International Reserve Management under Rollover Crises

Mauricio Barbosa-Alves [a] Javier Bianchi [b] César Sosa-Padilla [c]

[a]University of Minnesota [b]Minneapolis Fed [c]University of Notre Dame & NBER

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

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- Tractable model of rollover crises with long-duration bonds and reserves
    - Sunspot shocks, deterministic income
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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

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- Risk-neutral deep pocket international investors:
  - Discount future flows at rate r, assume $\beta(1+r) = 1$
- Markov equilibrium w/ Cole-Kehoe (2000) timing:
  - Borrowing at the beginning of the period
  - Settlement (repay/default) at the end

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:

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

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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

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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- Given $\beta(1+r) = 1$ and no uncertainty, we have constant consumption

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

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

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

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

subject to

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

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Bond price depends on the portfolio and reflects default prob:

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

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

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

0

To pay debt, need to use reserves or cut consumption

Multiplicity of Equilibria

- 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

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

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

Default thresholds

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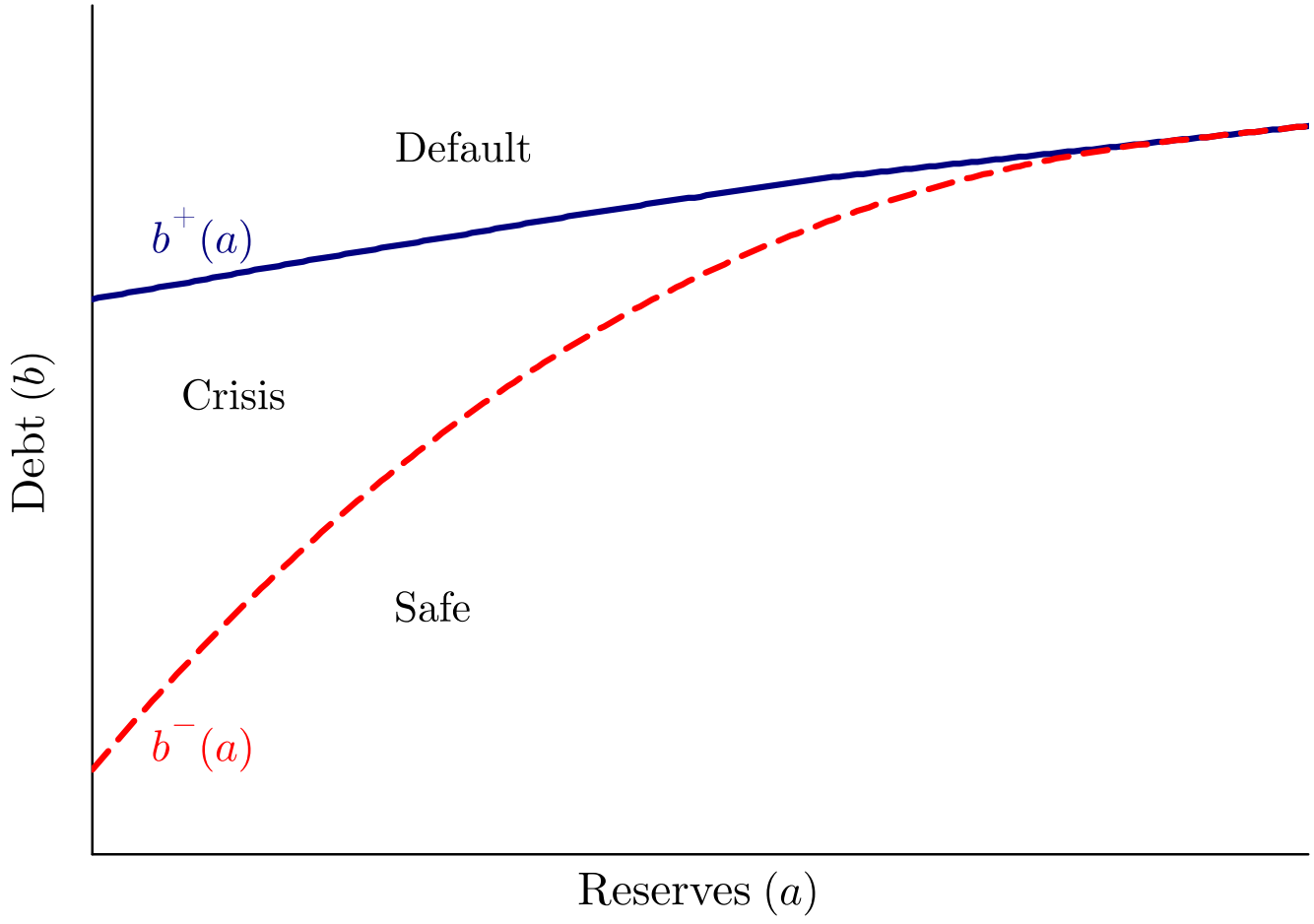
$$V_R^-(a,b) < V^D(a) \leq V_R^+(a,b)$$

Default thresholds

For a given level of reserves, two thresholds

Sunspot: assume government faces a run w/ prob λ 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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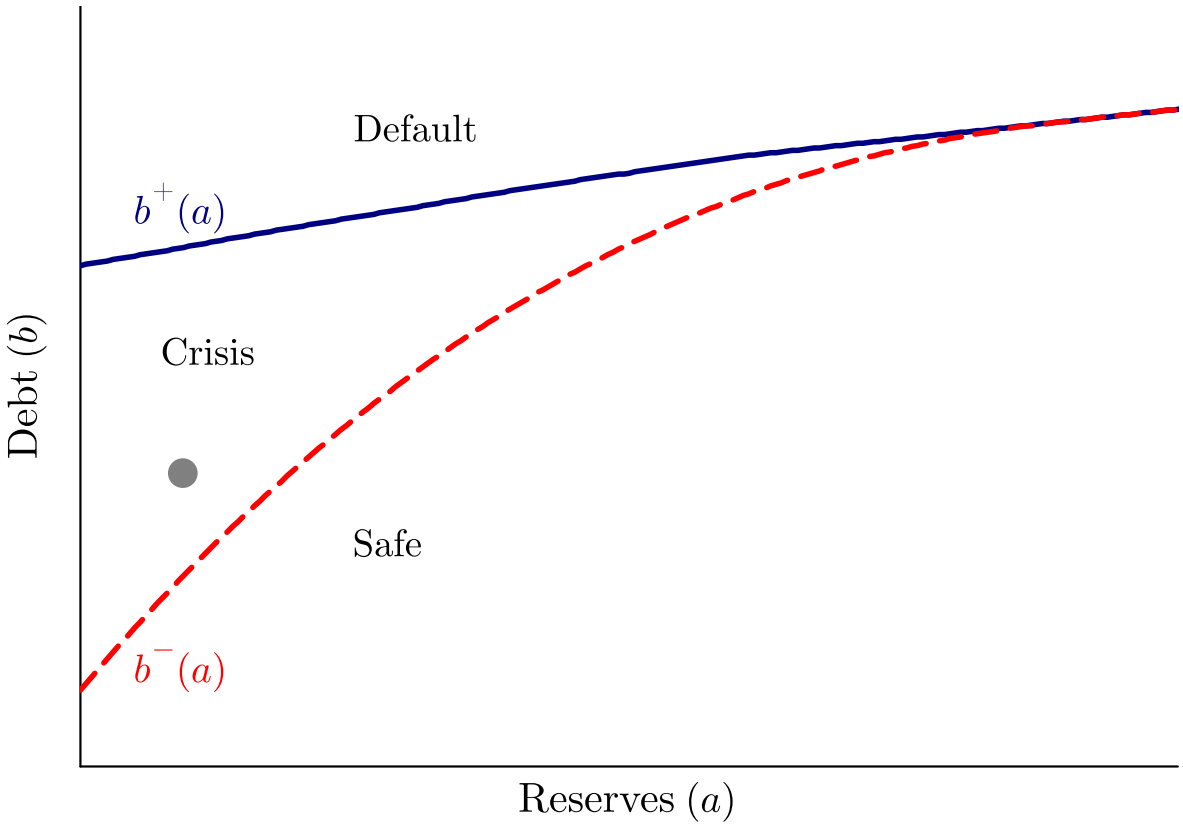
What's the best exit strategy for a country that is in the crisis zone (but didn't face a run today) ?

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

Possible Exit Paths



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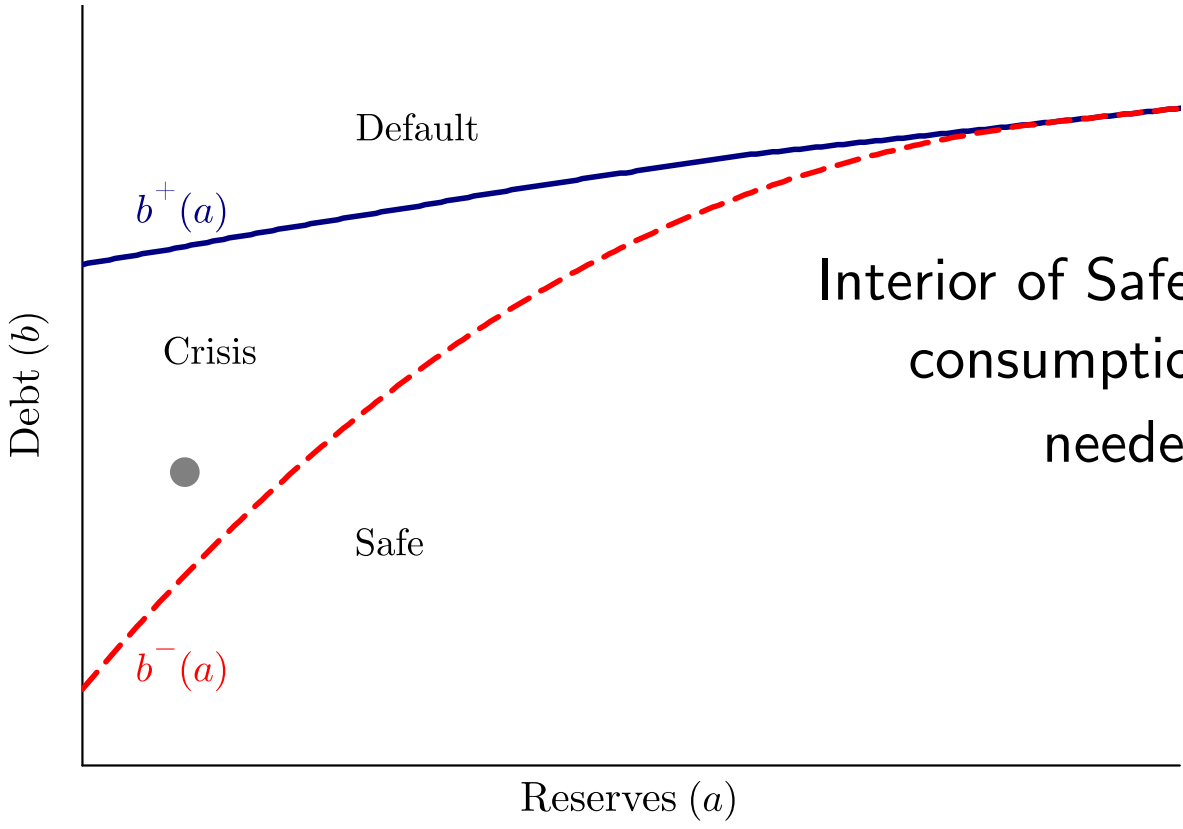
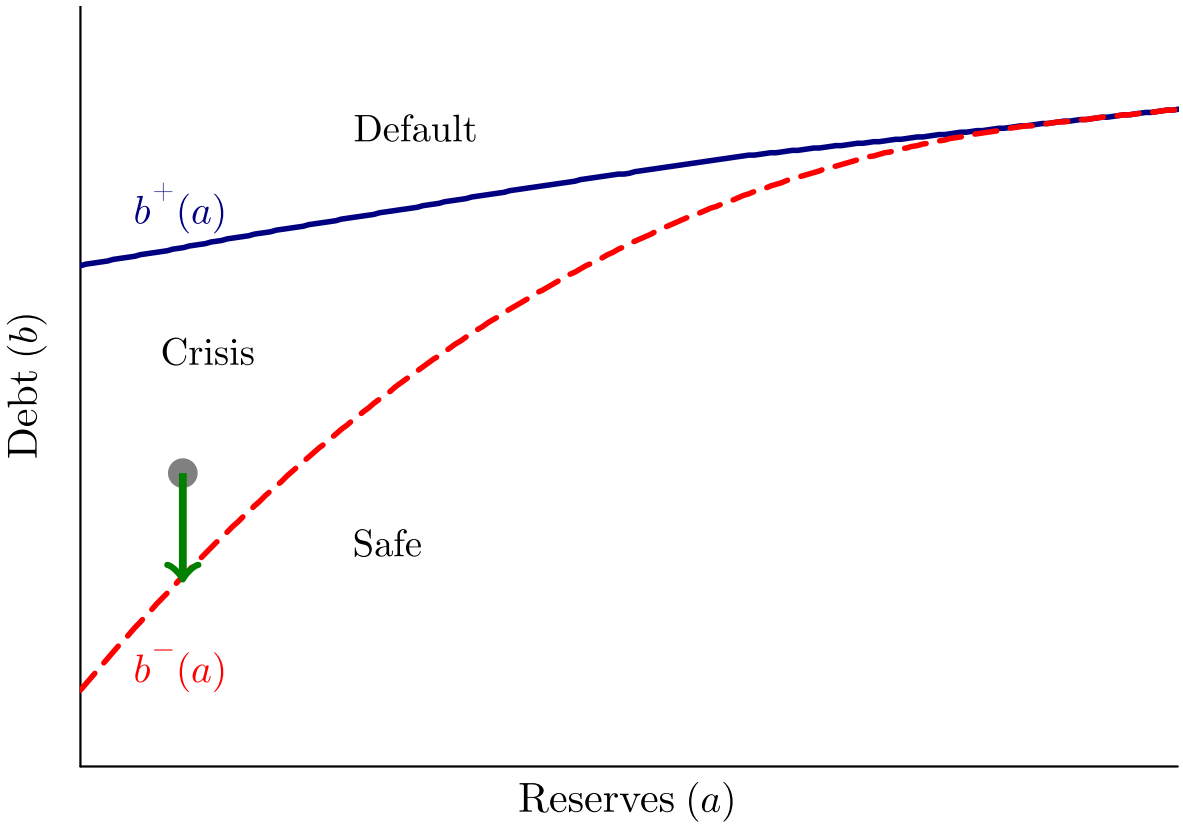


Interior of Safe zone isn't optimal: consumption cut larger than needed to be safe

