International Reserve Management under Rollover Crises

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Motivation

To reduce the vulnerability to a debt crisis:

- Should the government reduce the debt or increase reserves?

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Answer unclear:

- Reserves provide liquidity
  ... but reducing debt may lower vulnerability more

What we do

- Tractable model of rollover crises with long-duration bonds and reserves

  - Sunspot shocks, deterministic income

- How should the government exit the 'crisis zone'?

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Preview:

- If heavily indebted, optimal to initially reduce debt and keep zero reserves

- Once debt is reduced sufficiently, optimal to increase debt and accumulate reserves

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- If heavily indebted, optimal to initially reduce debt and keep zero reserves

- Once debt is reduced sufficiently, optimal to increase debt and accumulate reserves

- Borrowing to accumulate reserves can reduce spreads

Model

Environment

- Discrete time, infinite horizon. Constant endowment: $y_t = y$

- Government trades two assets ...
    - short-term risk-free reserves: a
    - long-term defaultable debt: b
      a bond issued in t promises to pay

      $$\kappa \left[1, \, (1 - \delta), \, (1 - \delta)^2, \, ... \right]$$

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- Markov equilibrium w/ Cole-Kehoe (2000) timing:
  - Borrowing at the beginning of the period
  - Settlement (repay/default) at the end

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Preferences and resource constraint

- Preferences:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [u(c_t) - \phi d_t]$$

where $d_t = 0$ (1) denotes repayment (default)

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- If the government repays:

$$c_t = \underbrace{y + a_t - \kappa b_t}_{\text{resources avail.}} - \underbrace{\frac{a_{t+1}}{1+r}}_{\text{reserve purchases}} + \underbrace{q_t [b_{t+1} - (1-\delta)b_t]}_{\text{debt issuance}}$$

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- If the government defaults:

$$c_t = y + a_t - \frac{a_{t+1}}{1+r} \qquad \text{Gov. saves on bond payments}$$

and faces permanent exclusion and utility loss ϕ

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Recursive Government Problem

- State is $s \equiv (a, b, \zeta)$

    ζ denotes an iid sunspot that coordinates the lenders

- The government chooses to repay or default

$$V(a, b, \zeta) = \max \{V_R(a, b, \zeta), V_D(a)\}$$

If indifferent, assume repay

Value of Default

$$V_D(a) = \max_{a' \geq 0} \left\{ u(c) - \phi + \beta V_D(a') \right\}$$

subject to

$$c \leq y + a - \frac{a'}{1+r}$$

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subject to

$$c \leq y + a - \frac{a'}{1 + r}$$

- Given $\beta(1 + r) = 1$, we have constant consumption

$$V_D(a) = \frac{u(y + (1 - \beta)a) - \phi}{1 - \beta}$$

Value of Repayment

Two cases, depending on whether the investors want to rollover
the debt

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the debt

Case 1. Investors **want** to rollover:

$$V_R^{\textbf{+}}(a, b) = \max_{a' \geq 0, b'} \left\{ u(c) + \beta \mathbb{E} V(a', b', s') \right\}$$

subject to

$$c = y + a - \frac{a'}{1 + r} - \kappa b + q(a', b') \left(b' - (1 - \delta)b \right)$$

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subject to

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Bond price depends on the portfolio and reflects default prob:

$$q(a', b') = \frac{1}{1 + r} \mathbb{E} \left[(1 - d(s')) \left(\kappa + (1 - \delta) q(a'', b'', s') \right) \right]$$

Value of Repayment

Two cases, depending on whether the investors want to rollover the debt

Case 2. Investors **don't want** to rollover:

$$V_R^-(a, b) = \max_{a' \geq 0} \left\{ u(c) + \beta \mathbb{E} V(a', (1 - \delta)b, s') \right\}$$

subject to

$$c = y + a - \frac{a'}{1 + r} - \kappa b + \quad q(a', b') \left(b' - (1 - \delta)b \right)$$

0

To pay debt, need to use reserves or cut consumption

Multiplicity of Equilbria

- Coordination failure may lead to self-fulfilling crises
  (Cole-Kehoe)

- If lenders expect...

  ... repayment, then they rollover, and the govt repays

  ... default, then they don't rollover, and the govt defaults

Characterization

Default thresholds

For a given level of reserves, two thresholds

$$b^-(a) \qquad\qquad b^+(a) \qquad\qquad Debt(b)$$

Default thresholds

For a given level of reserves, two thresholds

Default

$b^-(a)$ $b^+(a)$ $Debt(b)$

$$V^D(a) > V_R^+(a, b)$$

Default thresholds

For a given level of reserves, two thresholds

Safe $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ Default

$b^-(a)$ $\qquad\qquad\qquad\qquad\qquad\qquad$ $b^+(a)$ $\qquad$ $Debt(b)$

$V_R^-(a, b) \geq V^D(a)$ $\qquad\qquad\qquad\qquad\qquad$ $V^D(a) > V_R^+(a, b)$

Default thresholds

For a given level of reserves, two thresholds

Safe   **Crisis**   Default

$b^-(a)$ $b^+(a)$

$Debt(b)$

$$V_R^-(a, b) < V^D(a) \leq V_R^+(a, b)$$
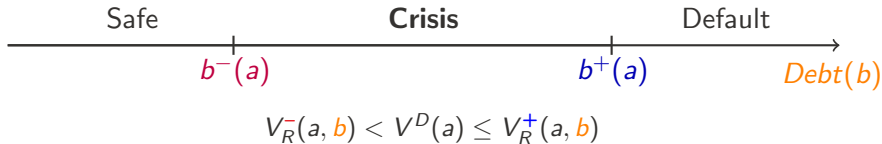
Default thresholds

