Efficient Sovereign Debt Management in Emerging Economies

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Motivation

- Argentina and Brazil experienced an economic crisis at the end of 1990s.
- Maturity shortened in both countries during that period.
- Argentina defaulted in 2001 and got excluded from markets until 2006.
- Brazil did not default and conducted costly buybacks since 2006.

Research Questions

- What can explain these opposite debt management?
- Which of these two debt management is more efficient?
- What are the specific roles of default, buyback and maturity?

This Paper

- Incomplete market economy with:
  - Impatient borrower with limited commitment.
  - Large number of foreign lenders.
- Pareto efficiency in market economy:
  - Assessment of Second Welfare Theorem.
  - Risk-sharing properties of default, buyback and maturity.
- Multiplicity of equilibria in market economy:
  - Assessment of First Welfare Theorem.
  - Role of lenders' beliefs.

Main Results

- Second Welfare Theorem holds:
  - No defaults on equilibrium path, costly buybacks instead.
  - Costly buybacks provide risk sharing and avoid dead weight loss of markets exclusion.
- First Welfare Theorem fails even under Markov equilibrium:
  - Link Markov equilibrium to emerging economies (not today).
  - Multiple equilibria due to lenders' beliefs on buybacks and risky lending.
- Difference between Argentina and Brazil is about coordination of lenders.
  - Brazil gets closer to constrained efficiency than Argentina.

Outline

General Setting

- Small open economy in infinite discrete time populated by:
  - A large number of risk neutral lenders with discounting $\frac{1}{1+r}$.
  - A risk averse borrower with discounting $\beta < \frac{1}{1+r}$ and $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$.
- Production function $F(k, \ell)$ with $F(0,1) > 0$.
  - Foreign lenders supply k and $\delta = 1$.
  - Shock $g \in \{g_H, g_L\}$ with $g_H > g_L > 0$ and $\pi(g'|g)$.
- Two types of bond contract: one-period, b_{st}, and perpetual, $b_{lt} \leq 0$.

Bond Contract

- A default corresponds to a missed coupon payment.
  - Markets exclusion with re-access with probability $\lambda \geq 0$.
- A buyback corresponds to $b'_{lt} \geq b_{lt}$:
  - Official buyback at $q_{lt}^{bb} = q_{lt} + \chi$ with $\chi > 0$.
  - Unofficial buyback at q_{lt}.
- Long-term bonds have to be re-issued anew every period.
  - Lenders need to form beliefs on official buybacks $\rightarrow$ Sunspot υ.

Timing of Actions

1. Shock $s \equiv (g, \upsilon)$ realizes, outstanding debt b_{st} and b_{lt}.
2. Lender supplies k and production takes place.
3. Borrower decides whether to repay and whether to pay χ.
4. Conditional on repayment, b'_{st} and b'_{lt} are issued.

Outline

Borrower's Problem

- Choice and history:
  - Choice set at t: $\mathcal{C}_{b,t} \equiv \{\overbrace{D_t}^{\text{Default}}, \overbrace{M_t}^{\text{Official buyback}}, \overbrace{b_{st,t+1}, b_{lt,t+1}}^{\text{New debt portfolio}}\}$.
  - History up to t: $h_b^t = (h^{t-1}, s_t, \underbrace{\mathbb{I}_{D,t}}_{\text{Default status}}, k_t)$ with $h^{t-1} = (h^{t-2}, s_{t-1}, \mathbb{I}_{D,t-1}, k_{t-1}, \mathcal{C}_{b,t-1})$.
- Maximization problem:

$$W^b(h_b^t) = \max_{\{\mathcal{C}_{b,t}\}_{t=0}^{\infty}} u(c_t) + \beta \mathbb{E}\left[W^b(h_b^{t+1}) \middle| h_b^t, \mathcal{C}_{b,t} \right]$$

$$\text{s.t.} \begin{cases} c_t + \overbrace{q_{st}\ b_{st,t+1}}^{\text{New short-term debt}} + \overbrace{q_{lt}\ (b_{lt,t+1} - b_{lt,t})}^{\text{New long-term debt}} = g_t F(k_t, 1) - k_t + b_{st,t} + b_{lt,t} & \text{if } D_t = 0 \wedge M_t = 0. \\ c_t + q_{st}\ b_{st,t+1} + q_{lt}\ b_{lt,t+1} = g_t F(k_t, 1) - k_t + b_{st,t} + \underbrace{b_{lt,t}(1 + q_{lt}^{bb})}_{\text{Official debt buyback}} \wedge \underbrace{b_{lt,t+1} \geq b_{lt,t}}_{\text{Buyback restriction}} & \text{if } D_t = 0 \wedge M_t = 1. \\ c_t = g_t F(0, 1) & \text{if } D_t = 1. \end{cases}$$

Sustainable Equilibrium

- A sustainable equilibrium: subgame perfection for all histories.
- Multiple equilibrium outcomes:
  - Trigger strategies: reversion to permanent autarky.