Possible Exit Paths



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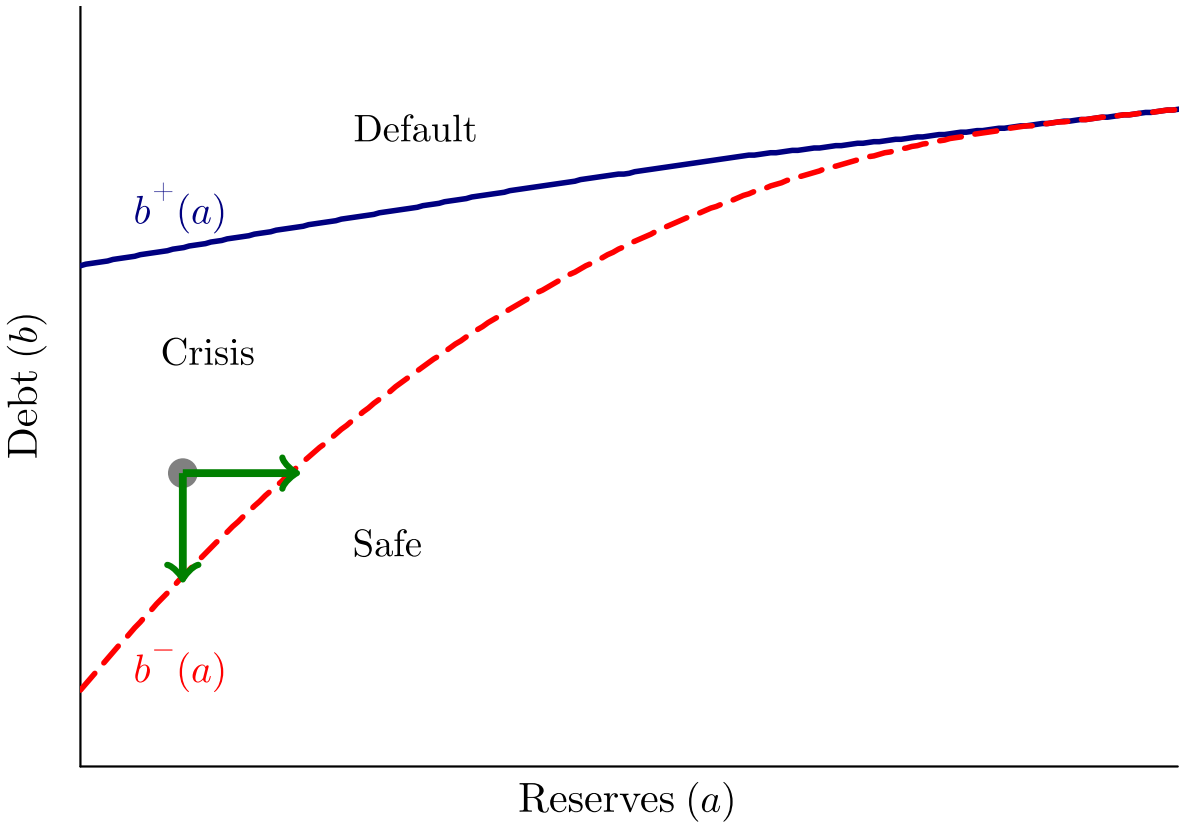

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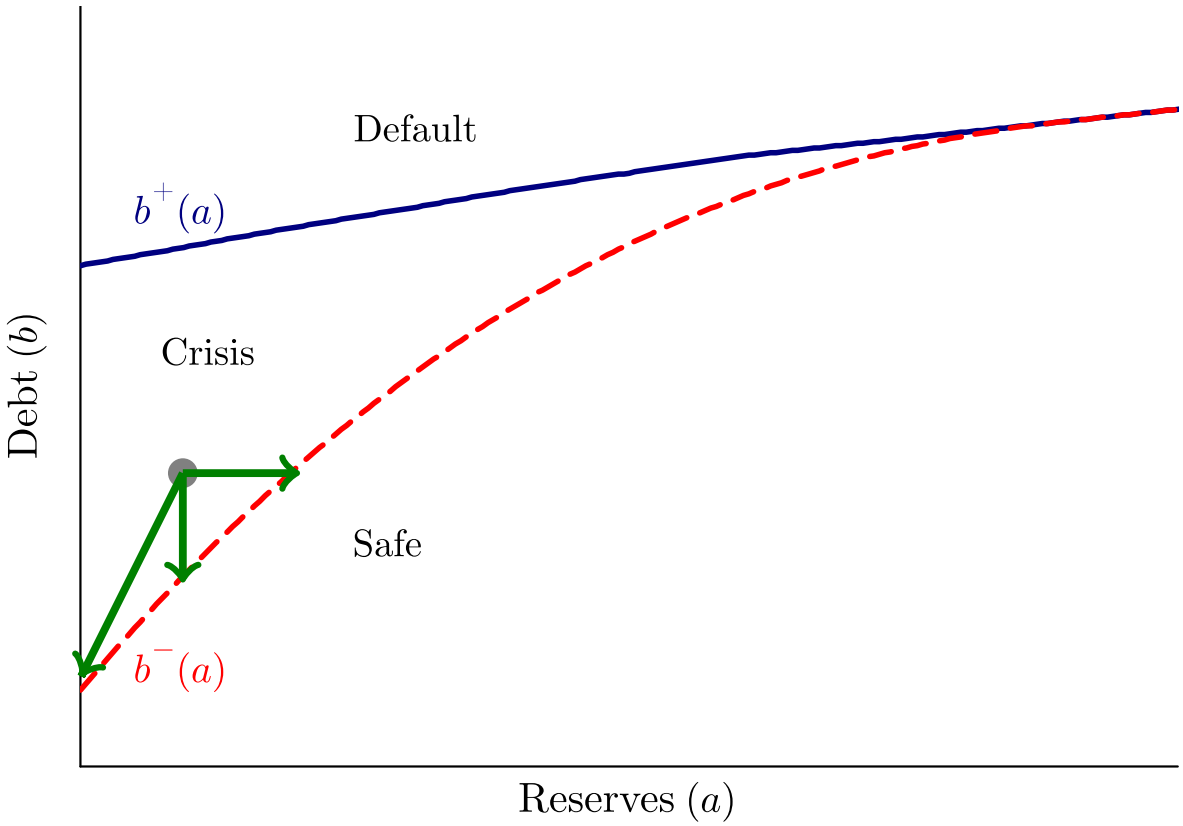

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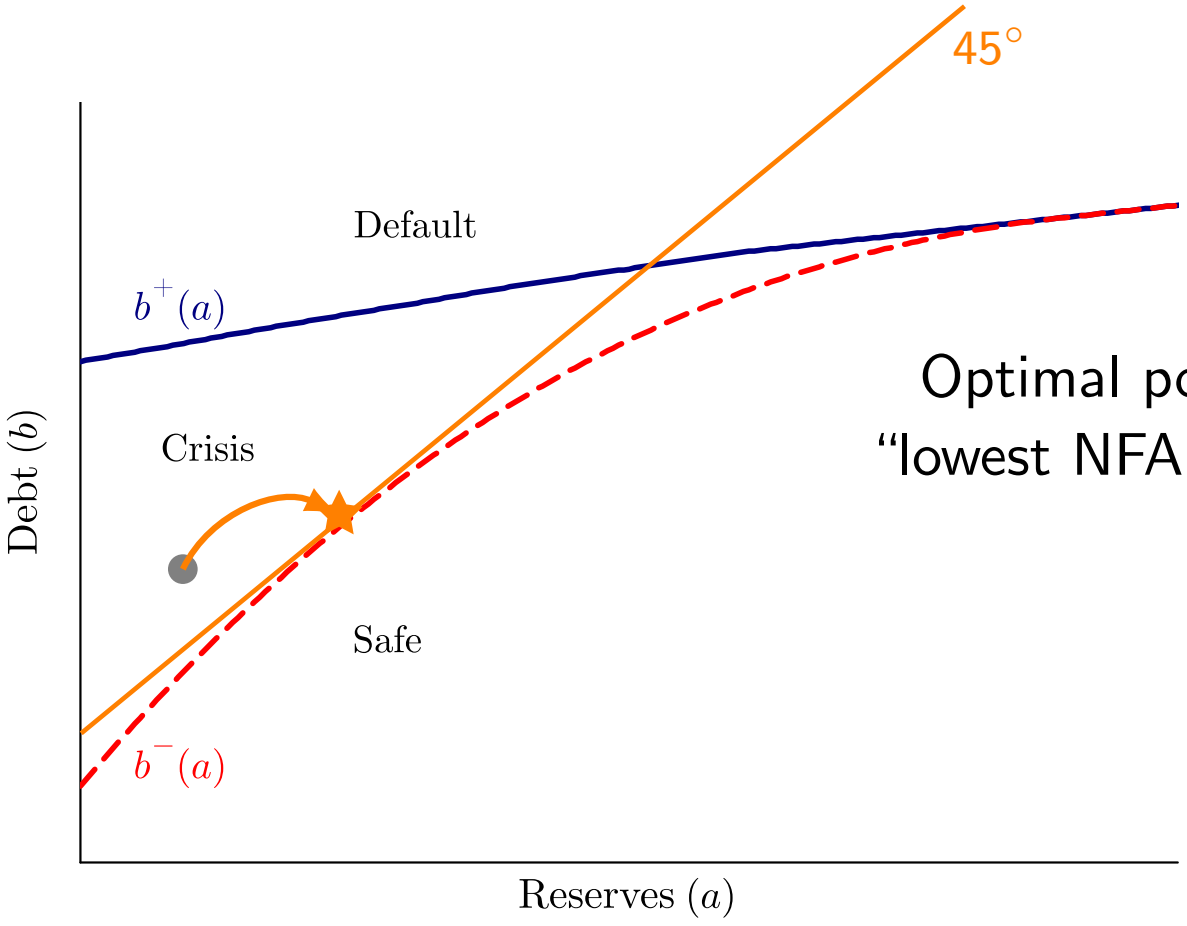
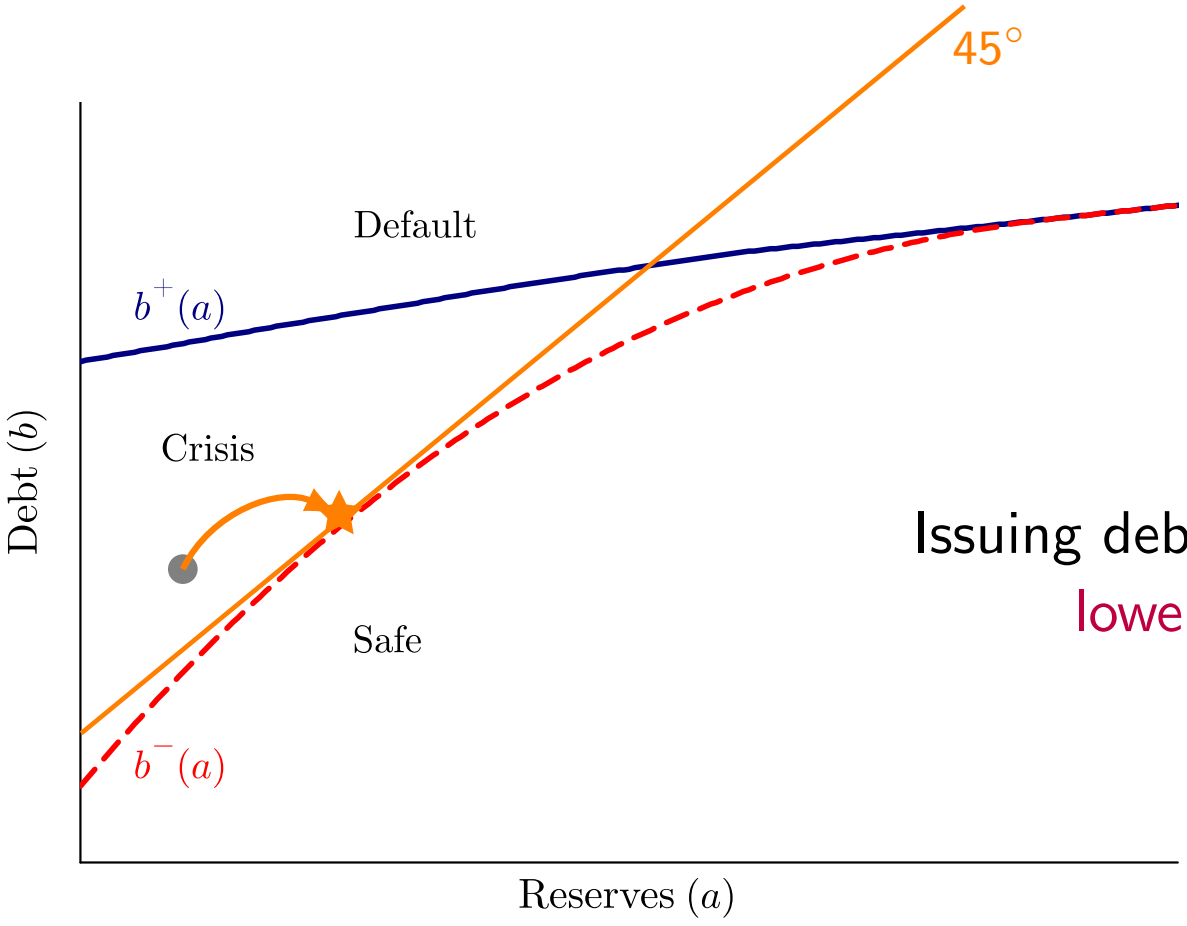


Optimal portfolio is the
"lowest NFA safe portfolio"