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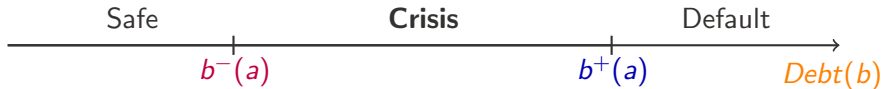
Sunspot: assume government faces a run w/ prob π when initial portfolio (a, b) is in the crisis zone

The Three Zones
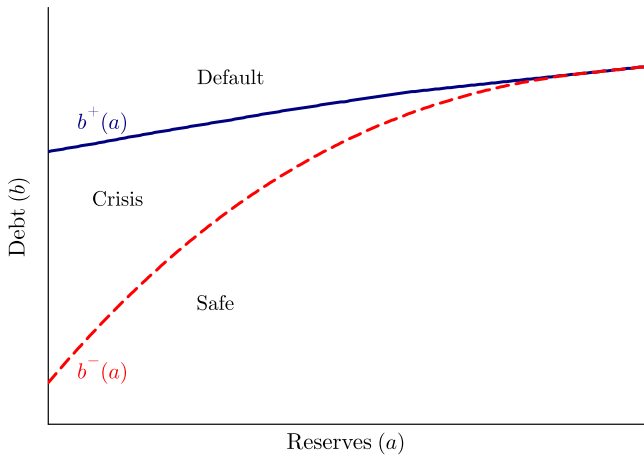
Given debt: higher reserves lower vulnerability

Escaping the Crisis Zone

How to Exit the Crisis Zone?

Remaining in the crisis zone is risky:

- in case of a run, the gov't defaults

But exiting is also costly:

- requires cutting consumption and improving NFA

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But exiting is also costly:

- requires cutting consumption and improving NFA

What's the best exit strategy for a country that is in the crisis zone (but didn't face a run today) ?

- Accumulate reserves ($a \uparrow$) or reduce debt ($b \downarrow$)?

Possible Exit Paths
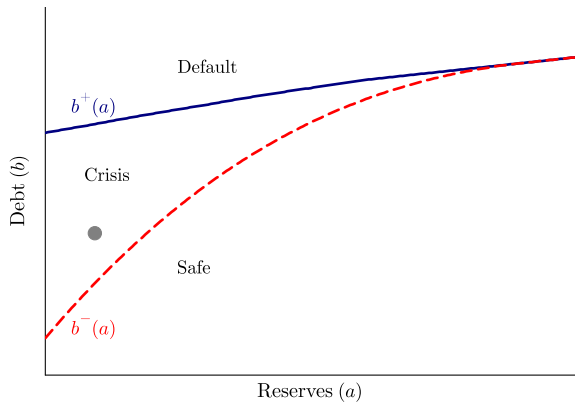
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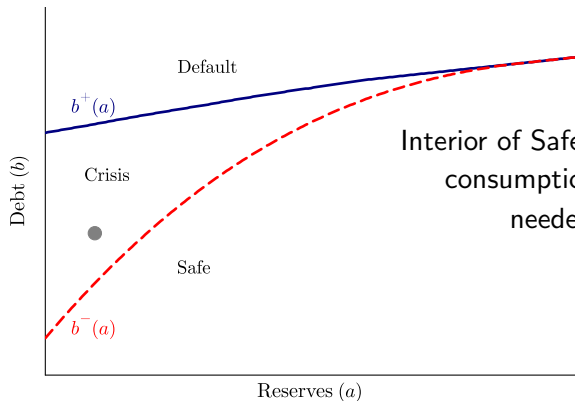
Interior of Safe zone isn't optimal:
consumption cut larger than
needed to be safe

