On the Optimal Speed of Sovereign Deleveraging with Precautionary Savings

Thomas Philippon[1] Francisco Roldán[2]

UdeSA Alumni Conference

December 2017

[1]NYU Stern, CEPR, NBER

[2]New York University

How fast should governments repay their debts?

Basic tradeoff

1. Aggregate demand
    - Tax increases induce recessions in a ***non-Ricardian*** world.
2. Sovereign risk
    - Literature thinks of
        1. Exclusion and large ex-post **output** costs
            - Eaton-Gersovitz 1982, Arellano 2008, Mendoza-Yue 2012...
        2. Financial **disruption**
            - Gennaioli et al. 2014, Bocola 2016, Pérez 2016...
    - We emphasize precautionary behavior of those *ultimately* exposed.

Sovereign Risk

- We model domestic savers as exposed to sovereign risk
  - Savers hold (most of) sovereign debt
    - Pension funds
    - Insurance companies
  - Their pricing kernel matters for bank **recapitalizations**.
- Precautionary behavior matters for aggregate demand through
  1. lower consumption by savers
  2. lower price of government debt $\implies$ higher taxes.
- Ricardian equivalence
  - Timing of debt repayment irrelevant
  - No effect from ***default*** risk
    - Haircuts just decrease the NPV of taxes.

Two Models

1. Two-period model with CARA preferences
    - Toy model for closed forms
    - $t = 1$ ('short-run'): **Fixed** prices and wages, deleveraging shock
    - $t = 2$ ('long-run'): **Flexible** prices and wages.
2. Dynamic model with Epstein-Zin preferences
    - Quantatively explore optimal speed of deleveraging
    - **Calibration** to the Eurozone.

- In both
    - Closed economy limit
    - Limits to **interest rate** movements (ZLB, ECB).

- Collects lump-sum taxes T_t, government purchases G
- Long-term debt B_t^g: decays at rate ρ, pays coupon κ
- Budget constraint

$$T_t + q_t \left(B_t^g - (1-\rho) B_{t-1}^g\right) = \kappa B_{t-1}^g + G$$

- Normalize $\kappa = r + \rho$ so $q^\star = 1$.
- Exogenous default risk (if default, **haircut** $\hbar$)

$$\pi\left(\frac{B_t^g}{\bar{Y}_t}; \epsilon_{\mathbf{t}}\right)$$

- Two types
  - $1-\chi$ *savers* with $\beta_s > \beta_b$ and an Euler equation
  - χ *borrowers* with

$$C_t^b = \frac{W_t^b}{P_t} N_t^b + B_t^h - B_{t-1}^h - T_t$$

and $B_t^h \leq \bar{B}_t^h$ ($=$ in eq'm)

- Closed economy limit

$$(1-\chi)\mathsf{S_t} = q_t B_t^g + \chi \frac{B_t^h}{R_t^h}$$

Production

- Linear in labor only

$$Y_t = \mathbf{N}_t \left(1 - \delta_{\mathbf{t}} \Delta\right)$$

  - $\mathbf{N}_t = N_{b,t}^{\chi} N_{s,t}^{1-\chi} \implies$ wage bill equal across types
  - $\delta_t = 1$ if default happened before or at t
  - Δ is output loss in case of default.
- Normalize steady-state to $\mathbf{N} = 1 + G, \mathbf{C} = 1, \mathbf{W} = 1$.

- Savers (and borrowers) maximize

$$e^{-\gamma C_1^i} - \kappa_n (N_1^i)^\varphi + \beta_i \mathbb{E}_1 \left[e^{-\gamma C_2^i} - \kappa_n (N_2^i)^\varphi \right]$$

- CARA/Cobb-Douglas: **Gross** debt positions irrelevant for aggregate labor supply
- Long-run with flexible prices

$$\mathbf{N}_2 = \bar{\mathbf{N}} = 1 + G$$

which means

$$C_2^s = 1 + \frac{\chi}{1-\chi} \left[B_1^h + (1 - \delta\hbar)\, B_1^g \right]$$