Possible Exit Paths



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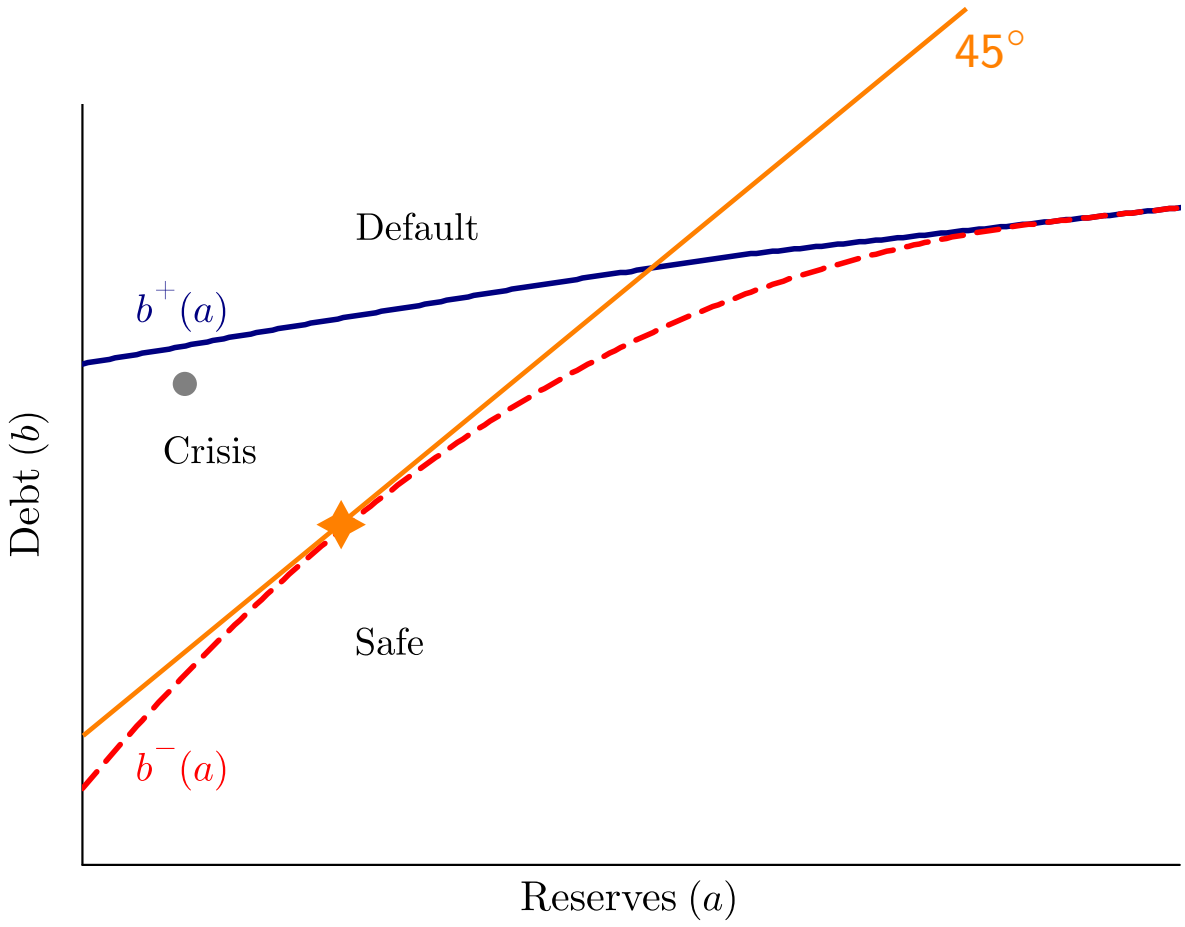
- Reserves also make default more attractive, but have lower marginal value:

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

Deep in the Crisis Zone

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

Deep in the Crisis Zone



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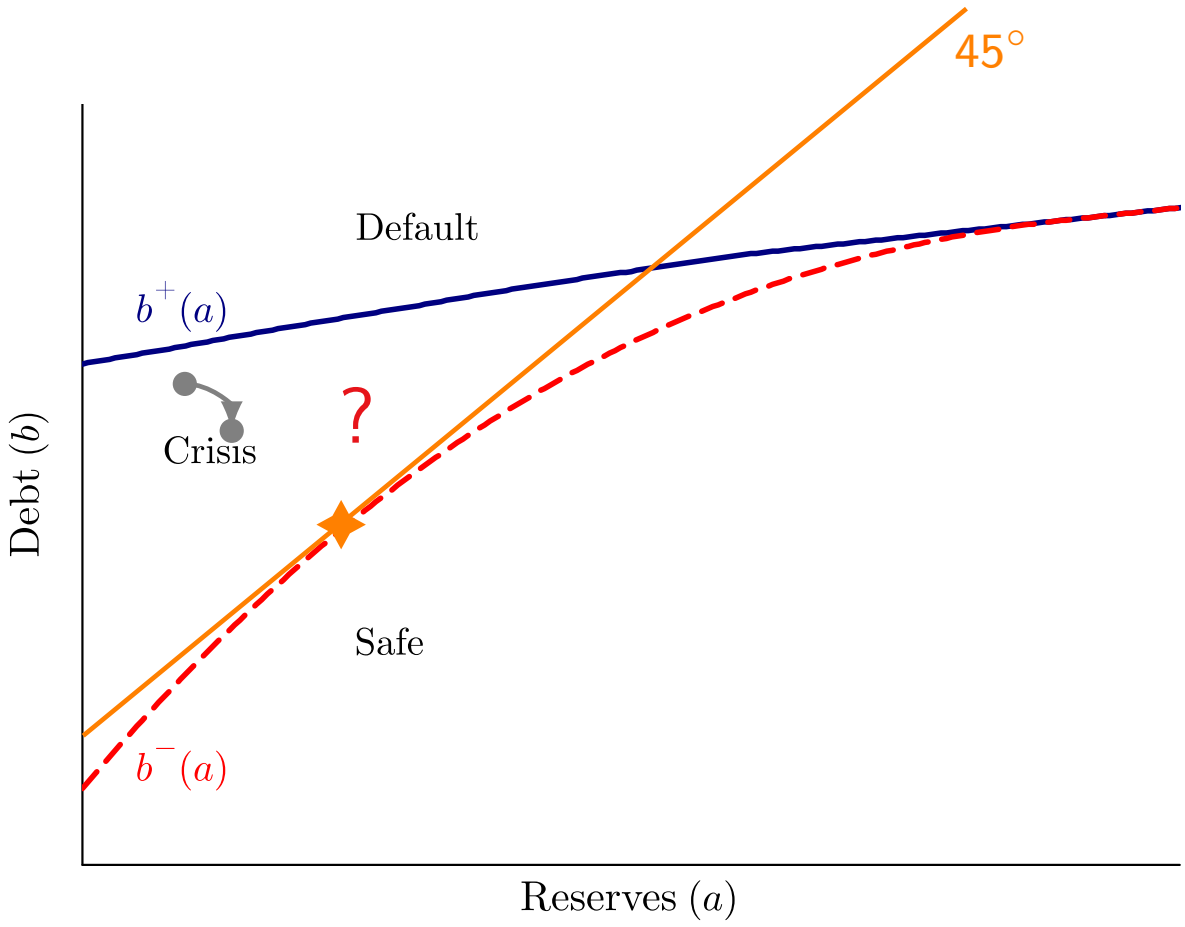

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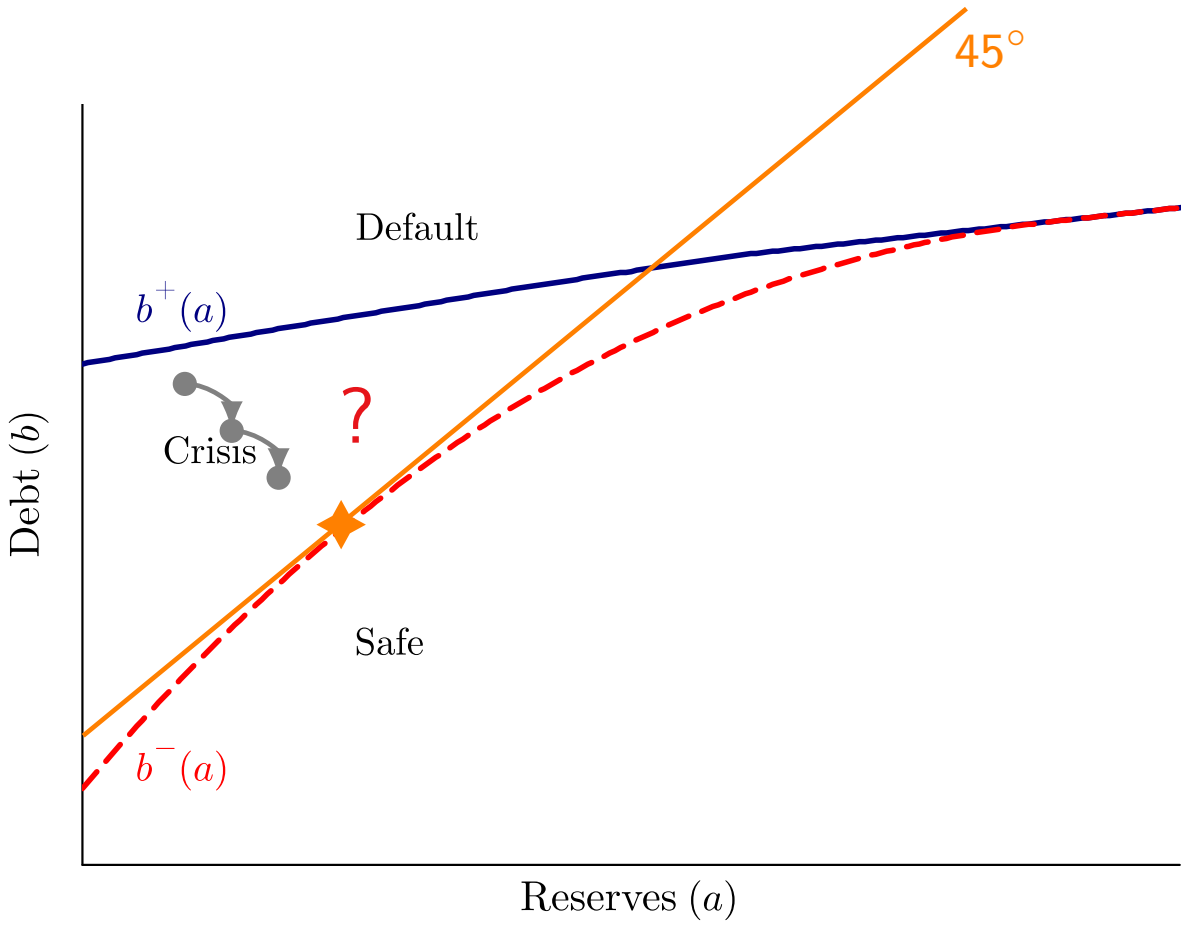

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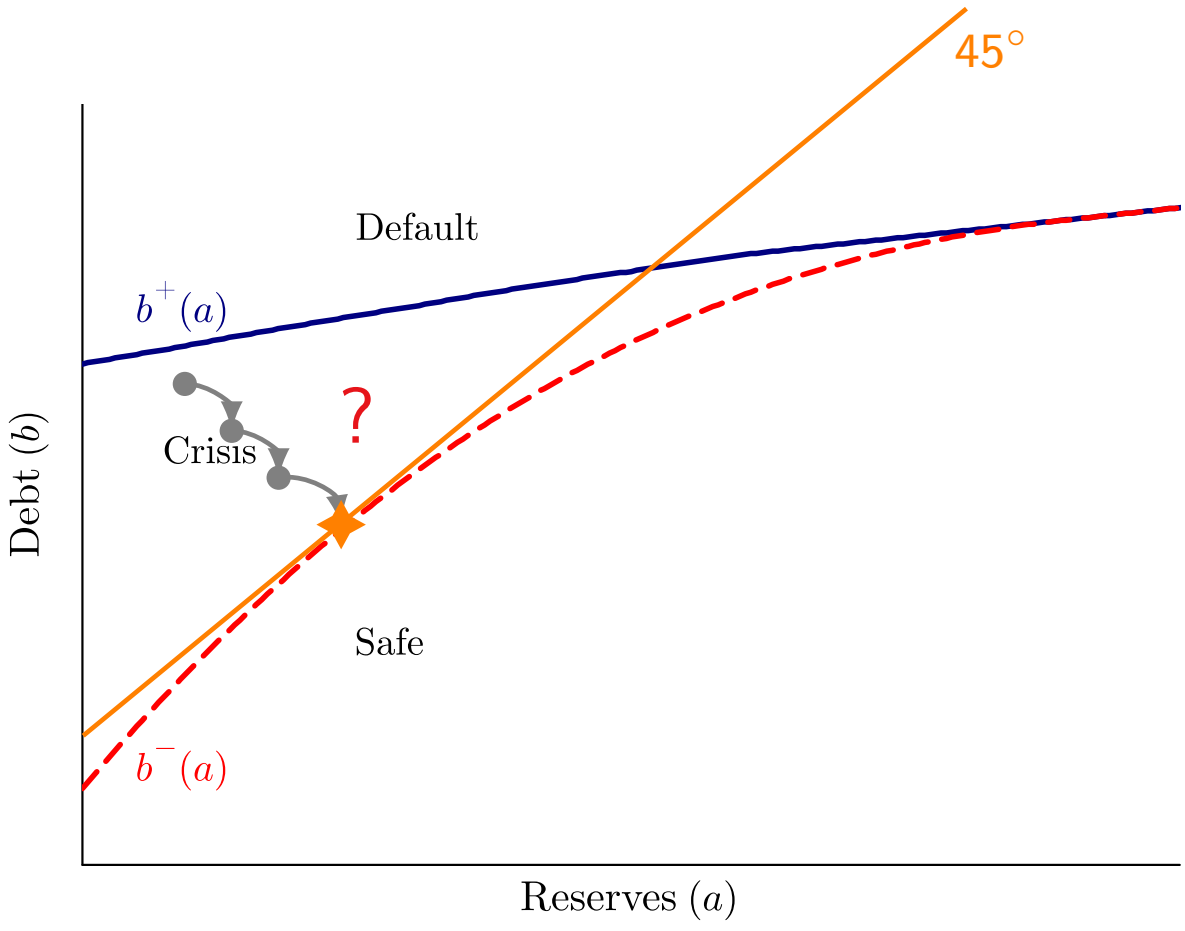