Possible Exit Paths
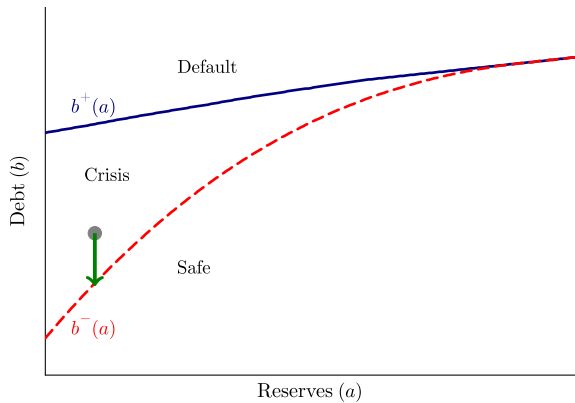
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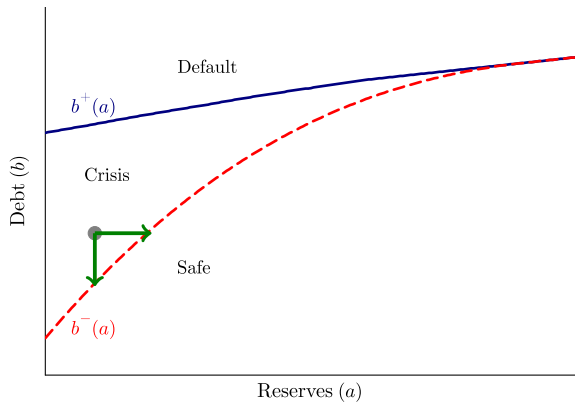
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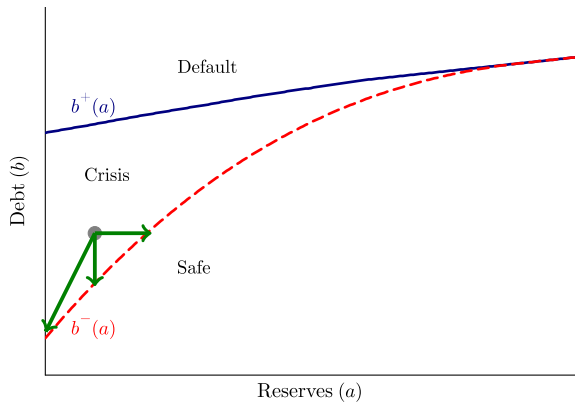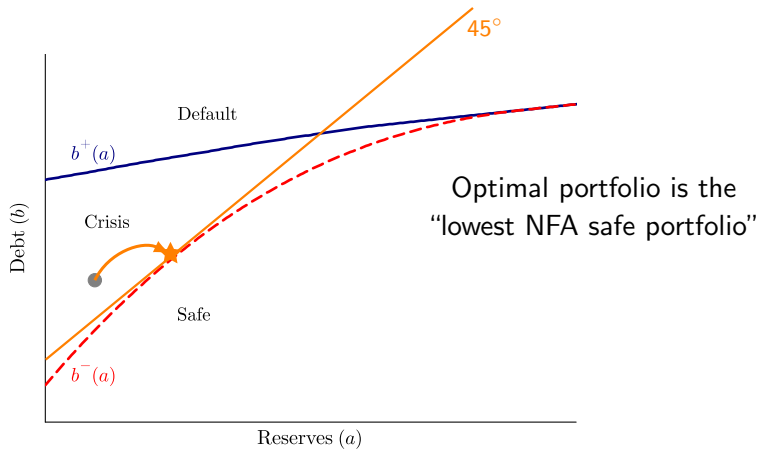
Issuing debt to buy reserves
lowers spreads!
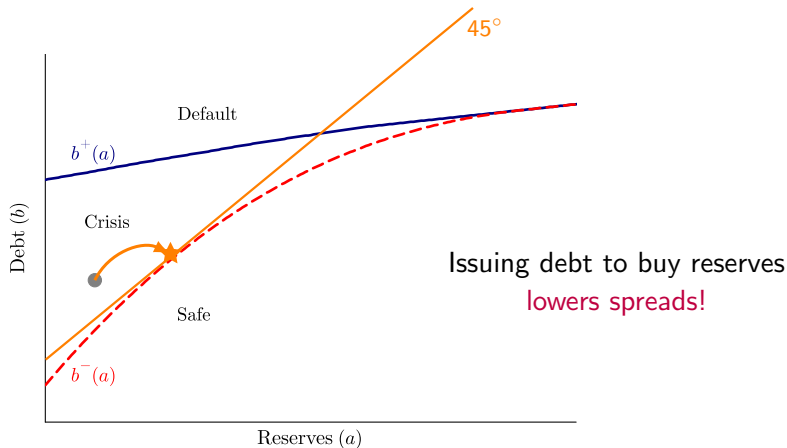
Why do reserves help exit the crisis zone?

Getting to the safe zone requires $V_R^-(a, b) \geq V_D(a)$

- More reserves help sustain higher gross debt & net debt
  ... even though reserves increase default value $V_D(a)$.

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  Intuition:
- Only a fraction κ of debt is due every period
- Reserves are liquid and can be used in a run:

$$c = y + \underbrace{a - \kappa b}_{\text{more resources}} - \frac{a'}{1 + r}$$

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- Reserves also make default more attractive, but have lower marginal value:

$$c_D = y + a - \frac{a'}{1 + r}$$

Deep in the Crisis Zone

Country has **higher** initial debt level: what to do?

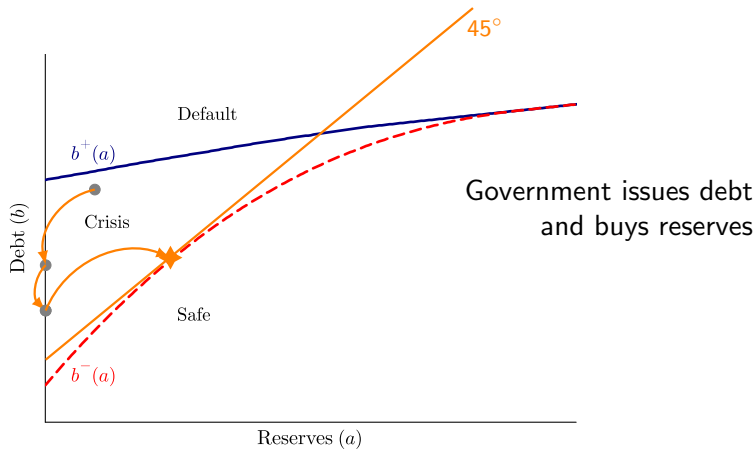# Deep in the Crisis Zone
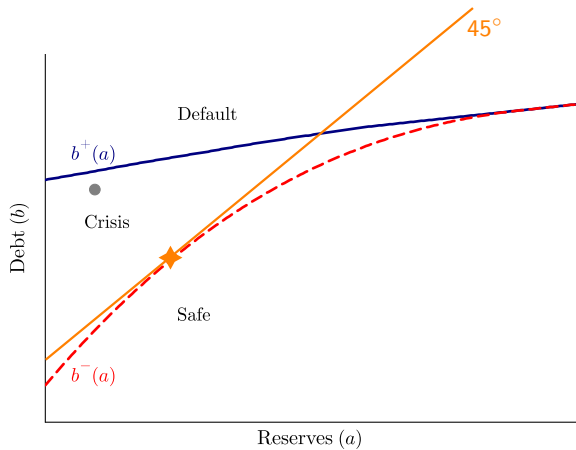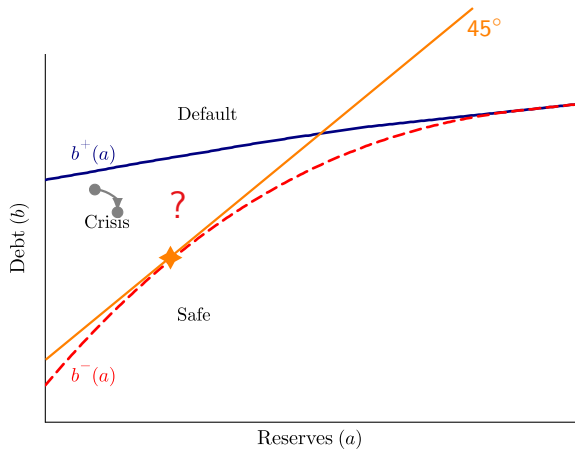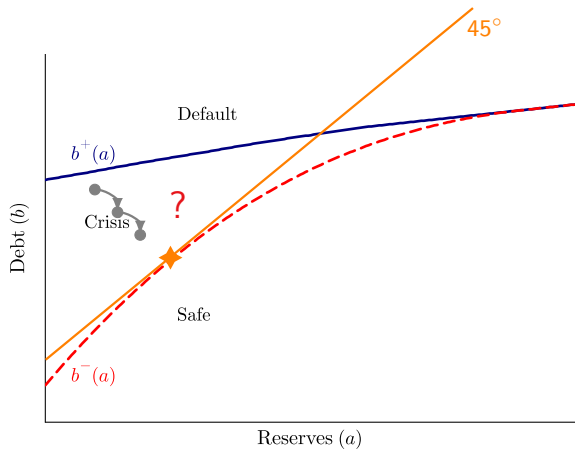
Deep in the Crisis Zone