Without Sovereign Risk

- 3 **equations**

$$C_2^s = 1 + \frac{\chi}{1-\chi}\left(\bar{B}_1^h + B_1^g\right) \qquad \text{(BC } t = 2\text{)}$$

$$u'(C_1^s) = \beta R_1 u'(C_2^s) \qquad \text{(Euler)}$$

$$C_1^s = \mathbf{N}_1 - G - \frac{\chi}{1-\chi}\left(\frac{\bar{B}_1^h + B_1^g}{R_1} - \left(B_0^g + B_0^h\right)\right) \qquad \text{(BC } t = 1\text{)}$$

- 3 main **effects**

Without Sovereign Risk

- 3 **equations**

$$C_2^s = 1 + \frac{\chi}{1-\chi}\left(\bar{B}_1^h + B_1^g\right) \qquad \text{(BC } t = 2\text{)}$$

$$u'(C_1^s) = \beta R_1 u'(C_2^s) \qquad \text{(Euler)}$$

$$C_1^s = \mathbf{N}_1 - G - \frac{\chi}{1-\chi}\left(\frac{\bar{B}_1^h + B_1^g}{R_1} - \left(B_0^g + B_0^h\right)\right) \qquad \text{(BC } t = 1\text{)}$$

- 3 main **effects**
    - Non-Ricardian

Without Sovereign Risk

- 3 **equations**

$$C_2^s = 1 + \frac{\chi}{1-\chi}\left(\bar{B}_1^h + B_1^g\right) \qquad \text{(BC } t = 2\text{)}$$

$$u'(C_1^s) = \beta R_1 u'(C_2^s) \qquad \text{(Euler)}$$

$$C_1^s = \mathbf{N}_1 - G - \frac{\chi}{1-\chi}\left(\frac{\bar{B}_1^h + B_1^g}{R_1} - \left(B_0^g + B_0^h\right)\right) \qquad \text{(BC } t = 1\text{)}$$

- 3 main **effects**
  - Private and public debts perfect substitutes for AD management

- 3 **equations**

$$C_2^s = 1 + \frac{\chi}{1-\chi}\left(\bar{B}_1^h + B_1^g\right) \qquad \text{(BC } t=2\text{)}$$

$$u'(C_1^s) = \beta R_1 u'(C_2^s) \qquad \text{(Euler)}$$

$$C_1^s = \mathbf{N}_1 - G - \frac{\chi}{1-\chi}\left(\frac{\bar{B}_1^h + B_1^g}{R_1} - \left(B_0^g + B_0^h\right)\right) \qquad \text{(BC } t=1\text{)}$$

- 3 main **effects**
  - Multiplier of government debt = $\left(1 + \frac{1}{R_1}\right)\frac{\chi}{1-\chi}$ when $\beta R_1 = 1$.

C_1^s equals:

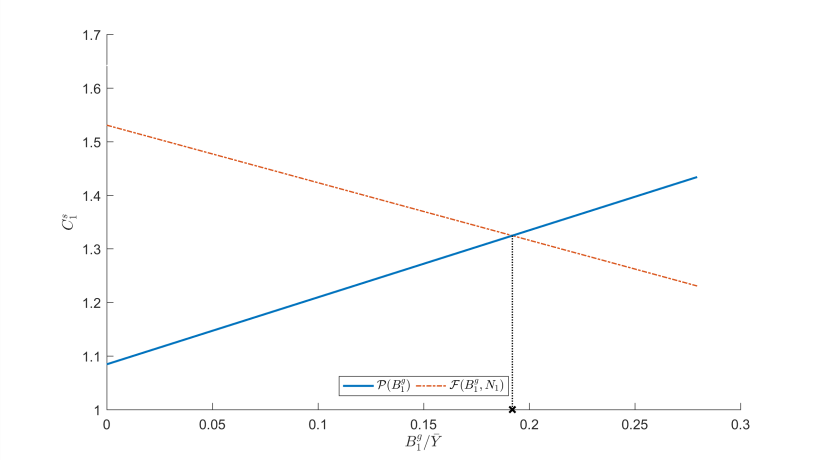
- A **present-value** curve (Euler + BC at time 2)

$$\mathcal{P}(B_1^g) = 1 + \frac{\chi}{1-\chi}\left(\bar{B}_1^h + B_1^g\right)$$

- A **funding** curve (BC at time 1)