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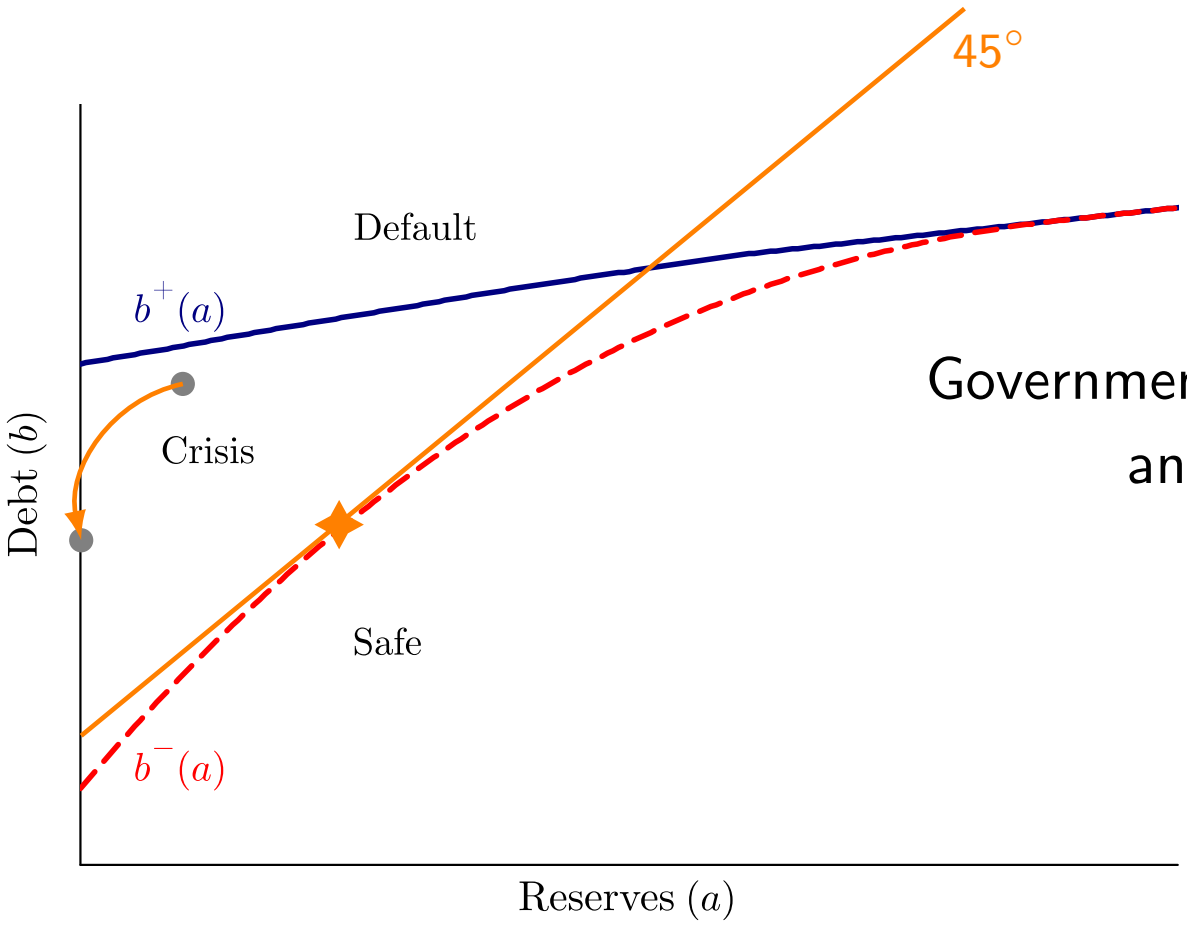
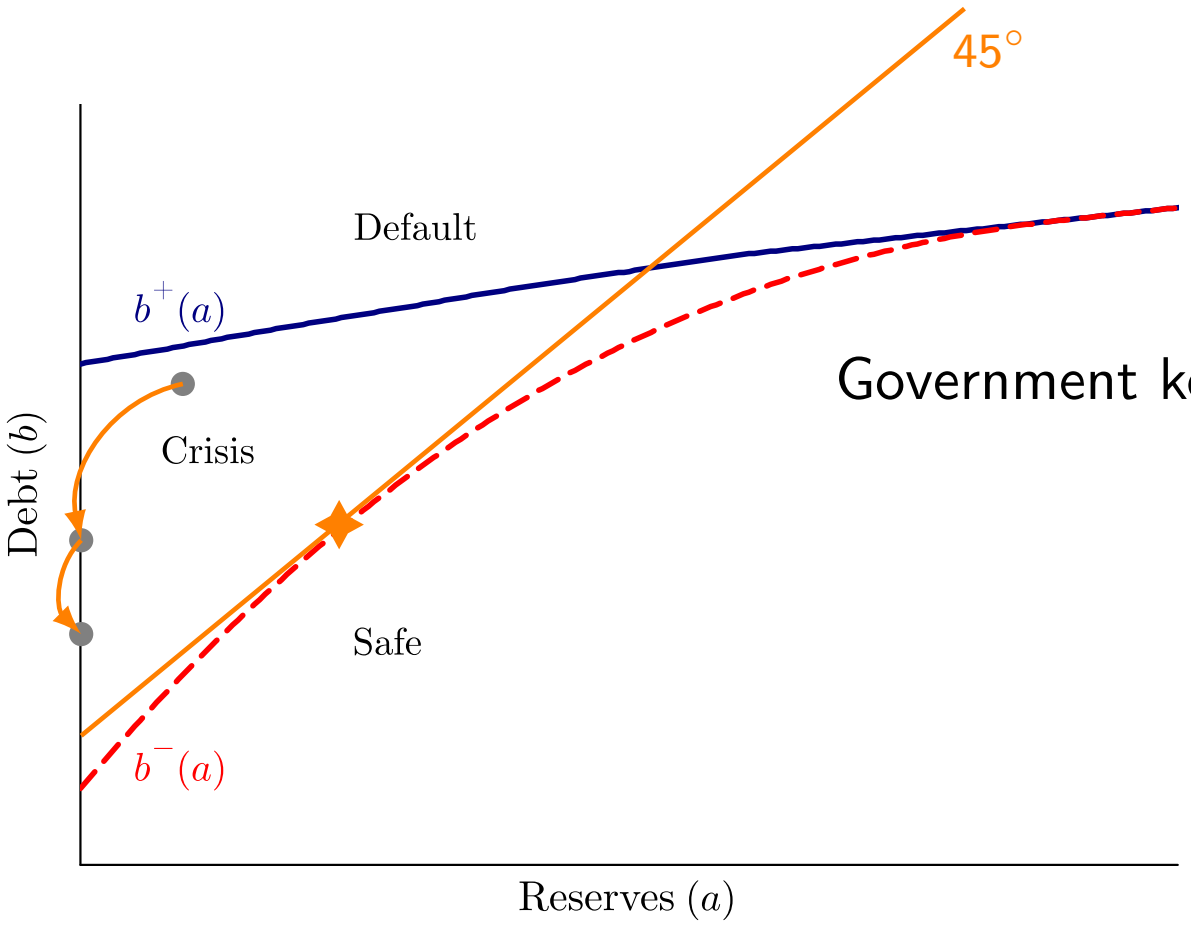


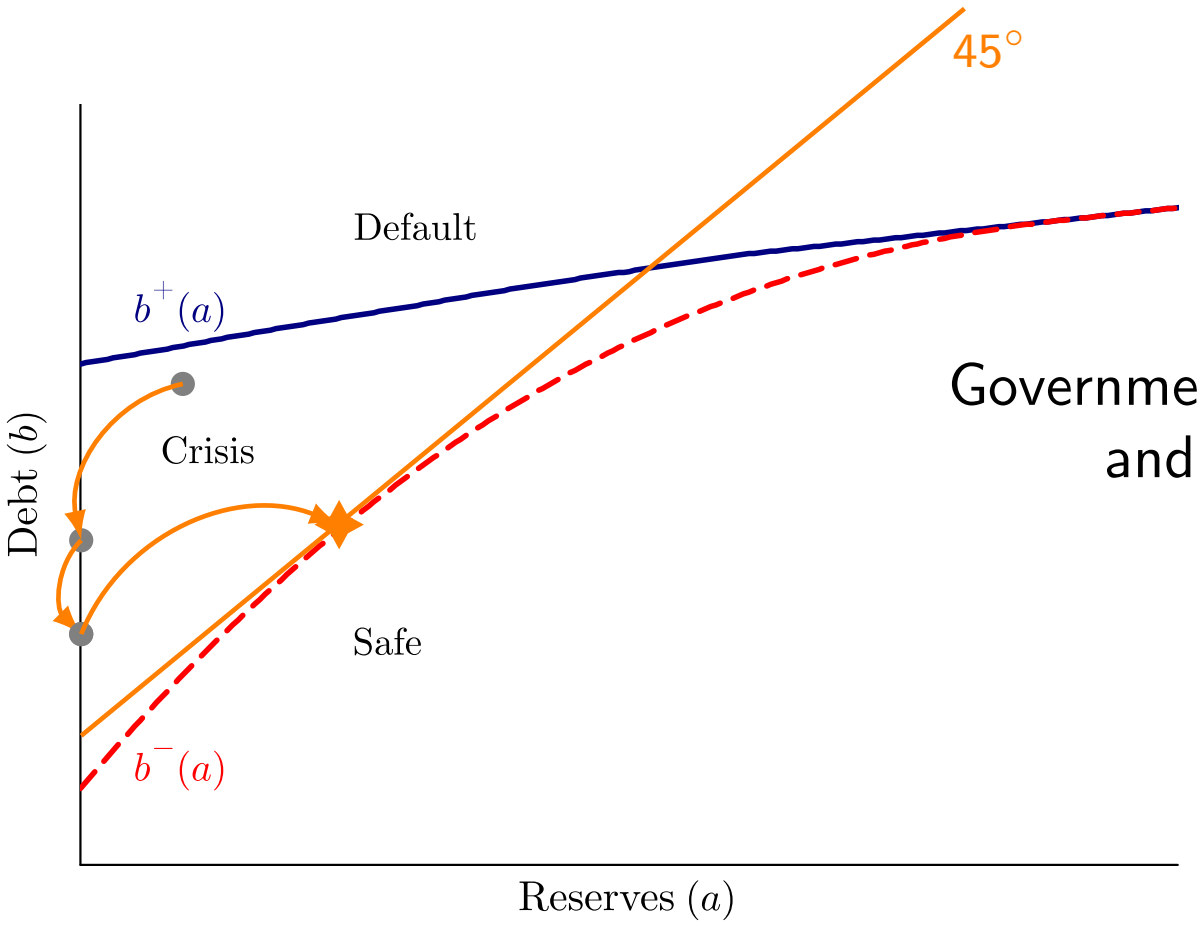
Government sells reserves and lowers debt

Deep in the Crisis Zone



Government keeps reducing debt

Deep in the Crisis Zone



Government issues debt
and buys reserves

Why selling reserves (initially)?

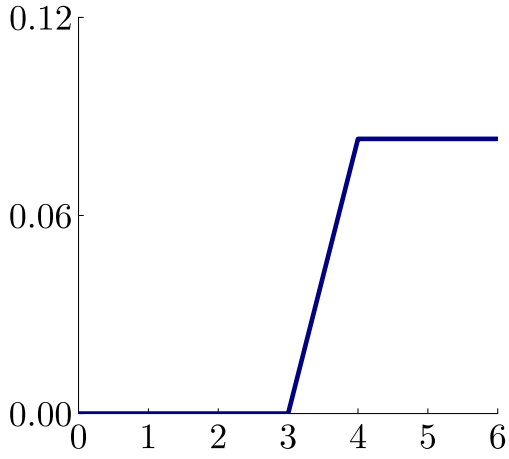
- When the government is 'deep' in the Crisis Zone, on the margin reserves do not change the probability of a run

- Using the reserves to lower debt allows the govt to save on interest payments and helps deleveraging

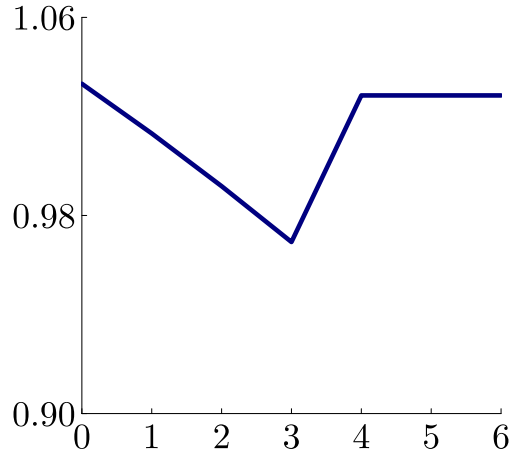
Deleveraging Dynamics

▸ More

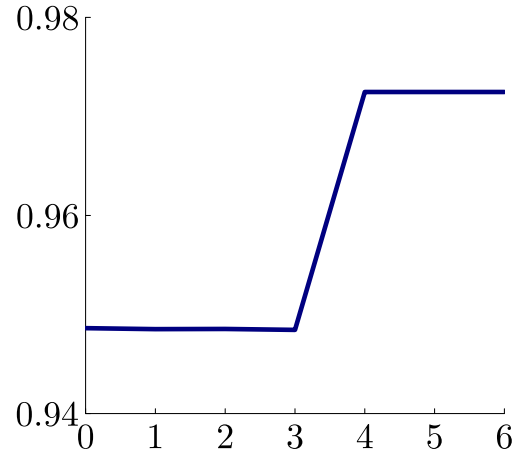
Reserves, a



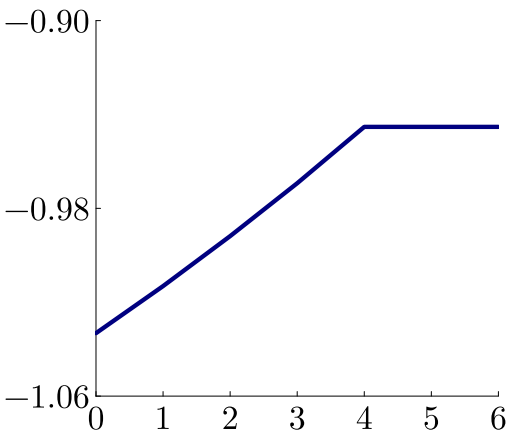
Debt, b



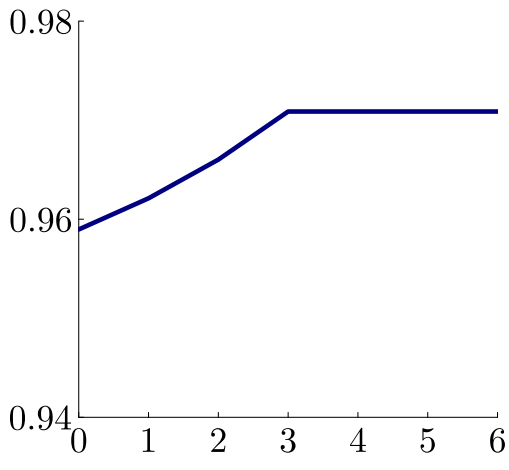
Consumption



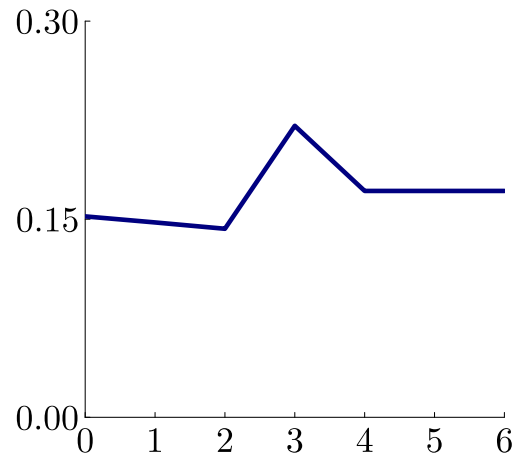
Net Foreign Assets



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



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



Deleveraging Dynamics

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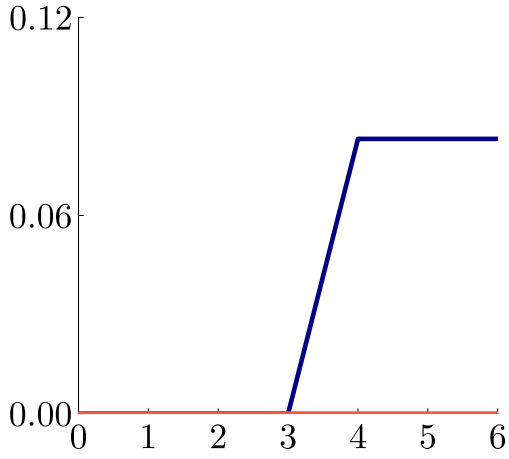