Deep in the Crisis Zone

Deep in the Crisis Zone

Deep in the Crisis Zone

45°

Default

$b^{+}(a)$

Crisis

Debt (b)

Safe

$b^{-}(a)$

Reserves (a)

Government <u>sells</u> reserves and lowers debt

Deep in the Crisis Zone

Deep in the Crisis Zone

Government issues debt
and buys reserves
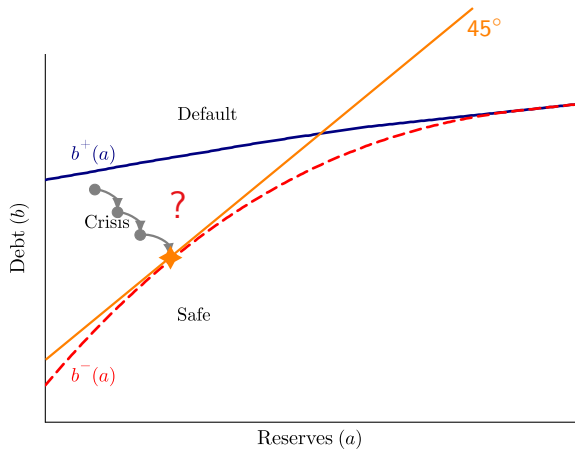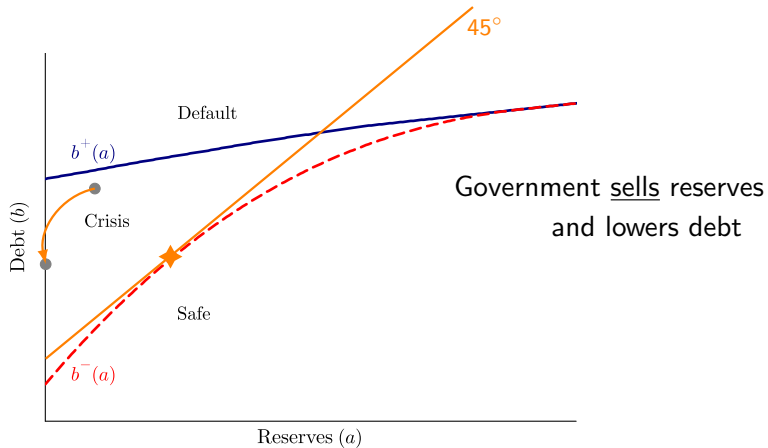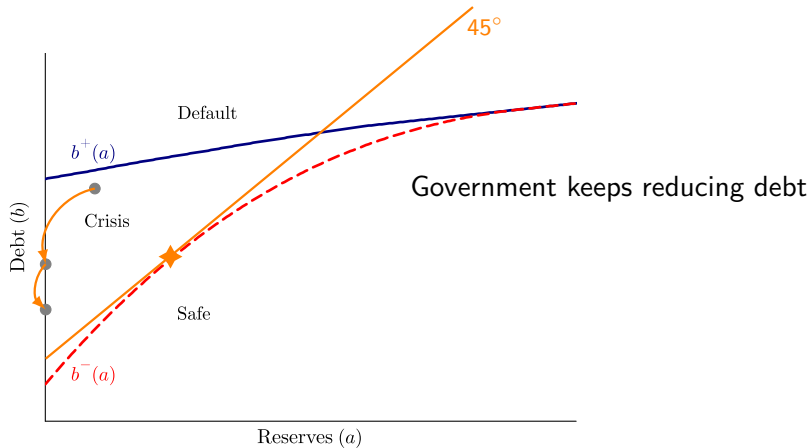
Why selling reserves (initially)?