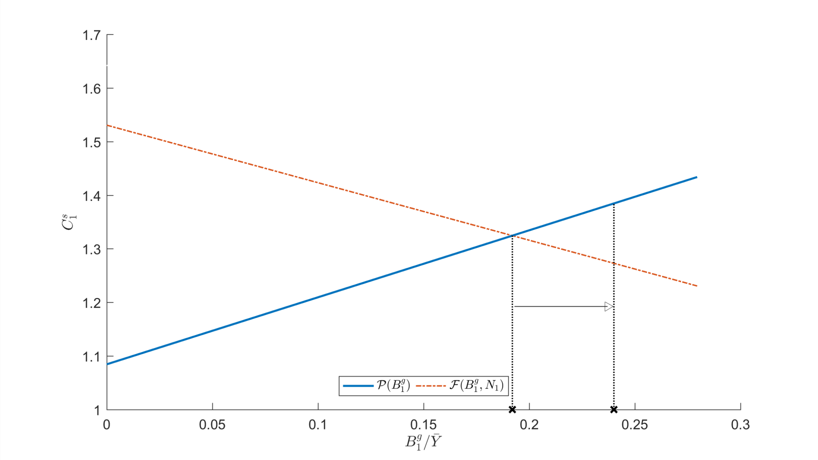
$$\mathcal{F}(B_1^g; \mathrm{N}_1) = \mathrm{N}_1 - G - \frac{\chi}{1-\chi}\left(\frac{\bar{B}_1^h + B_1^g}{R_1} - \left(B_0^g + B_0^h\right)\right)$$

- Equilibrium output $Y_1 = \mathrm{N}_1$ determined at intersection.



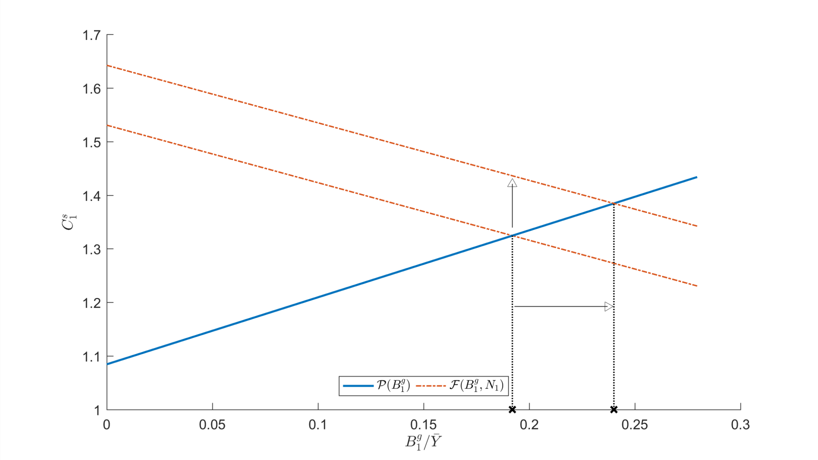
Arrows measure change in N_1 after a given change in B_1^g.

Equilibrium without Sovereign Risk



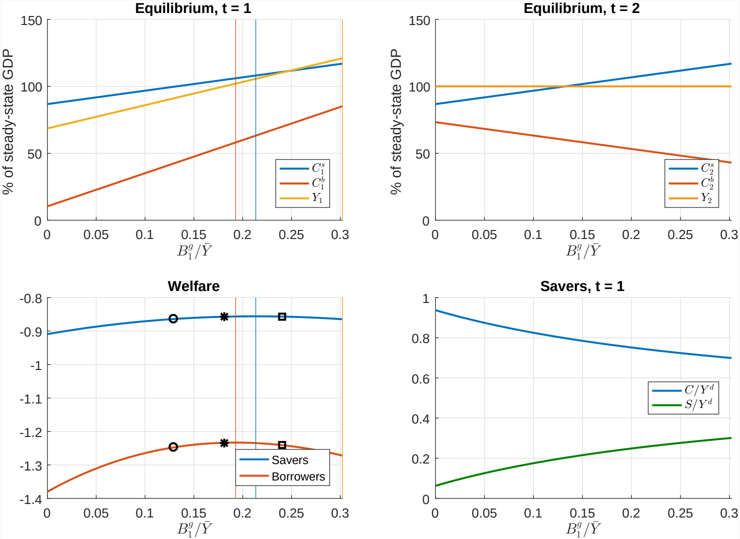
Arrows measure change in N_1 after a given change in B_1^g.

