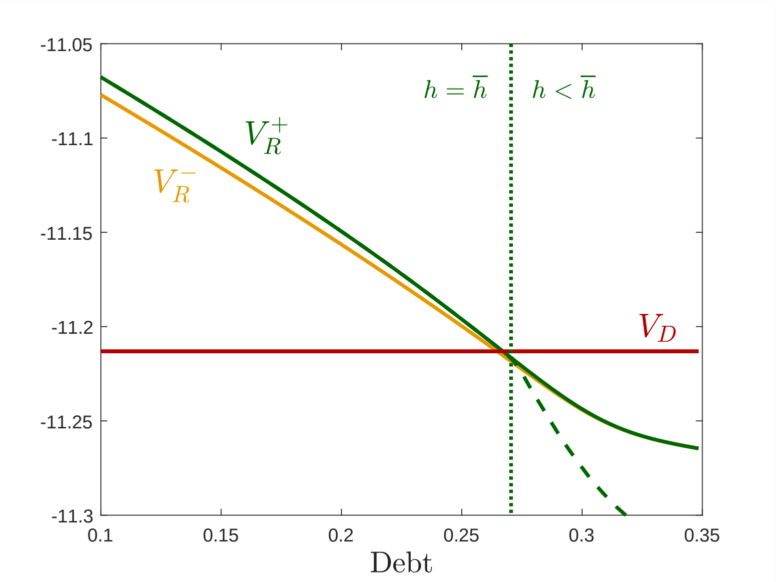
Recall crisis region with flexible wages



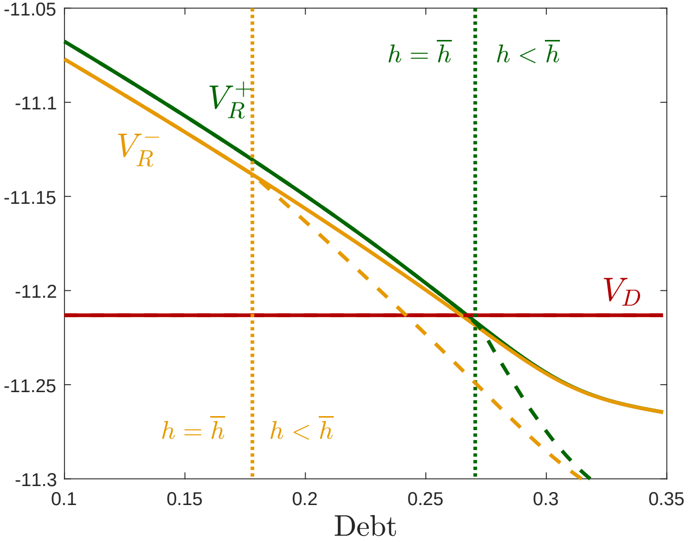
V_D is unaffected with $\overline{w}_{low}$



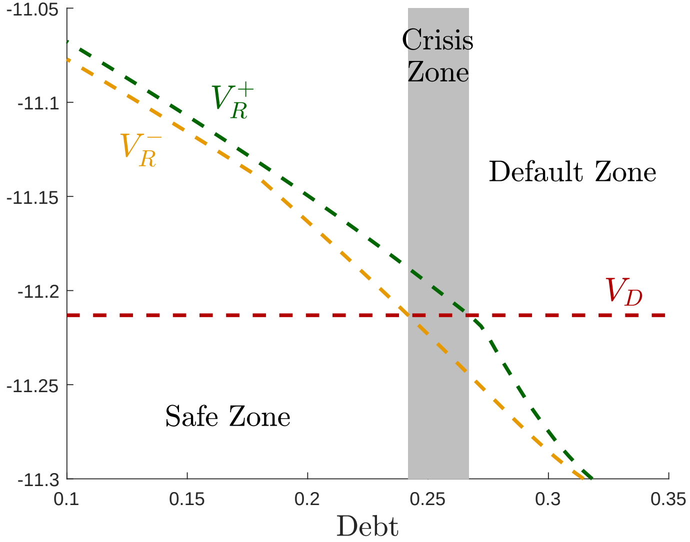
V^+ is reduced with $\overline{w}_{low}$