⇒ Second Welfare Theorem holds.

⇒ First Welfare Theorem fails even if restrict to Markov equilibria.

Outline

Optimal Contract

Details

- Perspective of a central Planner who:
  - Allocates c and k.
  - Accounts for limited commitment.
- Constrained efficient allocation features:
  - Risk sharing between borrower and lender.
  - Strictly positive capital, $k > 0 \rightarrow$ Inada conditions.

Decentralization

- Official buybacks on equilibrium path:
  - Buyback premium generates state contingency in bonds.
  - Official buybacks in good times.
- No default on equilibrium path:
  - Default triggers markets exclusion and $k = 0$.

Outline

Markov Equilibrium

- Markov equilibria rely on payoff-relevant space $\Omega \equiv (s, \mathbb{I}_D, b_{st}, b_{lt})$.
- Foundation of Markov equilibria:

$\Rightarrow$ Emerging economies are characterized by political instability and hazy fundamentals.

1. Borrower's memory goes back to $\mathcal{T} = \frac{1-\psi}{\psi}$ with $\psi \in [0, 1]$.
2. Privately-observed and i.i.d. utility shock: $\epsilon\varrho_{b,t}$ and $\epsilon\varrho_{l,t}$.

$\Rightarrow$ All sustainable equilibria are Markov for $(\epsilon, \psi) > 0$ arbitrarily close to zero.

Self-Fulfilling Official Buyback

Details

- Borrower cannot commit to pay the buyback premium χ.
- Lenders cannot detect a buyback before debt auction.
- Lenders can threaten not to buy new debt if χ not paid.
- State space Ω can be separated in two zones:
  1. Enforcement zone: if lenders believe official buyback happens, it does. Otherwise, it does not.
  2. Impunity zone: official buyback is not enforceable. Sunspot υ is irrelevant.

Strategic Complementarity

- Markets exclusion is detrimental to both borrower and lenders.
- Lenders would like to avoid default $\rightarrow$ Limit lending.
- Strategic complementarity in lenders' action:
  - Beliefs about behavior of other lenders.
  - Coordination on whether lending is risky.
- Markov equilibrium with or without default.

Multiple Markov Equilibria

Details

- Four different outcomes: whether lending is risky and whether official buybacks occur.
- Rule out possibility of having official buybacks and risky lending.
- Two Markov equilibria:
    1. Markov equilibrium with default (MA) where official buybacks never occur $\rightarrow$ Argentina.
    2. Markov equilibrium without default (MAND) where official buybacks can occur $\rightarrow$ Brazil.
- Is the MAND constrained efficient? This depends on υ and enforcement zone.

Outline

Calibration

Details

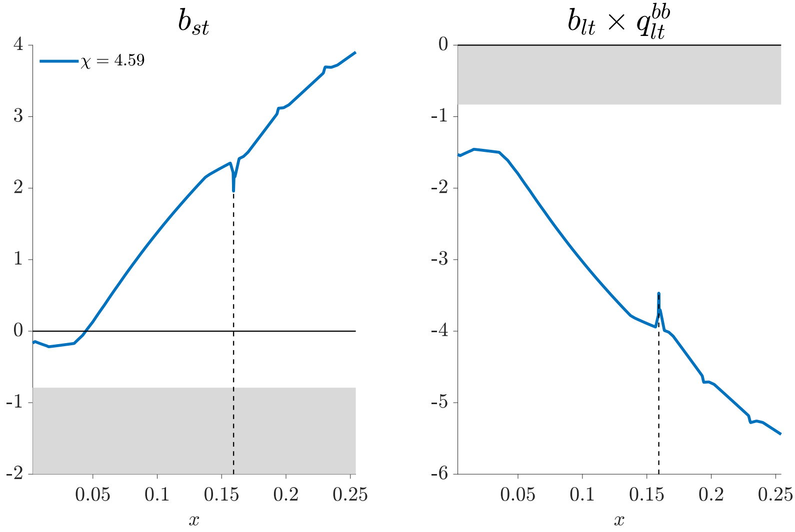
- My view is that Argentina and Brazil are alike in terms of economic fundamentals.
- The difference lies in the lenders' coordination of beliefs.
- Calibration strategy:
  - Calibrate MA to Argentina for the period 1995-2019.
  - Use the same calibration to solve the other equilibria.
  - Only difference is the specification of υ.