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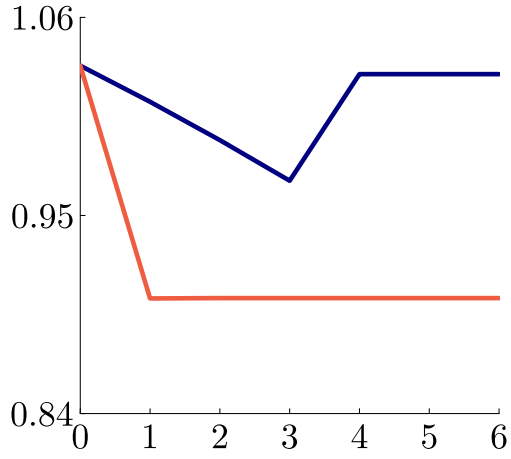

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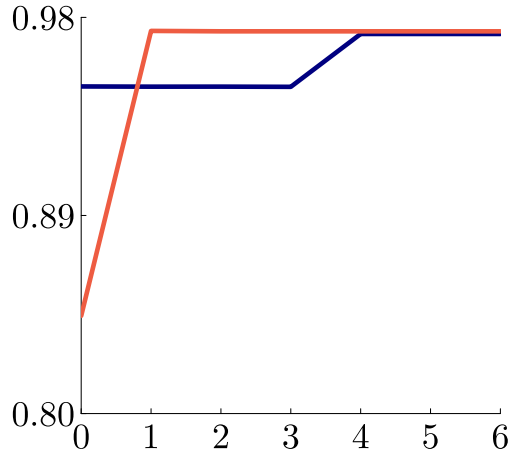

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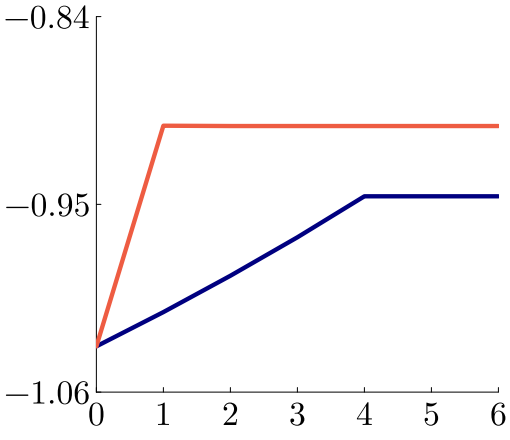

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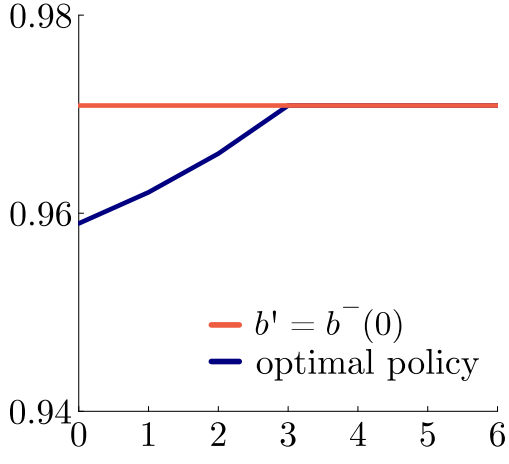

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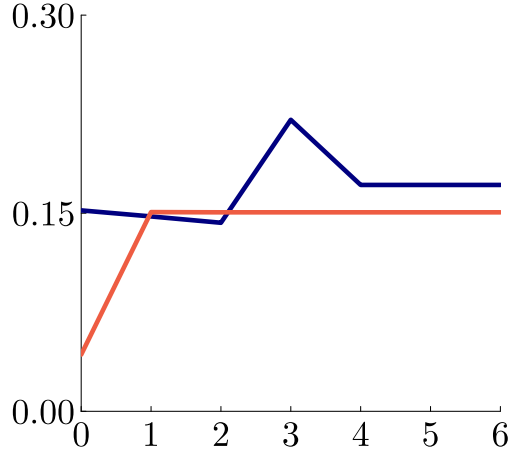
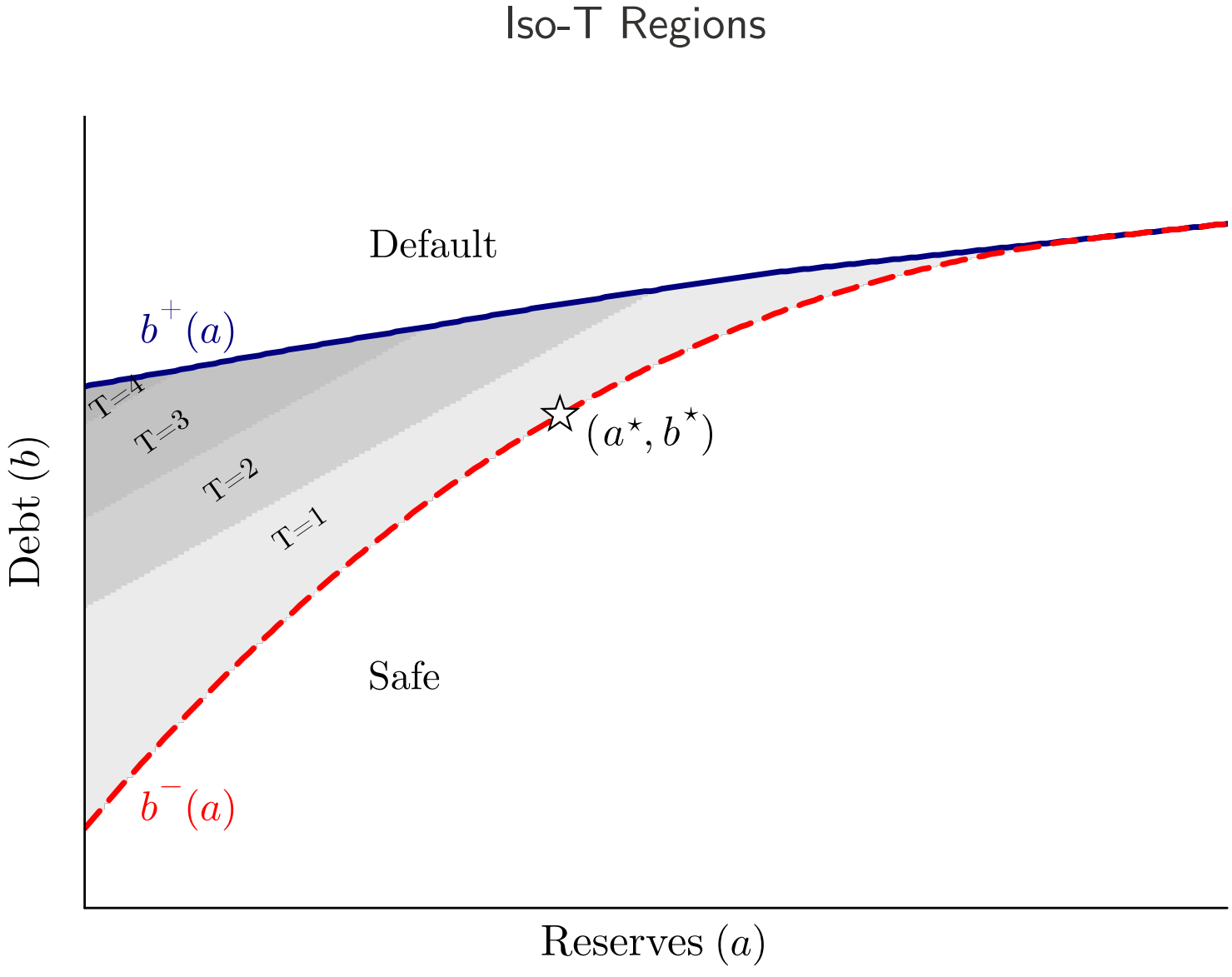


How many periods until exit?



Formalizing the Results

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

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

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

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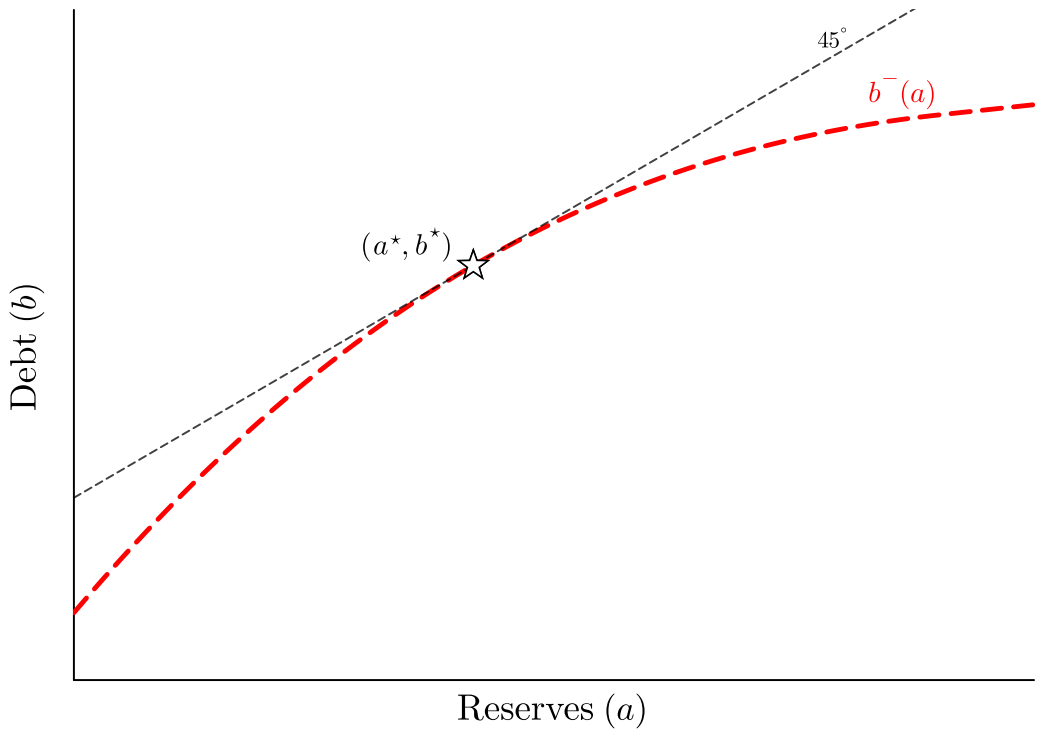

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Proposition 3 (Positive reserves)

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

▸ figure
▸ sensitivity

Formalizing the Results: Optimal portfolio

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

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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. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Connecting with the data – I

▸ levels

... 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

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

Robust standard errors in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

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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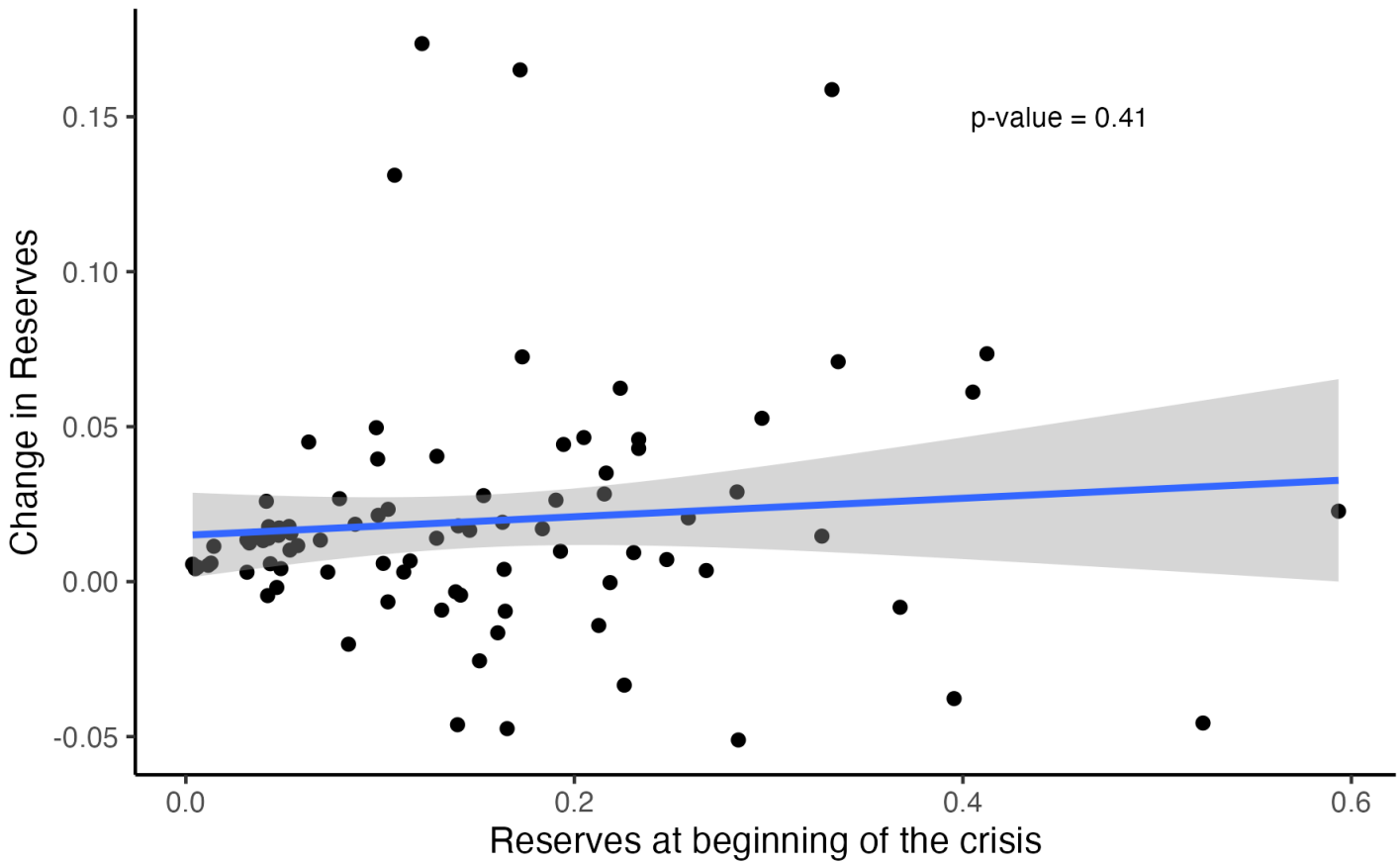