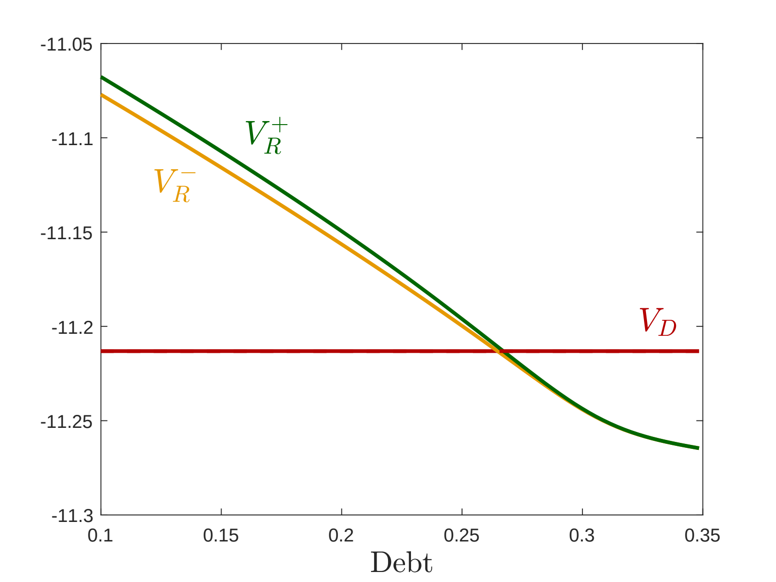
V^- is reduced by more than V^+



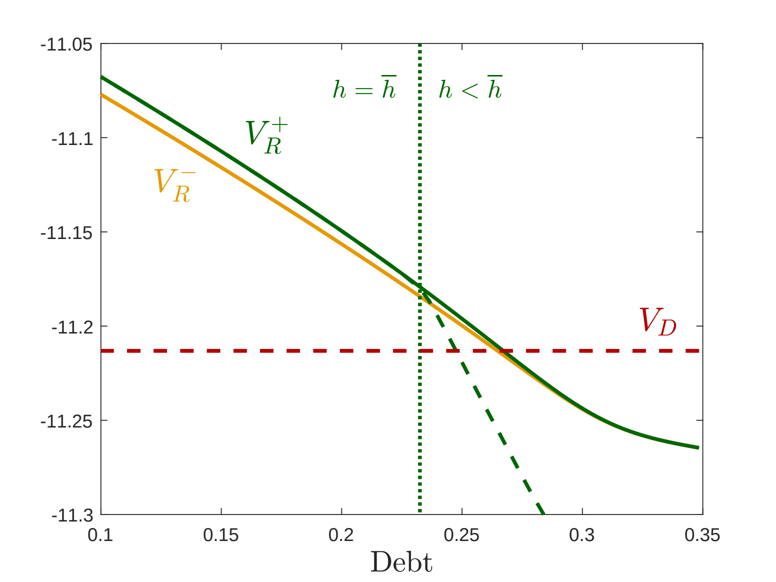
Wage rigidity leaves zones unaffected



Recall flexible wage



Higher wage rigidity affects crisis and default regions



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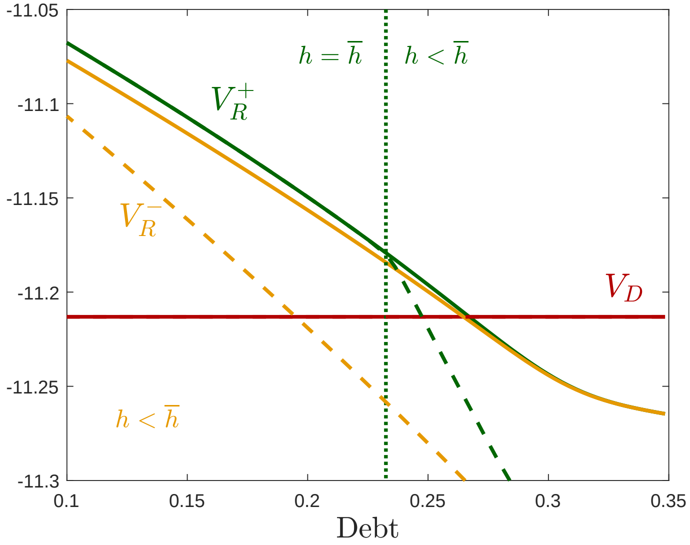