Calibration Outcome

A. Targeted Moments					
Variable	Argentina	MA	Brazil	MAND	CEA
i/y	14.26	14.22	17.98	16.22	14.61
$-b/y$	28.71	28.15	10.12	7.18	-353.20
Spread	14.17	12.88	4.97	3.85	3.95
corr(c, y)	0.96	0.94	0.88	0.95	0.68
B. Non-Targeted Moments					
Variable	Argentina	MA	Brazil	MAND	CEA
b/y in default	65.7	216.4	-	-	-
b/y in restructuring	29.9	17.5	-	-	-
b_{st}/b	9.7	44.0	12.6	21.7	112.5
b_{st}/b in default	11.7	84.1	-	-	-
b_{st}/b in restructuring	9.0	64.5	-	-	-

Non-Markov Implementation

Details χ

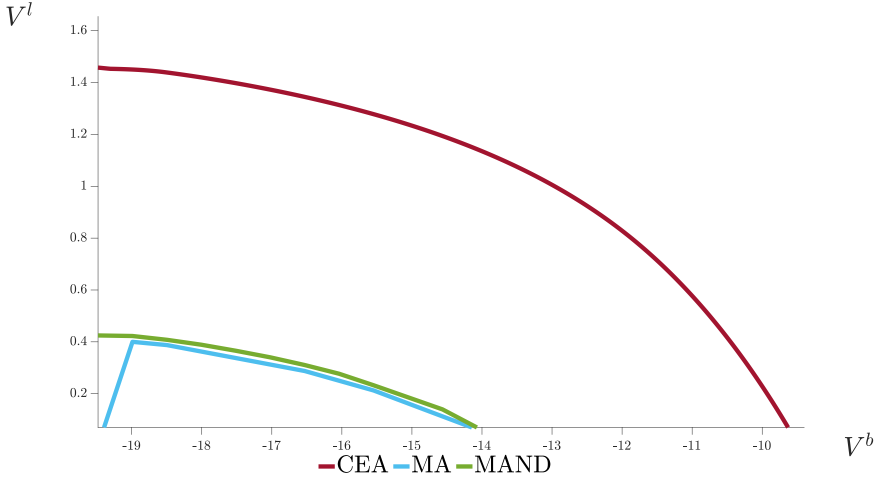


Equilibria Comparison

- Welfare gains in consumption equivalent with respect to MA.
- Distance to Pareto frontier.

State	Borrower welfare gains (percent)		Lenders welfare gains (percent)		$\mathscr{F}(g)$ (percent)		
	MAND	CEA	MAND	CEA	MA	MAND	CEA
g_H	0.01	0.07	0.5	1.7	23.6	26.3	100.0
g_L	0.84	0.85	1.9	3.4	18.7	21.2	100.0
average	0.17	0.22	0.8	2.0	22.6	25.3	100.0

Distance to Pareto Frontier



Conclusion

- Assessment of sovereign debt management in emerging economies:
  - Markov equilibrium is the relevant equilibrium concept for emerging economies.
  - Markov equilibria generally fail constrained efficiency + far from Pareto frontier.
- Defaults are an inefficient source of risk sharing, use buybacks instead $\rightarrow$ lenders' beliefs.
- Relate to the experience of Argentina and Brazil since 1995.

Thanks for your attention!

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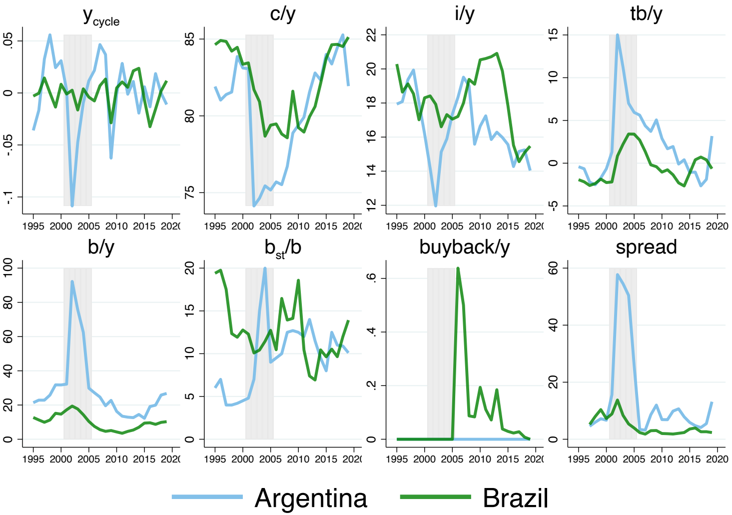
Appendix