Equilibrium without Sovereign Risk



Arrows measure change in N_1 after a given change in B_1^g.

Fiscal Policy without Sovereign Risk



Circles = neutral. Stars = full employment. Squares = constant debt.

2 equations

1. Present-value curve

$$\mathcal{P}(B_1^g;\pi) = 1 + \frac{\chi}{1-\chi}\left(\bar{B}_1^h + B_1^g\right) - \frac{1}{\gamma}\log\left(1 - \pi + \pi e^{\gamma \frac{\chi}{1-\chi}\hbar B_1^g}\right)$$

2. Funding curve

$$\mathcal{F}(B_1^g, \mathbf{N}_1; q_1) = \mathbf{N}_1 - G - \frac{\chi}{1-\chi}\left(\frac{q_1 B_1^g + \bar{B}_1^h}{R_1} - (B_0^g + B_0^h)\right)$$

+

3. Default probability

$$\pi = \pi(B_1^g)$$

4. Price of debt

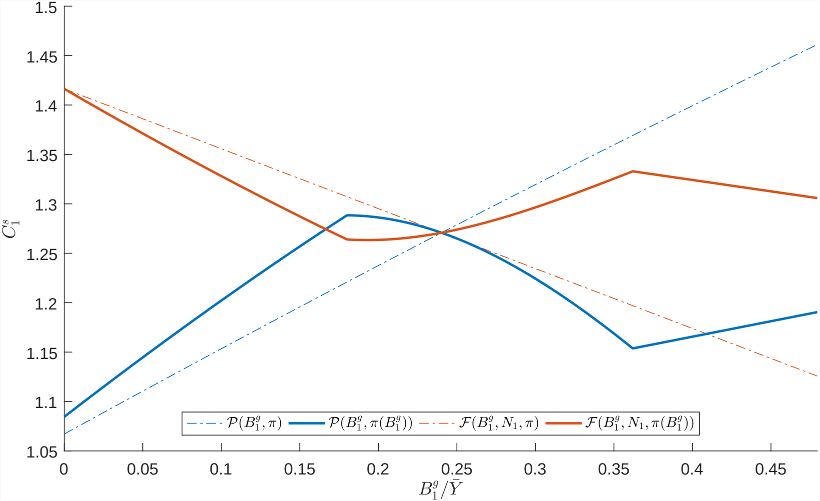
$$\mathbf{q}_1 = \beta\left(1 - \hbar\pi(B_1^g)e^{\gamma(C_1^S - C_2(1))}\right)$$

- First pass: Martin and Philippon (2014) estimate

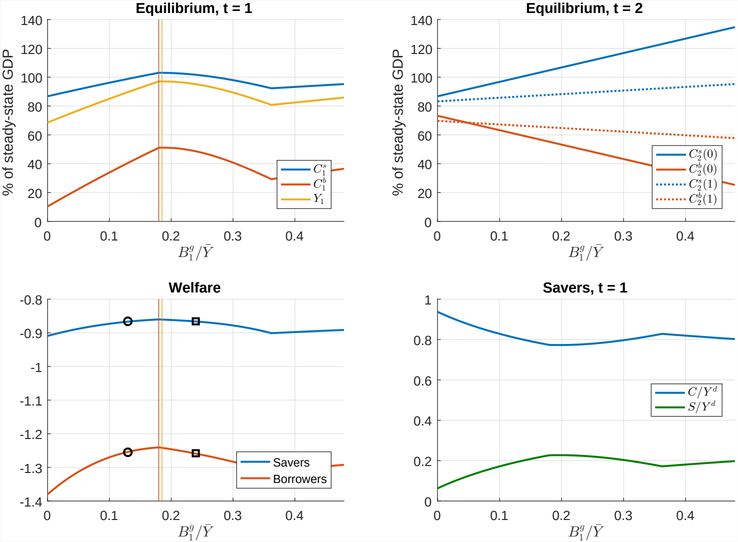
$$Spread_t^{crisis} = 1\% \cdot \mathbb{1}_{\{B^g_{t-2} \leq 0.9\}} + 10\% \cdot \mathbb{1}_{\{B^g_{t-2} > 0.9\}} \left(B^g_{t-2} - 0.9\right)$$

- Back-of-the-envelope calculation to back out π
  - Also consider a post-2012 $\pi^{\text{normal}} = \frac{1}{3}\pi^{\text{crisis}}$.