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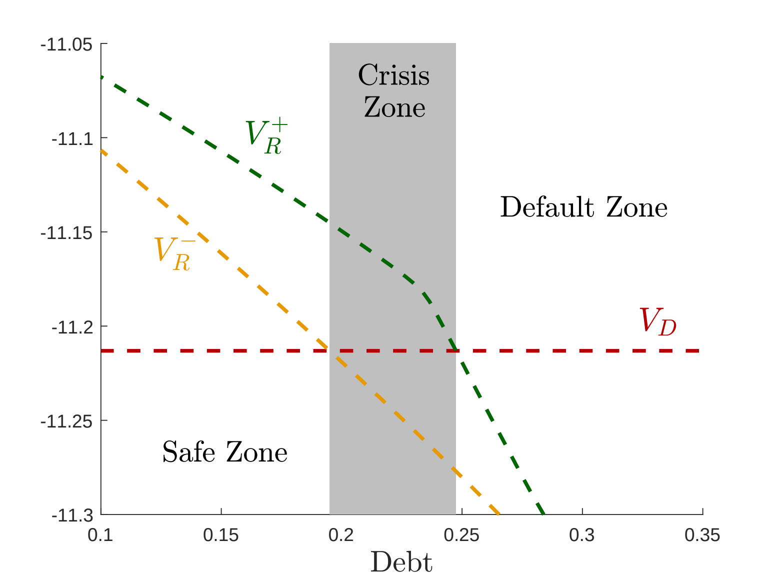
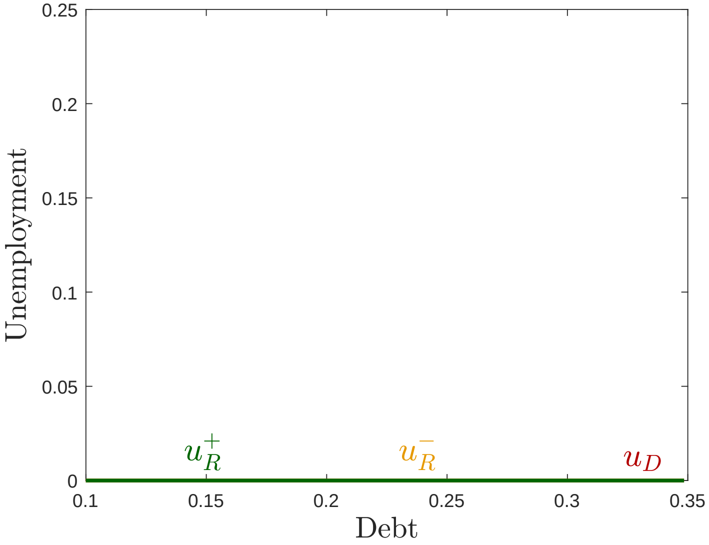


Explaining the increase in crisis region: the role of unemployment

Unemployment



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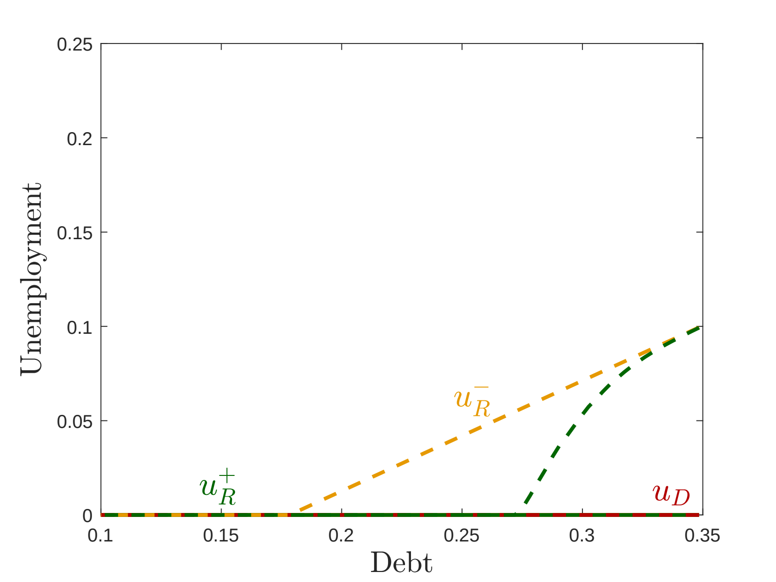