Argentina vs. Brazil

Go back



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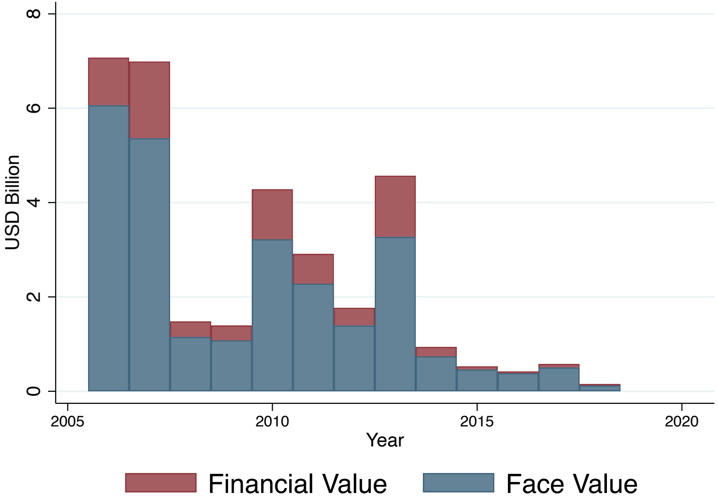
Brazilian buyback program

Go back



Appendix

Literature

Go back

- Sovereign debt defaults:
  - Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), Arellano (2008), **Mendoza and Yue (2012)**, **Arellano and Ramanarayanan (2012)**, Niepelt (2014), **Dovis (2019)** and Müller et al. (2019).
  - ⇒ Foundation of Markov equilibria + inefficiency of defaults + lenders' belief.
- Sovereign debt buybacks:
  - **Bulow and Rogoff (1988, 1991)**, Rotemberg (1991), Acharya and Diwan (1993), Cohen and Verdier (1995), Aguiar et al. (2019) and Aguiar et al. (2022).
  - ⇒ Efficiency of buybacks + self-fulfilling equilibrium.
- Sovereign debt maturity:
  - **Angeletos (2002)**, Buera and Nicolini (2004), Faraglia et al. (2010), Debortoli et al. (2017), Aguiar et al. (2019), Faraglia et al. (2019) and Kiiashko (2022).
  - ⇒ Approximation of constrained efficiency through Markov startegies.

- Lender provides k at price p which is taxed at fixed rate τ.
- The level of capital is such that

$$gf_k(k) = p.$$

- The price of capital is consistent with

$$\max_k \; p(1-\tau)k - k.$$

- With $\tau = 1 - \frac{1}{p}$, p is used to decentralize the distortion of k the Planner chooses.

 Go back

The price of one unit of bond is given by

$$q_{lt}(h^t) = \frac{1}{1+r}\mathbb{E}\Big[(1 - D(h^{t+1}))\Big\{1 + (1 - M(h^{t+1}))q_{lt}(h^{t+1}) + M(h^{t+1})q_{lt}^{bb}\Big\}\Big| h^t\Big],$$

$$q_{st}(h^t) = \frac{1}{1+r}\mathbb{E}\Big[(1 - D(h^{t+1}))\Big| h^t\Big].$$

Go back

$$\max_{\{k(g^t),c(g^t)\}_{t=0}^{\infty}} \mu_{b,0} \overbrace{\sum_{t=0}^{\infty} \beta^t \sum_{g^t} \pi(g^t|g_0) u(c(g^t))}^{\text{Value of borrower}} + \mu_{l,0} \overbrace{\sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t \sum_{g^t} \pi(g^t|g_0) T(g^t)}^{\text{Value of lender}}$$

$$\text{s.t.} \quad \sum_{j=t}^{\infty} \beta^{j-t} \sum_{g^j} \pi(g^j|g_t) u(c(g^j)) \geq \underbrace{V^D(g_t, k(g_t))}_{\text{Autarky value in Markov equilibrium with default}}, \qquad \text{(PC)}$$

$$T(g^t) = g_t f(k(g^t)) - c(g^t) - k(g^t), \ \forall g_t, g^t, t$$

with $\mu_{b,0}$ and $\mu_{l,0}$ given.