- When the government is 'deep' in the Crisis Zone, on the margin reserves do not change the probability of a run

- Using the reserves to lower debt allows the govt to save on interest payments and helps deleveraging
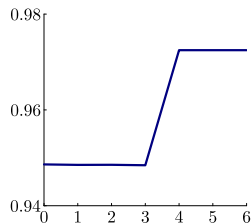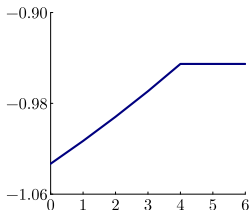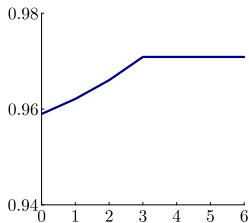
Deleveraging Dynamics
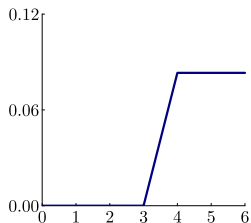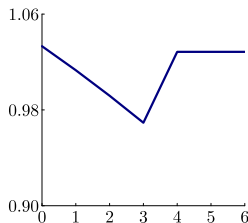
Reserves, a

Debt, b

Consumption

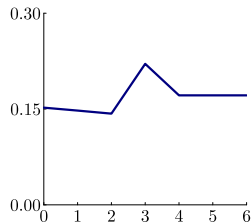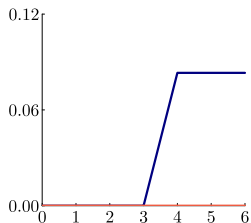Net Foreign Assets

Debt Price, $q(a', b', s)$

Issuance, $b' - (1-\delta)b$

16

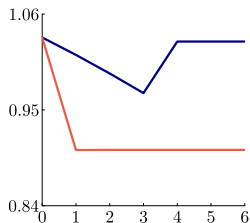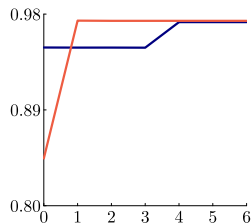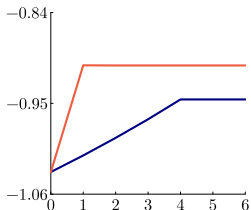# Deleveraging Dynamics

Reserves, a

Debt, b

Consumption

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Issuance, $b' - (1-\delta)b$

$b' = b^-(0)$
optimal policy

16
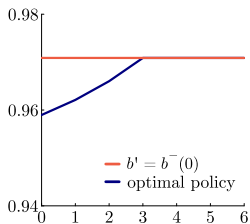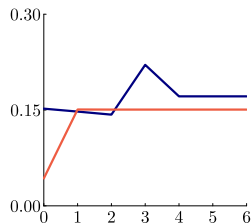
How many periods until exit?

Iso-T Regions
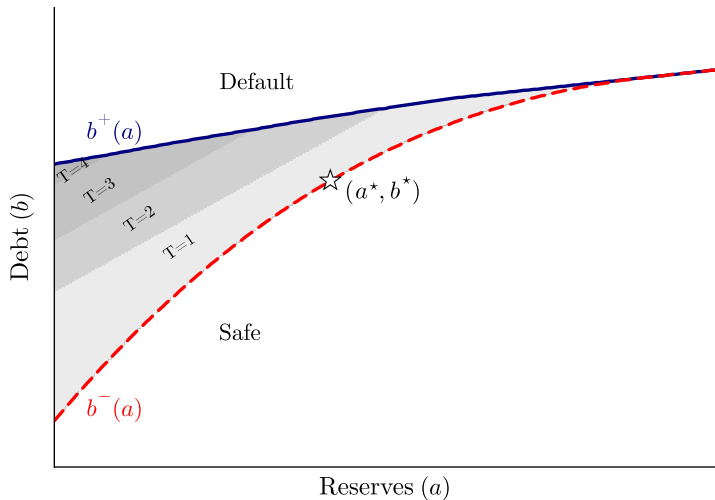
Formalizing the Results

$(a^\star, b^\star)$ is a focal point – we call it **Lowest-NFA safe portfolio**

Question: When do we have $a^\star > 0$?

Formalizing the Results: (a^*, b^*) portfolio

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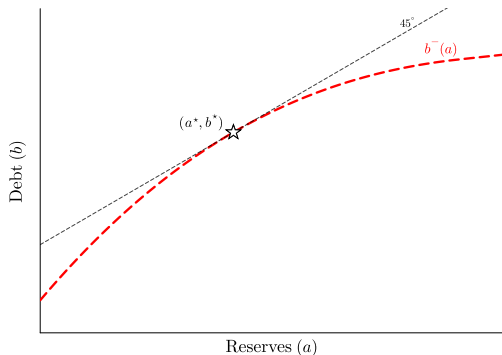
Lowest-NFA safe portfolio, $(a^\star, b^\star)$

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Proposition 3 (Positive reserves)

Suppose that the boundary of the crisis region at zero reserves $b^-(0)$ satisfies

$$\beta(1-\delta)\left[u'\left(y - \kappa b^-(0)\right) - u'\left(y - (1-\beta)(1-\delta)b^-(0)\right)\right] > u'(y)$$

Then, the lowest-NFA safe portfolio has strictly positive reserves, $a^\star > 0$

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When does it fail?

1. low curvature in $u(c)$,

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When does it fail?

1. low curvature in $u(c)$,   ▸ figure
2. one-period debt ($\delta = 1$) [**Prop. 4**]   ▸ sensitivity

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Formalizing the Results: Optimal portfolio

To exit crisis zone, first deleverage, then raise debt and reserves

Formalizing the Results: Optimal portfolio

To exit crisis zone, first deleverage, then raise debt and reserves

Proposition 5 (Optimal portfolio)

Consider an initial portfolio $(a, b) \in \mathbf{C}$. The optimal portfolio satisfies:

- If (a, b) is such that $a - b < a^\star - b^\star$ and $(a', b') \in \mathbf{S}$. Then we have $T = 1$ and $a' = a^\star$, $b' = b^\star$

- If (a, b) is such that $a - b \geq a^\star - b^\star$. Then, we have $T = 1$ and any portfolio $(a', b') \in \mathbf{S}$ and $a - b = a' - b'$ is optimal.
  If $a = 0, b = b^\star - a^\star$, then $a' = a^\star, b = b^\star$.

- If (a, b) is such that $(a', b') \in \mathbf{C}$. Then, the optimal solution features $a' = 0$.