Conclusions

- 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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- Reserves as 'buffer': after buildup, no use of reserves in eqm.
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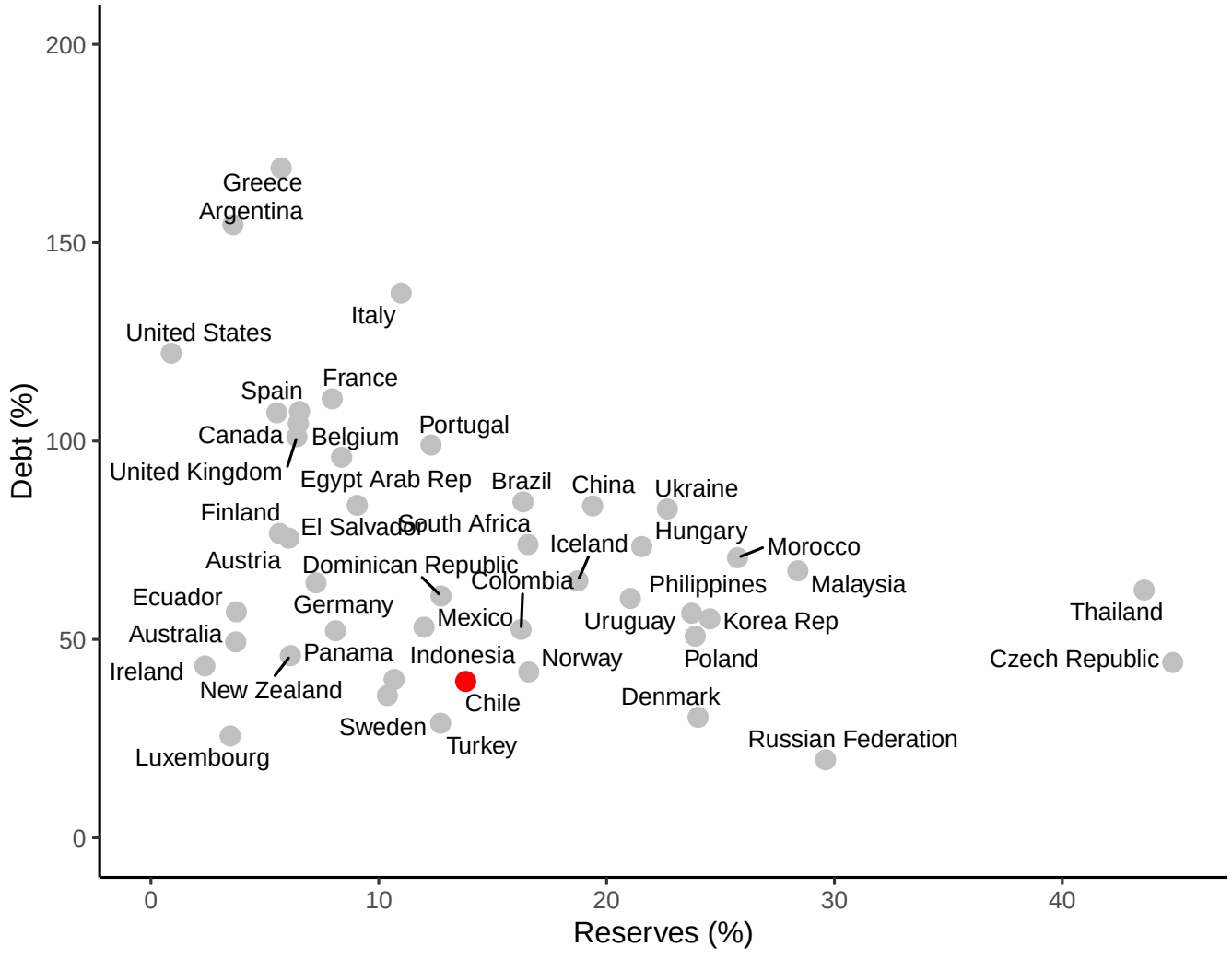
- Issuing debt to accumulate reserves can reduce spreads
- Findings speak to policy discussions on appropriate level of FX reserves (e.g. IMF)
  - Following a debt crisis, IMF often prescribes increasing reserves
  - However, we find holding reserves not optimal at beginning of deleveraging process

Scan to find the paper!

THANKS!

Data: Government Debt and International Reserves

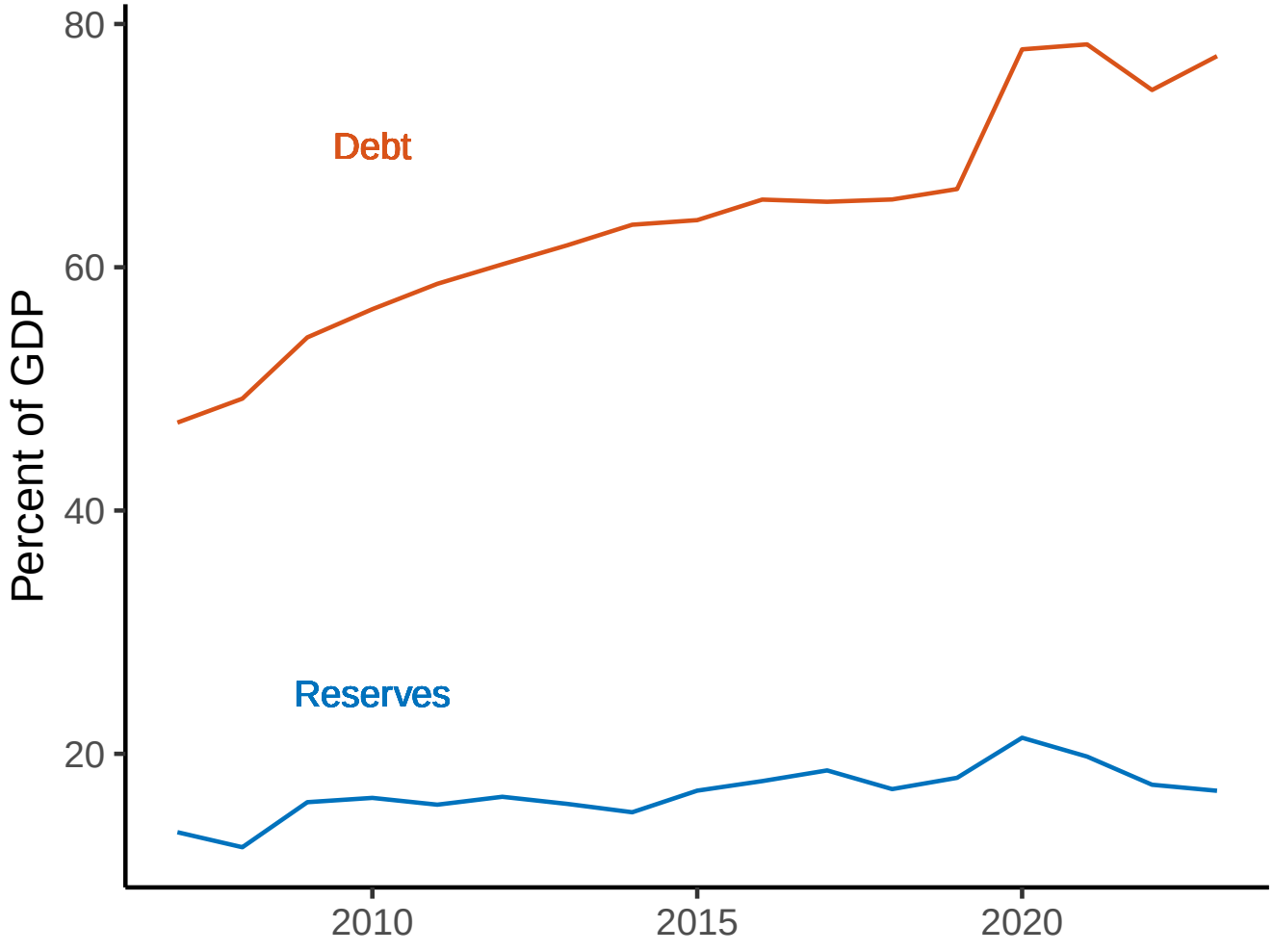
back



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

Evolution of Debt and Reserves

back



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

Literature

back

- Alfaro and Kanczuk (2008): no reserves with one-period debt
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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)

Characterization: Value in the Safe zone

back

- 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 **S**

Characterization: Crisis zone

back

- 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:

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

Characterization: Fundamental Bond Price

back

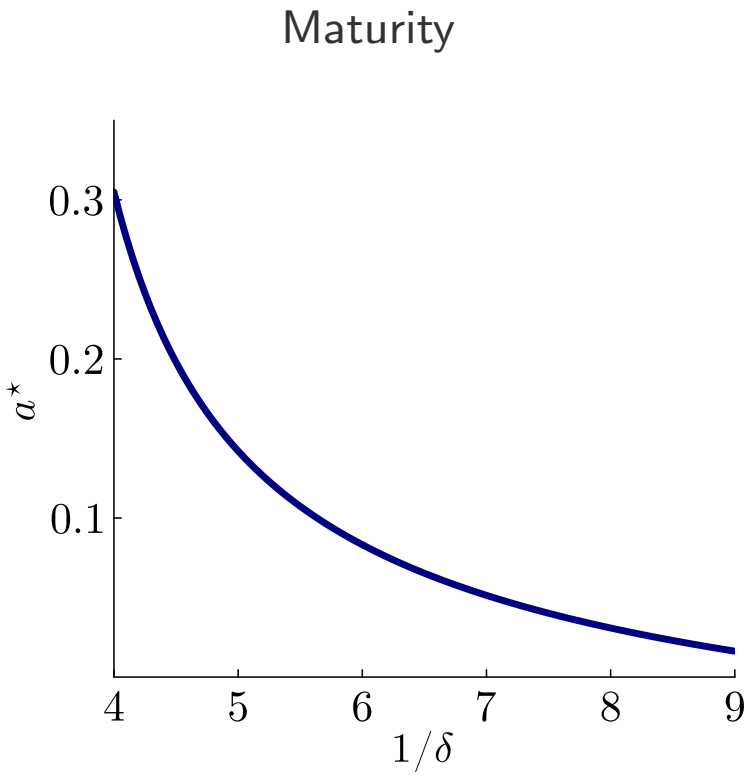
We have that for any $T > 0$ the bond price is given by

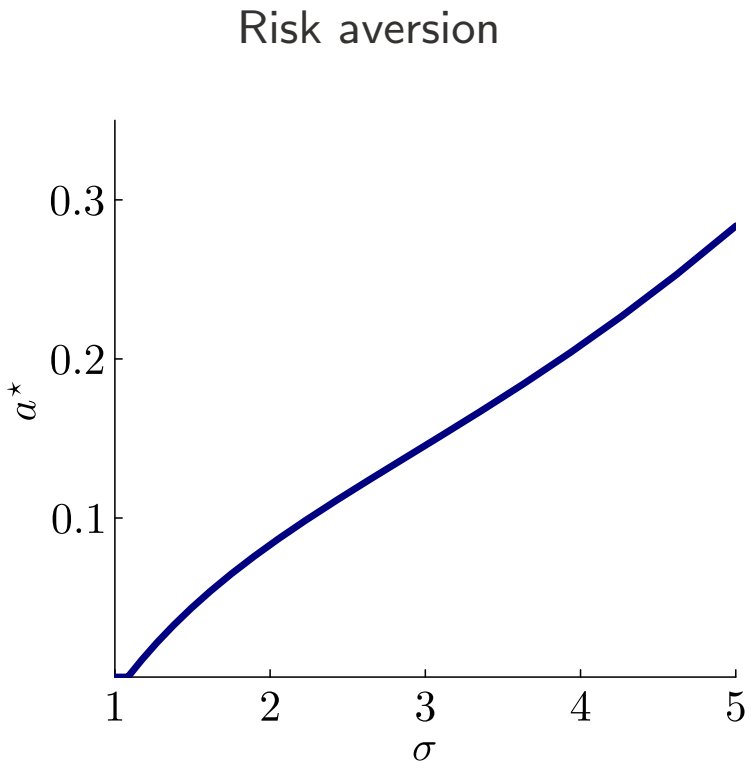
$$q(a', b') = \kappa \sum_{t=1}^{T-1} \left(\frac{1-\lambda}{1+r} \right)^t (1-\delta)^{t-1} + \left[\frac{(1-\lambda)(1-\delta)}{1+r} \right]^{T-1} \frac{1}{1+r}$$

- First term: bond coupon payments investors expect to receive
- Second term: risk-free price of the bond once the government exits the crisis zone

Sensitivity: effect of maturity and risk-aversion on $a^\star$

back

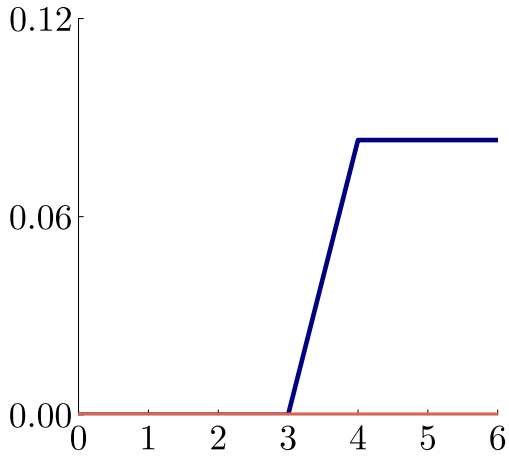




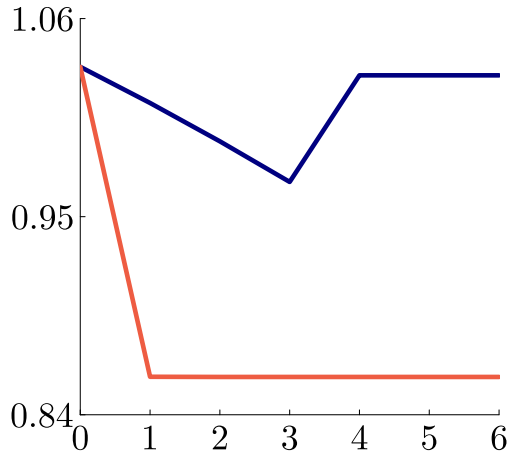
Deleveraging Dynamics: $b' = (1-\delta)b_0$