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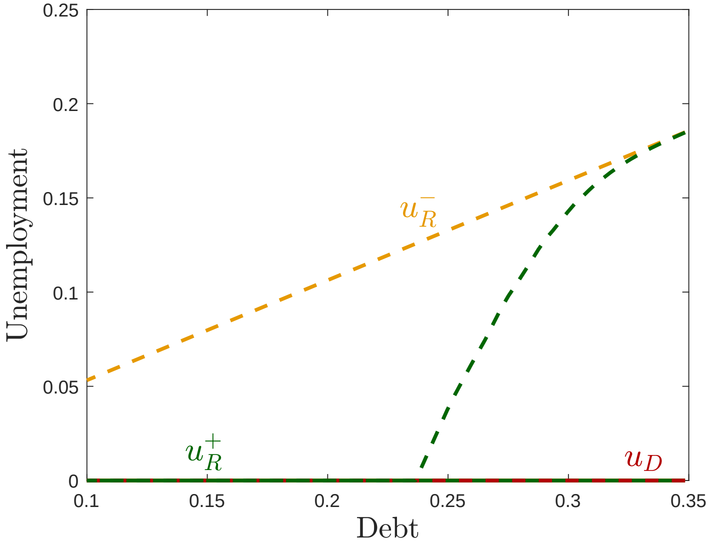
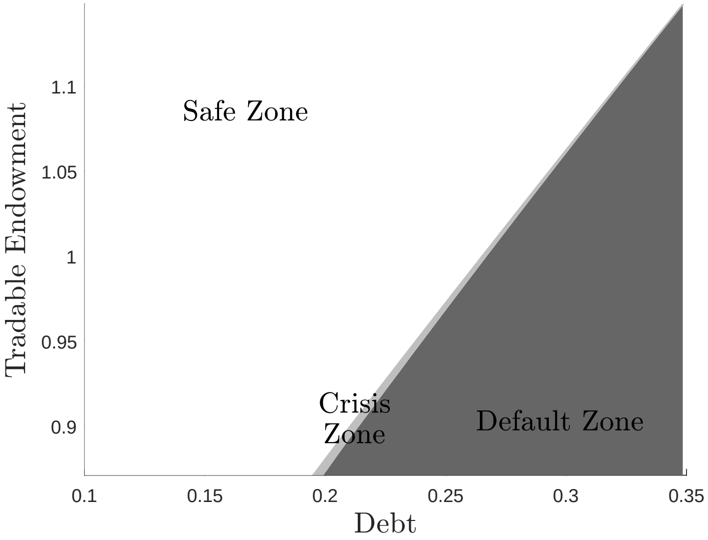
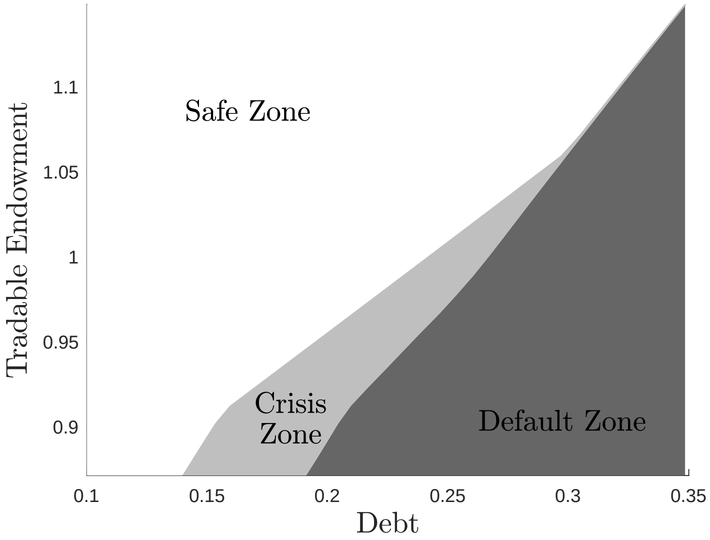


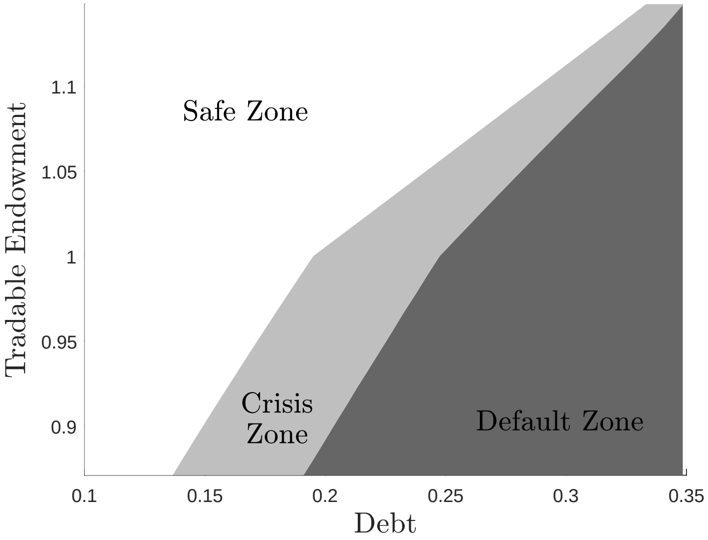
Zones: Flexible Wages



Zones: Low Wage Rigidity



Zones: High Wage Rigidity



Theoretical Characterization

We show in the paper

- Safe region shrinks with wage rigidity
- Default region expands with wage rigidity
- For given level of y^T, higher wage rigidity implies that:
  - Economy enters in crisis zone with lower debt
  - There $\exists\ \hat{w}$ such that length of crisis zone is increasing in $\bar{w}\ \forall\ \bar{w} < \hat{w}$