Optimal contract in recursive form

Go back

- Following Marcet and Marimon (2019),

$$FV(g,x) = \mathcal{SP} \min_{\{\nu(g)\}} \max_{\{k(g),c(g)\}} x\left[(1+\nu(g))u(c(g)) - \nu(g)V^D(g,k)\right] + T(g) + \frac{1}{1+r}\sum_{g'} \pi(g'|g) FV(g',x')$$

$$\text{s.t.} \quad T(g) = gf(k(g)) - c(g) - k, \qquad x'(g) = (1+\nu(g))\eta x \ \forall g.$$

- Value functions take the following form,

$$FV(g,x) = xV^b(g,x) + V^l(g,x) \quad \text{with}$$

$$V^b(g,x) = u\left(c(g)\right) + \beta \mathbb{E}_{g'|g}\left[V^b\left(g',x'\right)\right] \quad \text{and} \quad V^l(g,x) = T(g) + \frac{1}{1+r}\mathbb{E}_{g'|g}\left[V^l\left(g',x'\right)\right].$$

Appendix

Contract properties

Figure Go back

The allocation is such that:

1. (Production). There exists a level of relative Pareto weight $x^*(g)$ such that $k(g,x) = k^*(g)$ for $x \geq x^*(g)$ and $x^*(g_H) > x^*(g_L)$. Conversely, for all $x, \tilde{x} \in X$ with $x^*(g) > x > \tilde{x}$, $0 < k(g,\tilde{x}) < k(g,x) < k^*(g)$.

2. (Risk-Sharing). $c(g_L,x) \leq c(g_L,x)$ and $x'(g_L,x) \leq x'(g_H,x)$ for all x with equality when $x \geq x^*(g_H)$.

3. (Liabilities). $V^l(g_L,x) < V^l(g_H,x)$ for all x.

Appendix

Constrained efficiency

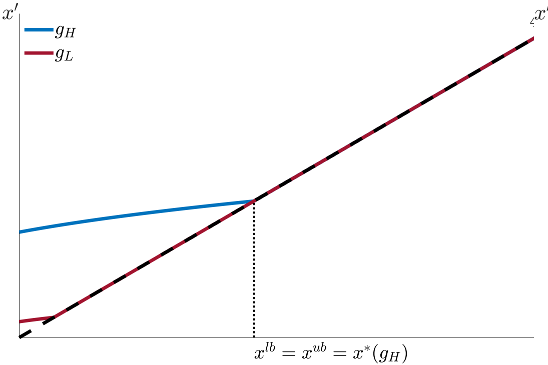
Go back

- The utility possibility frontier is strictly increasing.
  - $V^b(g, x)$ is strictly increasing in x.
  - $V^l(g, x)$ is strictly decreasing in x.
- The autarkic allocation is not optimal.
  - Inada conditions on production function.
  - Region of *ex post* inefficiencies around $k = 0$.

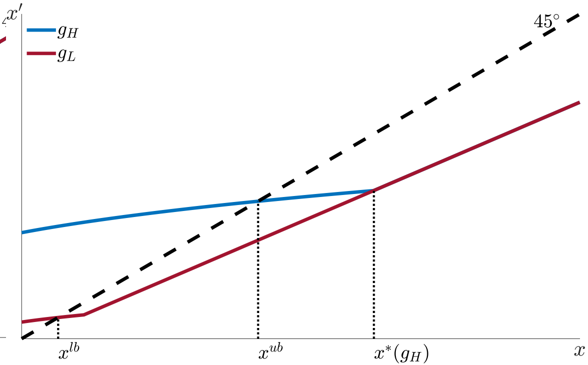
Appendix

Steady state

Go back



(a) $\beta(1 + r) = 1$



(b) $\beta(1 + r) < 1$

Appendix

Implementation

Go back

- No default $\Rightarrow$ neither x^{lb} nor x^{up} can be interpreted as default.
- Costly buybacks $\Rightarrow$ $r^{bb} < r$ necessary to generate some (negative) spread.
- Holdings at buybacks:

$$b_{st}(x) = \frac{V^I(g_H, x)[1 + q_{lt}] - V^I(g_L, x)[1 + q_{lt}^{bb}]}{q_{lt}^{bb} - q_{lt}} \lesseqqgtr 0$$

$$b_{lt}(x) = -\frac{V^I(g_H, x) - V^I(g_L, x)}{q_{lt}^{bb} - q_{lt}} < 0.$$

- Recall: buyback enforceable with Markov strategies if $b'_{st} < 0$ and low χ.