Back

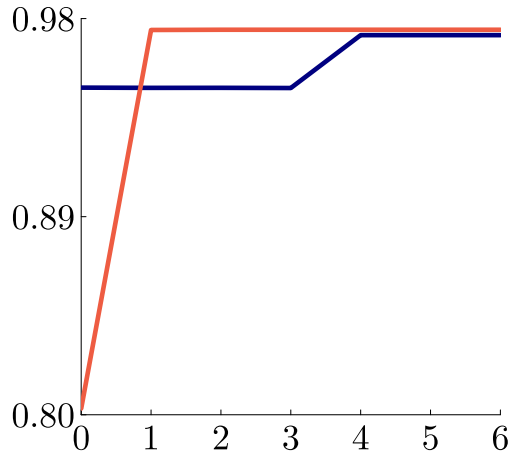
Reserves, a



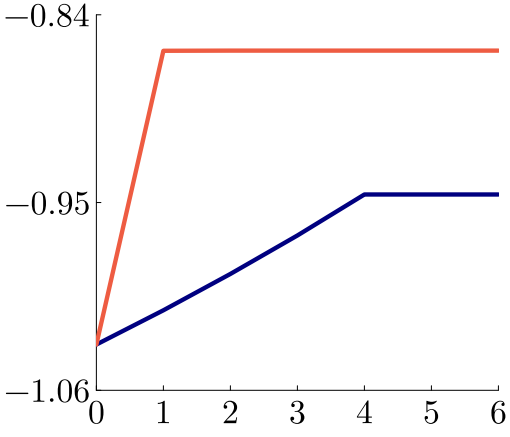
Debt, b



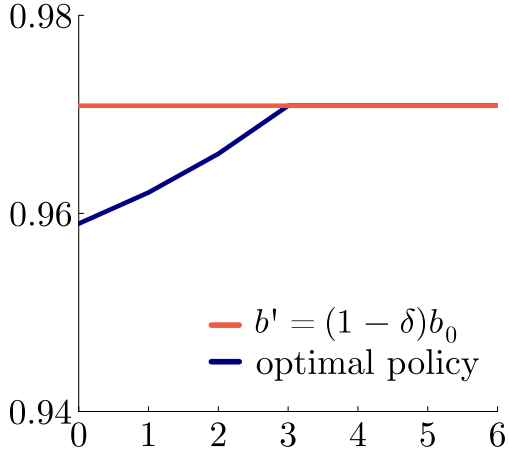
Consumption



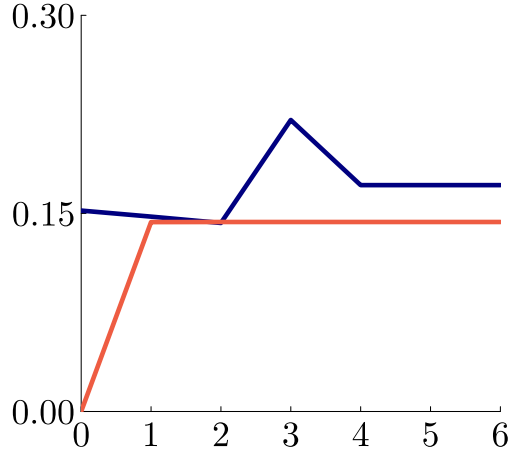
Net Foreign Assets



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



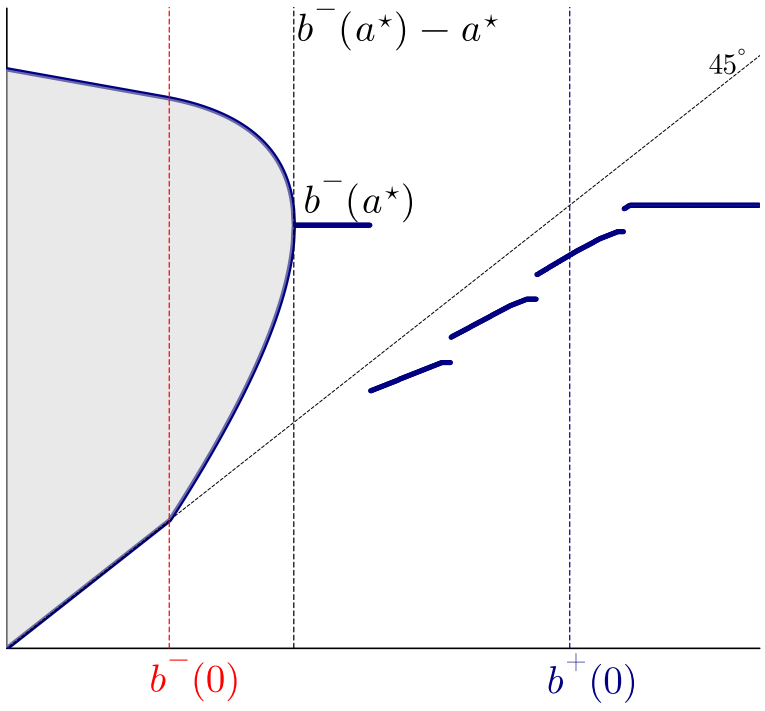
Issuance, $b' - (1-\delta)b$



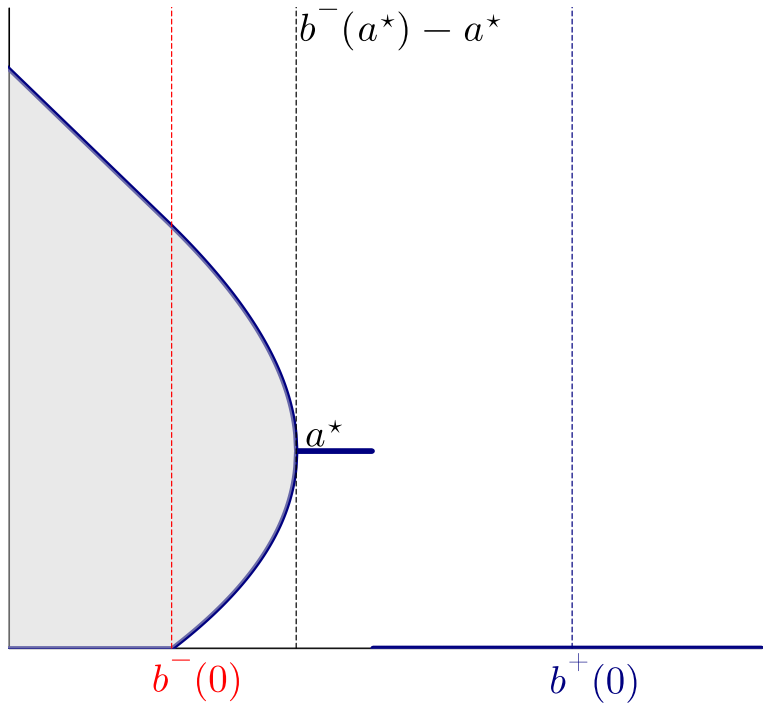
Policies

Back

Debt, b'



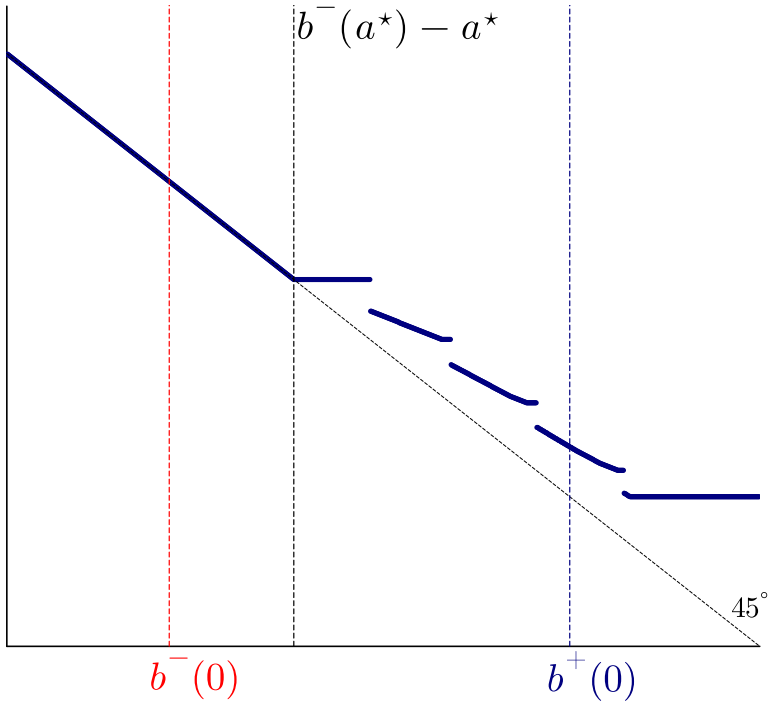
Reserves, a'



Policies

Back

Net Foreign Assets, $a' - b'$



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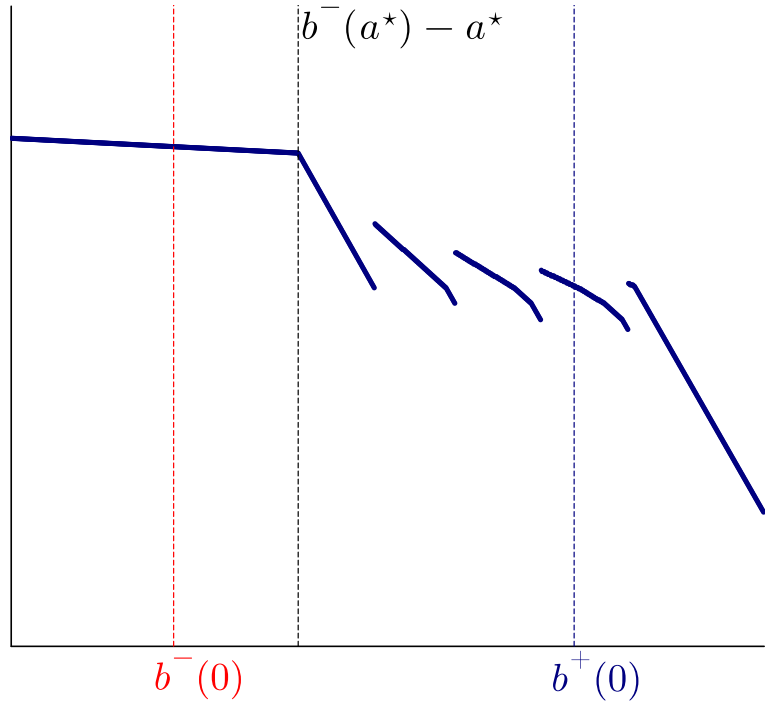
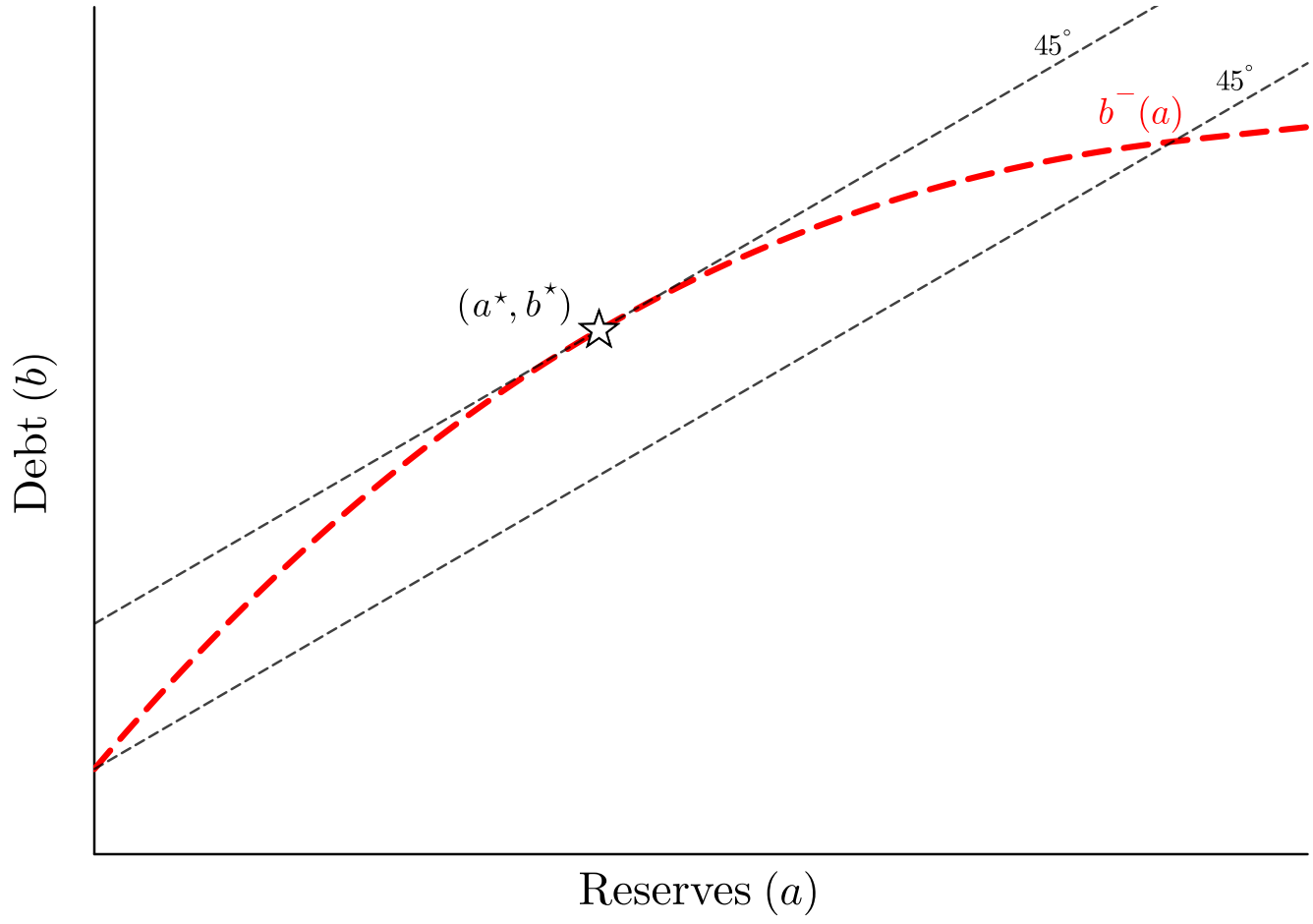