Connecting with the data

We test two predictions of our theory:

1. Borrowing to save ($\uparrow b$ and $\uparrow a$ simultaneously) lowers spreads.

2. Once the government builds up its stock of reserves, it does not actually use it.

Connecting with the data – I

Theory predicts that borrowing to accum. reserves lowers spreads

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$$\Delta \log(\text{Spread})_{it} = \beta_0 + \beta_{\text{Res}} \, \Delta\text{Reserves}_{it} + \beta_{\text{Debt}} \, \Delta\text{Debt}_{it} + \beta'_{\text{M}} \, \text{M}_{it} + \epsilon_{it}$$

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	Full Sample
Δ Reserves	-2.14***
	(0.74)
Δ Debt	0.46*
	(0.24)
Num.Obs.	4,468
R2 Adj.	0.352

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Theory also predicts **stronger** effect for low Debt or high NFA

Connecting with the data – I

Stronger effect in **low debt** periods ...

	Full Sample	Low Debt	High Debt
Δ Reserves	-2.14***	-3.72*	-1.23***
	(0.74)	(1.73)	(0.46)
Δ Debt	0.46*	1.24***	0.19
	(0.24)	(0.32)	(0.28)
Num.Obs.	4,468	2,559	1,909
R2 Adj.	0.352	0.424	0.263

All specs. include year dummies and additional macro controls (as in Sosa-Padilla and Sturzenegger, 2023).

Robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

… also stronger effect in **high NFA** periods

	Full Sample	Low NFA	High NFA
Δ Reserves	-2.14***	-1.32***	-3.27**
	(0.74)	(0.51)	(1.56)
Δ Debt	0.46*	0.34	1.19**
	(0.24)	(0.25)	(0.49)
Num.Obs.	4,468	2, 226	2,242
R2 Adj.	0.352	0. 282	0.416

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Robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Connecting with the data – II

Once accumulated, reserves are not used.

- Focus on two global crises, GFC and Covid
- **Find:** no evidence that countries w/ higher reserves at beginning of crises used them more

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- Focus on two global crises, GFC and Covid
- **Find:** no evidence that countries w/ higher reserves at beginning of crises used them more
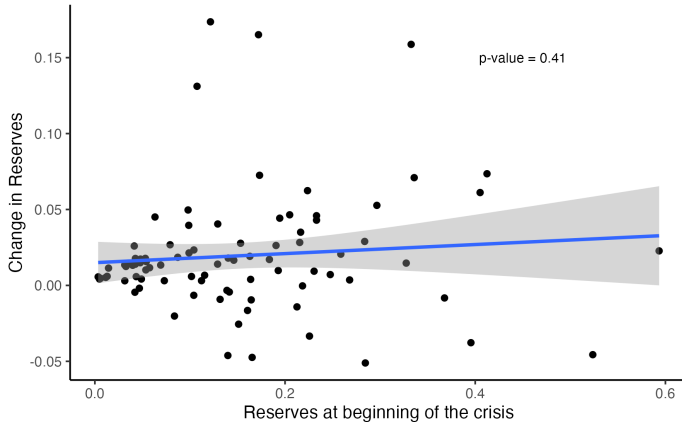
Conclusions

- Simple theory of optimal res. management w/ rollover crises

- Optimal to accumulate reserves to reduce vulnerability

  - However, only after debt has been reduced towards safety

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- Findings speak to policy discussions on appropriate level of FX reserves (e.g. IMF)

  - Following a debt crisis, IMF often prescribes increasing reserves

  - However, we find holding reserves <u>not optimal</u> at beginning of deleveraging process

Scan to find the paper!

THANKS!
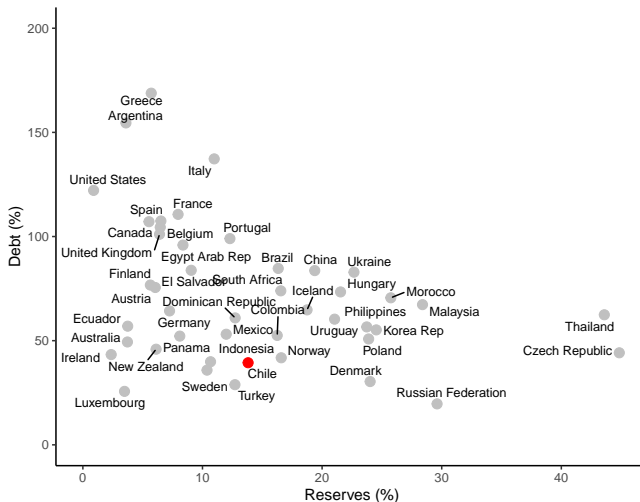
Government debt and reserves (as % of GDP), 2023

Evolution of Debt and Reserves

Avg. Government debt and reserves (as % of GDP)

Literature

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- Hernandez (2019): numerical simulations w/ fundamental and sunspot shocks

Cole-Kehoe (2001); Corsetti-Dedola (2016); Aguiar-Amador (2020); Bianchi-Mondragon (2022); Bianchi and Sosa-Padilla (2023); Corsetti-Maeng (2023ab)

- If $(a, b) \in \mathbf{S}$: we assume gov. stays in safe zone

$$V^S(a - b) = \frac{u(y + (1 - \beta)(a - b))}{1 - \beta}$$

- **Note:** relevant state variable is the NFA, $a - b$

  For a high enough δ: can establish that gov. finds it optimal to stay in $\mathbf{S}$

- If $(a, b) \in \mathbf{C}$, govt. seeks to exit in finite time (may default along the way if bad sunspot hits)

  - Staying in the crisis zone implies eventually costly default

  - Speed of exit depends on curvature of $u(\cdot)$ and probability of bad sunspot