- A sustainable equilibrium is Markov if for any $(h_b^t, \overbrace{h_l^t}^{(h^{t-1}, s_t, \mathbb{I}_{D,t})}) \neq (\tilde{h}_b^t, \tilde{h}_l^t)$ ending with the same $\Omega_t \equiv (g_t, \mathbb{I}_{D,t}, b_{st,t}, b_{lt,t})$, strategies are the same such that

$$W^b(h_b^t) = W^b(\tilde{h}_b^t) \;\wedge\; \underbrace{W^l}_{\text{Value of lender}}(h_l^t) = W^l(\tilde{h}_l^t).$$

- Bounded memory rules out sequential conditioning on past history.

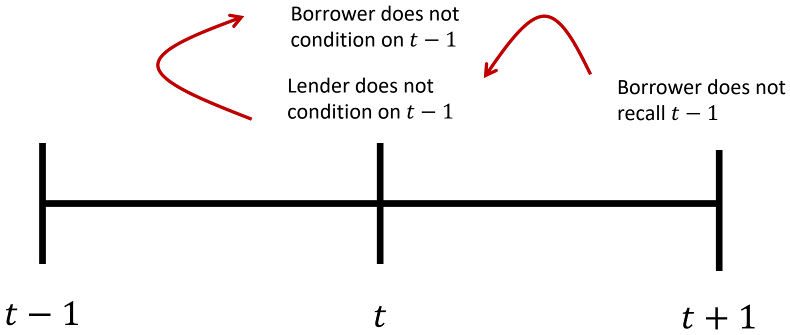
- Utility shocks rule out weak-Markov equilibrium.

Appendix

Markov equilibrium

Go back

- Suppose borrower's memory goes back $\mathcal{T} = 1$ period.
- Sequential moves: first borrower then lender.



Appendix

Markov equilibrium with default

Bond prices Go back

- Value of debt contract:

$$W^b(s,0,b_{st},b_{lt}) = \max_{D\in\{0,1\}} \Big\{(1-D)\overbrace{V^P(s,0,b_{st},b_{lt})}^{\text{Value under repayment}} + D\underbrace{V^D(s,0,k)}_{\text{Value under default}}\Big\}.$$

- Value under default:

$$V^D(s,0,k) = u(gF(k,1)) + \beta\mathbb{E}_{s'|s}\Big[(1-\lambda)V^D(s',1,0) + \underbrace{\lambda}_{\text{Probability of market re-access}} W^b(s',0,w_{st},w_{lt})\Big].$$

- Value under repayment:

$$V^P(s,0,b_{st},b_{lt}) = \max_{b'_{st},b'_{lt},M} u(c) + \beta\mathbb{E}_{s'|s}W^b(s',0,b'_{st},b'_{lt})$$

$$\text{s.t.}\begin{cases} c + q_{st}b'_{st} + q_{lt}(b'_{lt} - b_{lt}) = gF(k,1) - k + b_{st} + b_{lt} & \text{if } M = 0. \\ c + q_{st}b'_{st} + q_{lt}b'_{lt} = gF(k,1) - k_t + b_{st} + b_{lt}(1+q^{bb}_{lt}) \ \wedge \ b'_{lt} \geq b_{lt} & \text{if } M = 1. \end{cases}$$

Appendix

Bond prices

Go back

The price of one unit of bond of maturity $j \in \{st, lt\}$

$$q_{lt}(s, b'_{st}, b'_{lt}) = \frac{1}{1+r}\mathbb{E}_{s'|s}\Big[(1 - D(\Omega'_P))\Big\{1 + (1 - M(\Omega'_P))q_{lt}(s', b''_{st}, b''_{lt}) + M(\Omega'_P)q^{bb}_{lt}\Big\}\Big],$$

$$q_{st}(s, b'_{st}, b'_{lt}) = \frac{1}{1+r}\mathbb{E}_{s'|s}\Big[(1 - D(\Omega'_P))\Big],$$

Appendix

Buyback enforcement

Go back

- Lender's threat is sudden stop on debt: $b'_{st} \geq 0$ and $b'_{lt} \geq b_{lt}$.