Quantitative analysis

Calibration Strategy

- Spain 1996-2015 as a case of study
- A period is a year.
- Calibrate directly:
    - Preference elasticities (intra- and inter-temporal) and discount factor
    - Production parameters and process for y^T
    - Maturity
    - For now, sunspot process is iid with probability $\pi = 0.03$
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- First, we look at flex economy. Calibration of fixed wage economy in progress

Benchmark Calibration

Parameter	Value	Description
α	0.750	Labor share in nontradable production
β	0.905	Discount factor
δ	0.176	Maturity of debt
ψ	0.240	Probability of Re-entry
μ	0.205	Elasticity of substitution
ω	0.300	Share of tradables
σ	2.000	Risk aversion
π	0.100	Sunspot probability
r	0.020	Risk-free rate
$\bar{h}$	1.000	Normalization
ρ	0.777	Persistency of shock
σ_ε	0.029	Standard deviation of shock
κ_0	0.375	Mean spread 1.05%
κ_1	1.825	Debt-GDP 22%

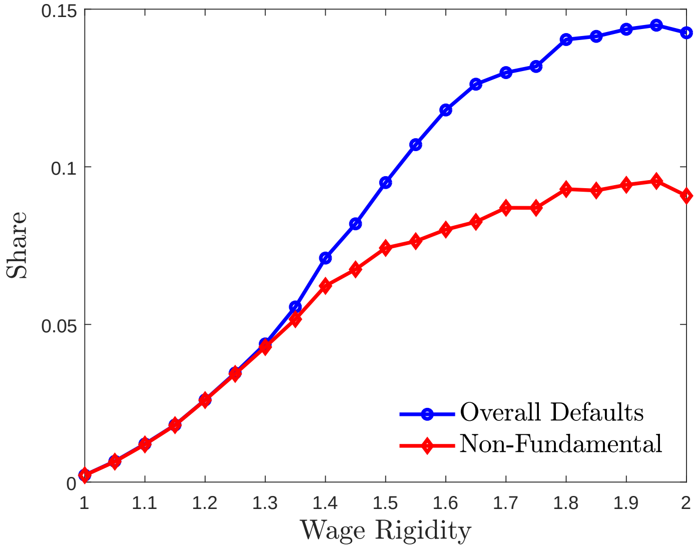
Statistics

Rigidity $\bar{w}$ is set 10% above the lowest wage in flex economy

- No unemployment along equilibrium path

Statistic	Flexible wage	$\bar{w} = 1.50$
$\mu(r^* - r)$	1.03	1.78
$\mu(\bar{b}/y)$	0.22	0.21
$\mu(\bar{h} - h)$	0	0
$\rho(y, c)$	0.95	0.95
$\rho(y, r^* - r)$	-0.81	-0.76
$\rho(y, TB)$	-0.54	-0.60
$\sigma(\hat{c})/\sigma(\hat{y})$	1.3	1.4
$\sigma(r^* - r)$	0.2	0.73
$\sigma(\bar{h} - h)$	0	0
Defaults due to rollover crisis	0.02	0.16

Fundamental and Non-Fundamental Defaults



Conclusion

Uncover new cost from currency unions:

- Lack of monetary independence makes an economy more prone to rollover crisis

Lender of last resort is more important than we thought

Avenues ahead:

- Applications to ZLB, managed exchange rates
- Interactions with fiscal policies

EXTRAS

Mario Draghi: "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"

Safe and Default Zones and $\bar{w}$

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

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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

$$\mathcal{C}_{y^T} \equiv \left(\bar{B}^S_{y^T}, \bar{B}^D_{y^T}\right] \qquad \& \qquad \Delta\mathcal{C}_{y_T} \equiv \bar{B}^D_{y^T} - \bar{B}^S_{y^T}$$

$\bar{B}^S_{y^T}, \bar{B}^D_{y^T}$ 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 $\bar{w} > 0$

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

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

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

subject to

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

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

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

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

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Even if unemployment not "observed", rigidity can trigger crisis