Continuation value:

$$\mathbb{E}V(a', b', \zeta') = \begin{cases} V^S(a' - b') & \text{if } (a', b') \in \mathbf{S} \\ (1 - \lambda)V_R^+(a', b') + \lambda V_D(a') & \text{if } (a', b') \in \mathbf{C} \\ V_D(a') & \text{if } (a', b') \in \mathbf{D} \end{cases}$$

We have that for any $T > 0$ the bond price is given by

$$q(a', b') = \kappa \sum_{t=1}^{T-1} \left(\frac{1-\lambda}{1+r}\right)^t (1-\delta)^{t-1} + \left[\frac{(1-\lambda)(1-\delta)}{1+r}\right]^{T-1} \frac{1}{1+r}$$

- First term: bond coupon payments investors expect to receive

- Second term: risk-free price of the bond once the government exits the crisis zone
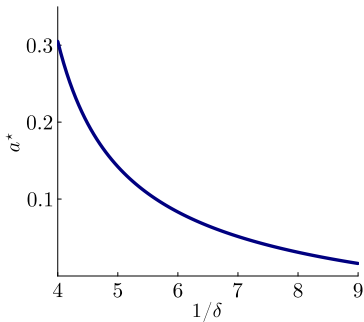
Deleveraging Dynamics: $b' = (1-\delta)b_0$

Policies
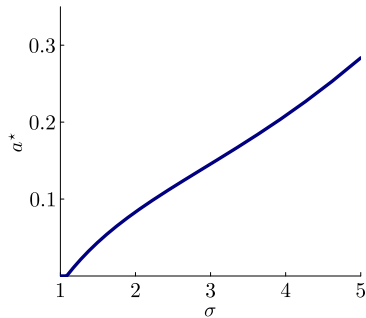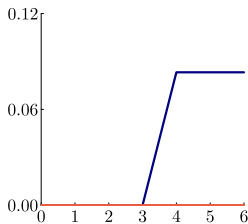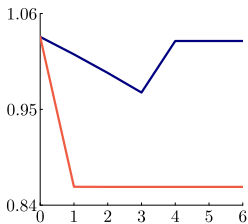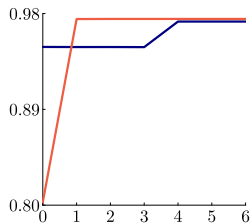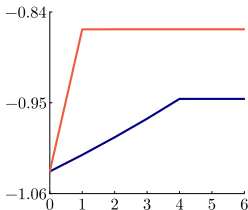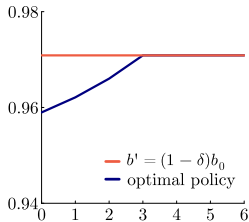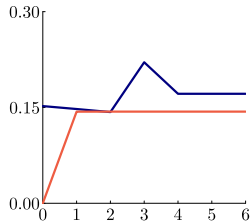
Back

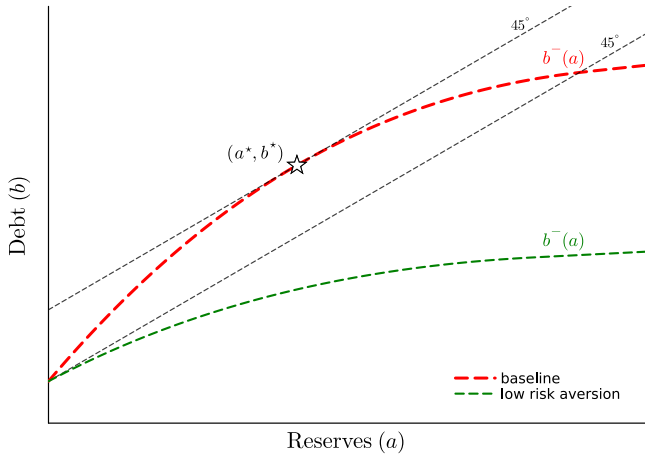Debt, b'
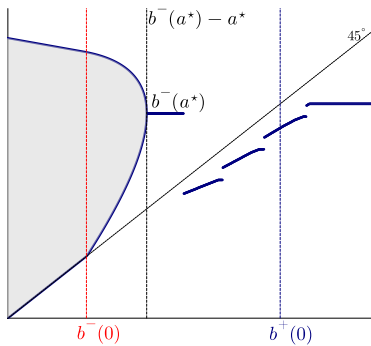
Reserves, a'
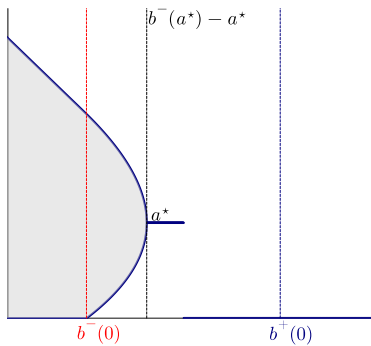
Net Foreign Assets, $a' - b'$
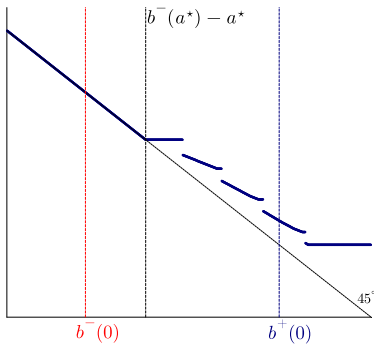
Consumption
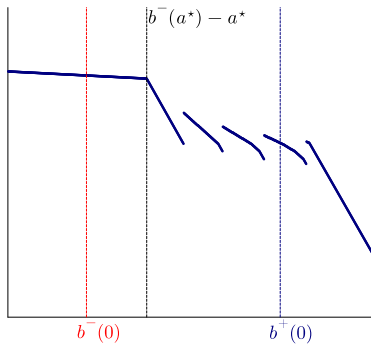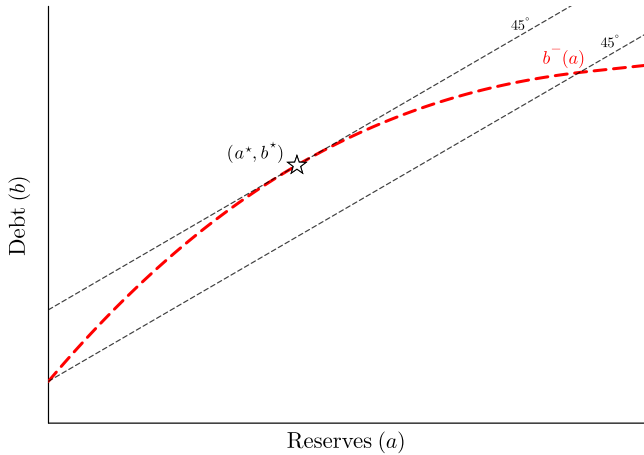
Parametrization