- When is the threat credible?

  - If $b'_{st} \geq 0$, an *official* buyback is not enforceable for any (b_{st}, b_{lt}).

  - If $b'_{st} < 0$, an *official* buyback is enforceable when either $-b_{st}$ is sufficiently large or $-b_{lt}$ and χ are not too large.

Go back

- Two types of multiplicity:

  1. Static $\rightarrow$ current period behavior as in Cole and Kehoe (2000).
  2. Dynamic $\rightarrow$ future behavior as in Aguiar and Amador (2020).

- Sunspot is composed of two parts: $\upsilon_t = \underbrace{\varpi_0}_{\text{Dynamic coordination}}(1 + \overbrace{\omega_t}^{\text{Static coordination}})$.

Appendix

Optimal contract main policy functions

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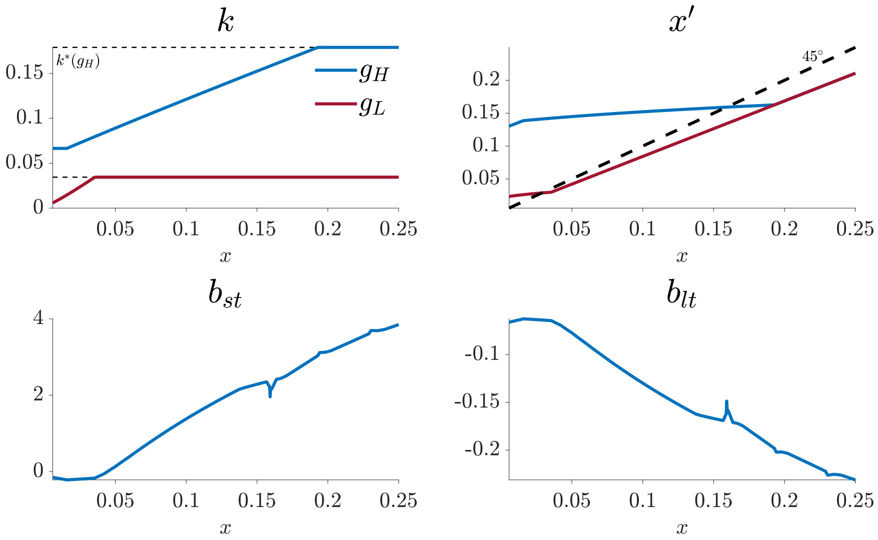

Appendix

Parameters

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Parameter	Value	Description	Targeted Moment
A. Based on Literature			
ϑ	2.00	Relative risk aversion	
r^f	0.01	Risk-free rate	
B. Direct Measure from the Data			
$\pi(g_H\|g_H)$	0.93	Probability staying high state	
$\pi(g_L\|g_L)$	0.68	Probability staying low state	Real total factor productivity
g_L	0.44	Productivity in low state	
$1-\alpha$	0.70	Labor share	Labor income share
χ	4.59	*Official* buyback premium	Financial over face value of debt
r^e	0.04	Excess return	US excess return on debt
C. Based on Model solution			
β	0.80	Discount factor	Debt-to-GDP ratio
g_H	1.12	Productivity in high state	Correlation consumption and output
ϕ	1.50	CES production	Investment-to-GDP ratio
λ	0.281	Probability re-accessing market	Average spread

CRRA utility $u(c) = \frac{c^{1-\vartheta}}{1-\vartheta}$, excess return $r = r^e + r^f$, and $\upsilon = \mathbb{I}_{g=g_H}$ and CES $F(k,\ell) = \left[\alpha k^{\frac{\phi-1}{\phi}} + (1-\alpha)\ell^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}$.

Welfare decomposition

Go back

State	MAND		CEA	
	State contingency (percent)	Cost of default (percent)	State contingency (percent)	Cost of default (percent)
g_H	1.90	98.10	15.67	84.33
g_L	99.13	0.87	98.70	1.30
average	20.38	79.62	31.45	68.55