Lowest-NFA safe portfolio, $(a^\star, b^\star)$

back



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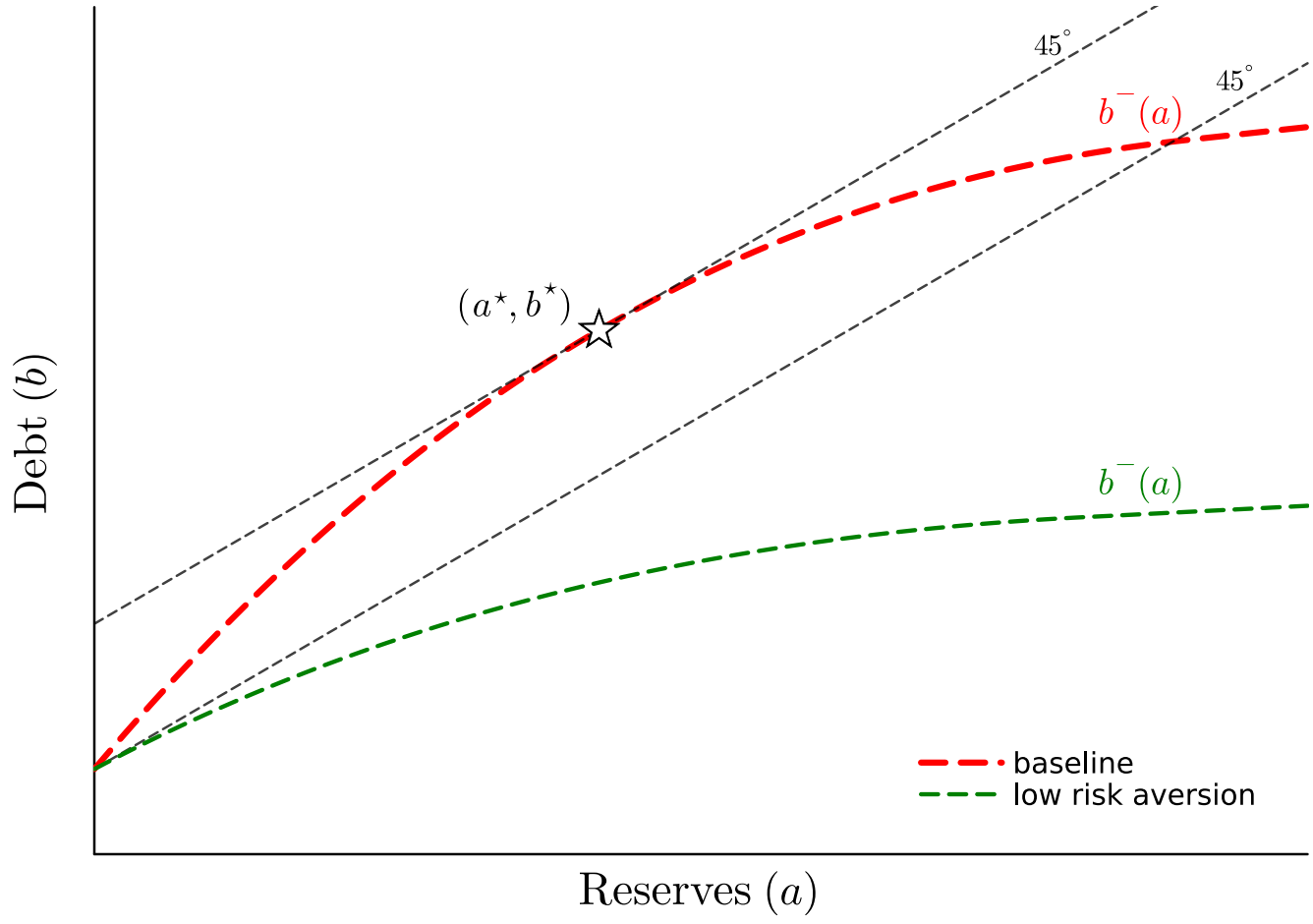

Parametrization

Back

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

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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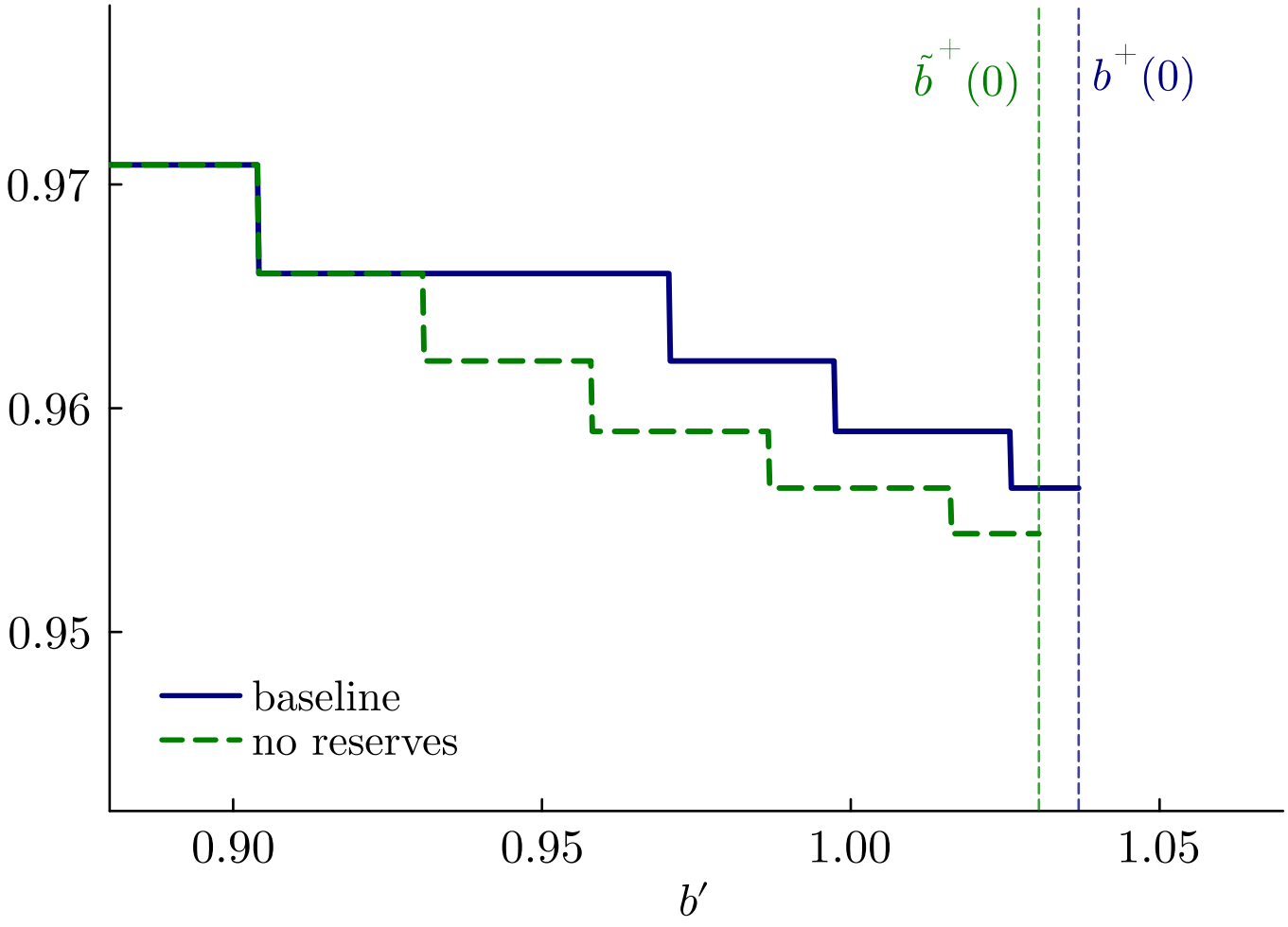
Without reserves: $\downarrow b^{+}$. More costly to deleverage $\Rightarrow$ lower debt-carrying capacity

▸ Default zone expands

▸ back

Price Schedule, $q(0, b')$

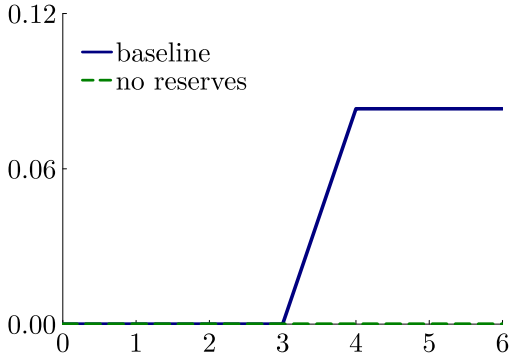
back



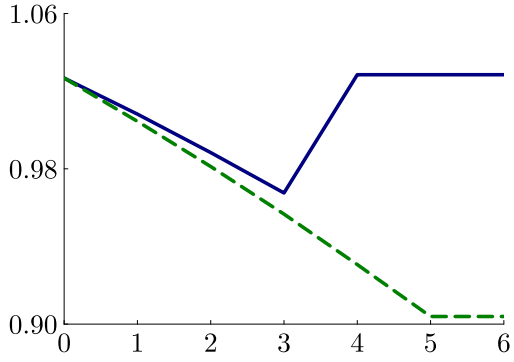
Lower consumption without reserves

back

Reserves, a



Debt, b



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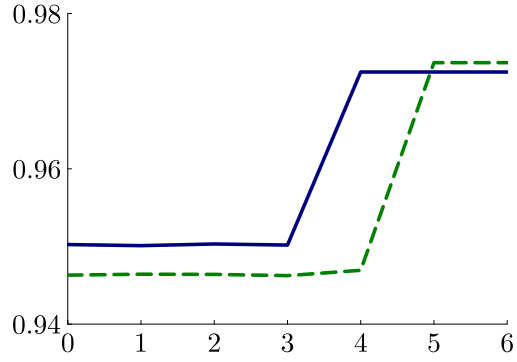

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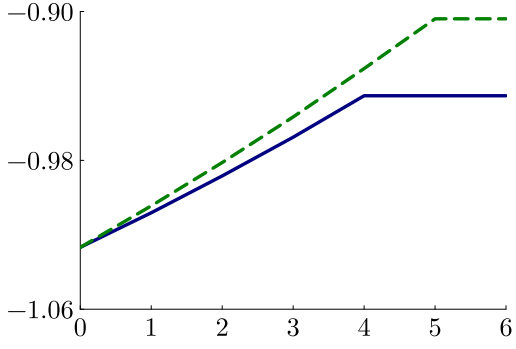

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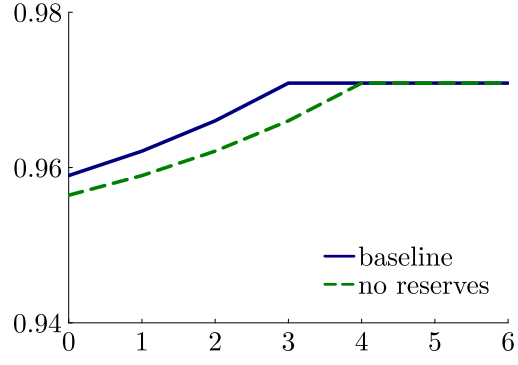
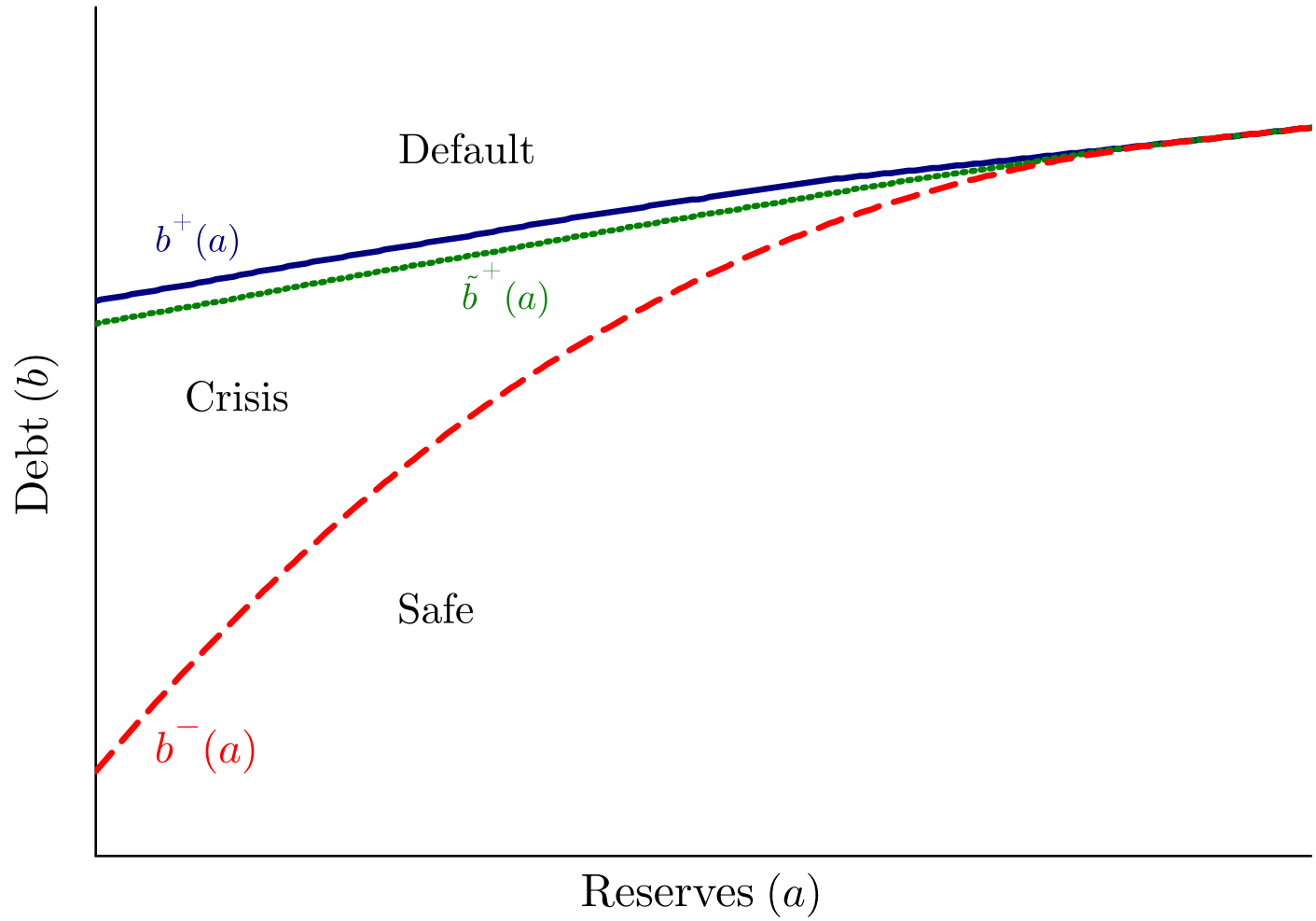


Default zone expands

back



Increasing reserves and debt lowers spreads (levels)

back

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)
$(\text{Sov.Debt})^2$			−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).