$$u(c) = \frac{(c - \underline{c})^{1-\sigma}}{1 - \sigma}$$

Parameter	Value	Description	Source
y	1	Endowment	Normalization
σ	2	Risk-aversion	Standard
r	3%	Risk-free rate	Standard
$1/\delta$	6	Maturity of debt	Italian Debt
$\underline{c}$	0.68	Consumption floor	Bocola-Dovis (2019)
β	0.97	Discount factor	$\beta(1 + r) = 1$
λ	0.5%	Sunspot probability	Baseline
ϕ	0.33	Default Cost	Debt-to-income $=100\%$
κ	$\frac{\delta + r}{1 + r}$	Coupon	Normalization

Experiment – How reserves help exit crisis zone

- Assume gov. starts w/ portfolio (a, b), **but** from t+1 onward, $a' = 0$

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<u>Without reserves:</u> $\downarrow b^+$. More costly to deleverage $\Rightarrow$ lower debt-carrying capacity
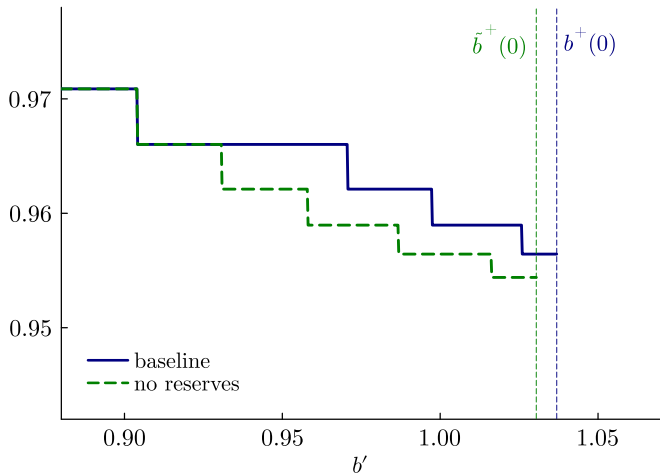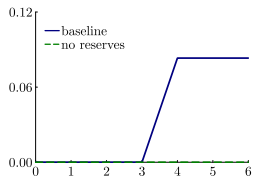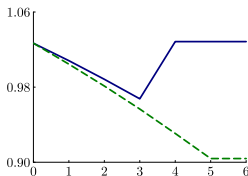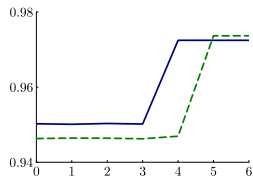
Lower consumption without reserves

Reserves, a
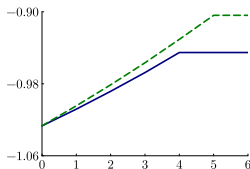
Debt, b

Consumption

Net Foreign Assets

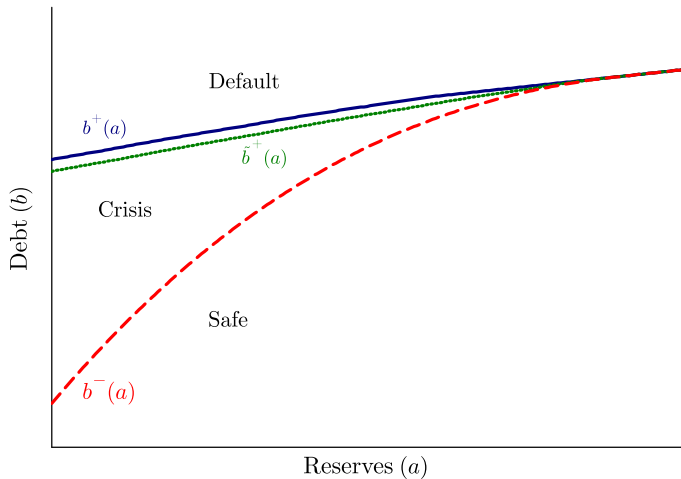Debt Price, $q(a', b', s)$
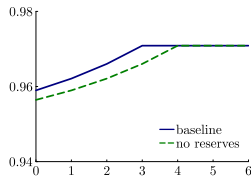
Increasing reserves and debt lowers spreads (levels)

Dep. Variable:		log(Spread)	
	(0)	(1)	(2)
Reserves	−2.39***		
	(0.11)		
Sov.Debt	1.25***	−1.13***	1.58***
	(0.10)	(0.14)	(0.20)
NFA_public		−2.39***	−2.69 ***
		(0.11)	(0.11)
(Sov.Debt)^2			−5.48***
			(0.31)
Num.Obs.	4497	4497	4497
R2	0.791	0.791	0.997

$+$ p $<$ 0.1, * p $<$ 0.05, ** p $<$ 0.01, *** p $<$ 0.001

All specs. include country FEs, year dummies and additional macro controls (as in Sosa-Padilla and Sturzenegger, 2023).