Appendix

Cost of Buybacks

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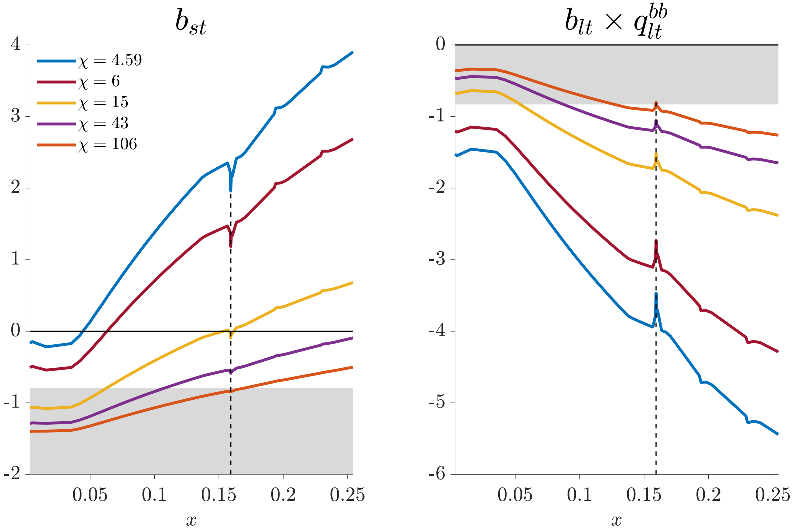

Appendix

Impulse responses

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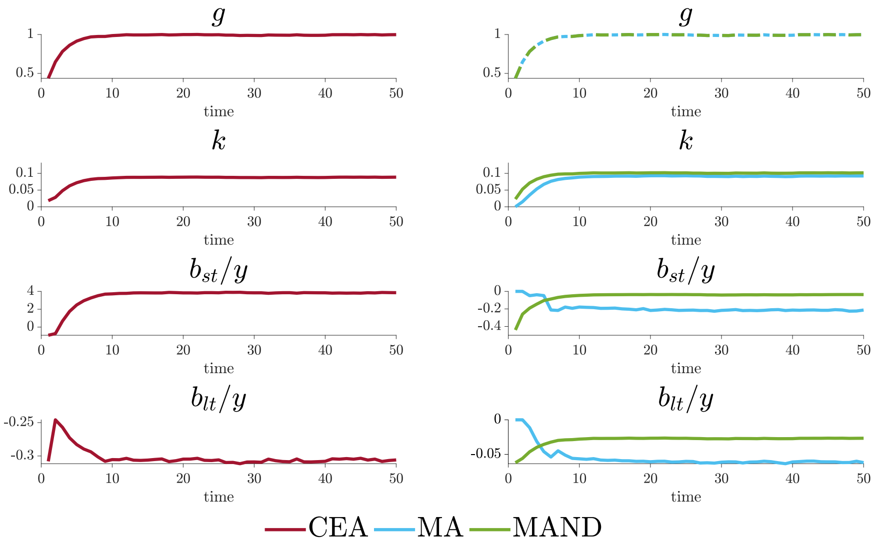

Appendix

Simulation

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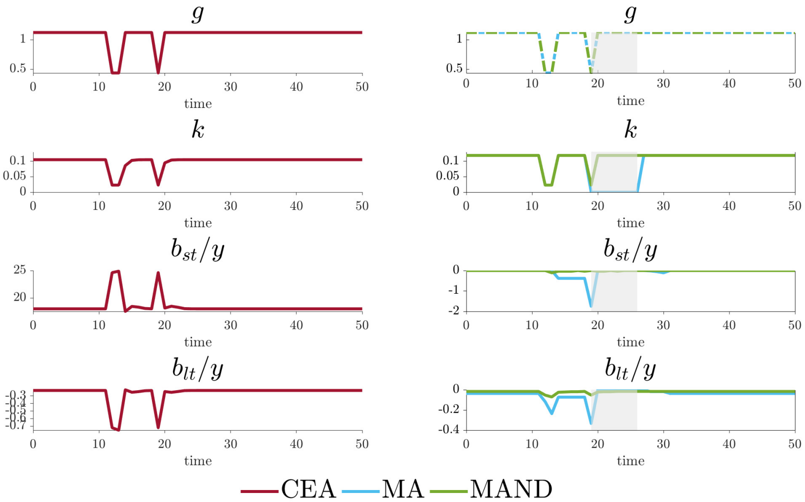

Appendix

Distance Pareto Frontier

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- With the implementation, I get a correspondence between x and (b_{st}, b_{lt}).
- Define $\ddot{V}^l : G \times X \to \mathbb{R}$ as the lender's value in a Markov equilibria expressed in X.
- The distance to the Pareto frontier is then

$$\mathscr{F}(g) = \frac{\int_{\underline{x}}^{\overline{x}} \ddot{V}^l(g, x) dx}{\int_{\underline{x}}^{\overline{x}} V^l(g, x) dx}.$$