Equilibrium with Sovereign Risk



Fiscal Policy with Sovereign Risk: Complete Agreement!



Circles = neutral. Stars = full employment. Squares = constant debt.

Dynamic Risk-Sensitive Model

- Truncated infinite horizon
  - After some (large) $\mathcal{T}$, flexible prices and no risk
  - Before $\mathcal{T}$, rigid prices and wages
  - Government **default** can happen *once* at any $t < \mathcal{T}$
- Epstein-Zin preferences with EIS $\psi \neq$ CRA γ

$$V_{i,t}^{\frac{\psi-1}{\psi}} = (1-\beta)u_{i,t}^{\frac{\psi-1}{\psi}} + \beta\left(\mathbb{E}_t\left[V_{i,t+1}^{1-\gamma}\right]\right)^{\frac{\psi-1}{\psi(1-\gamma)}}$$

$$u_t = C_t^{\alpha}\left(\kappa_n - N_t\right)^{1-\alpha}$$

- Stochastic discount factor of savers

$$M_{t+1} = \beta\left(\frac{C_{t+1}^s}{C_t^s}\right)^{-1}\left(\frac{u_{t+1}^s}{u_t^s}\right)^{\frac{\psi-1}{\psi}}\left(\frac{V_{s,t+1}}{\mathbb{E}_t\left[V_{s,t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\psi}-\gamma}$$

Scenarios

- Calibration to a (hypothetical) Greek-style default in Italy Details
- Private debt: From 80% to 70% of potential GDP over 5 years
- Unexpectedly, $\epsilon_t = 1$ for $t \geq 5$
- Consider different scenarios for public debt
  1. A benchmark no-risk simulation
  2. A range of deleveraging simulations
     - All of them end at 90% of potential GDP
- Solution: backward induction from $\mathcal{T}$ Details

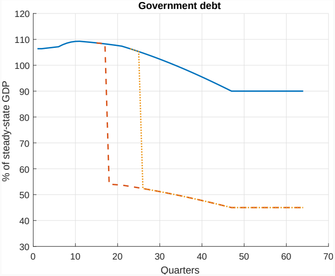
- The government chooses a time T^d to start deleveraging
  - Changing the tax *rate* is costly

$$\frac{T_t}{Y_t} = \begin{cases} \tau_o & \text{if } 0 < t < T^d \\ \tau_d & \text{if } T^d \leq t < 45 \\ \tau_p & \text{if } 45 \leq t \end{cases}$$

  - All paths reach $B_t^g = 90\%$ of potential GDP at $t = 45$

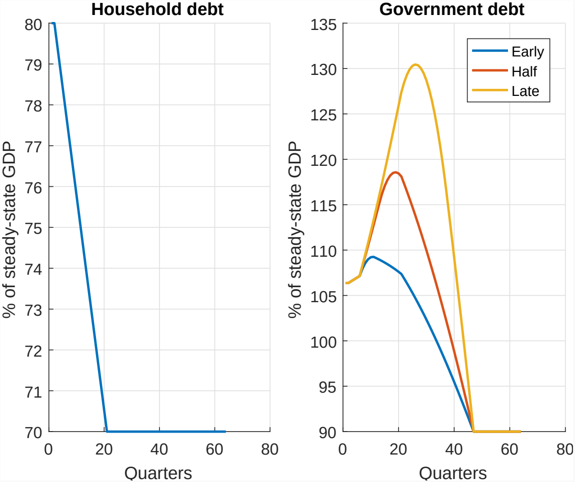
- After default, haircut $\hbar$ but deleveraging continues as planned.

$$B_t^{g,\delta=1} = (1-\hbar)B_t^{g,\delta=0}$$

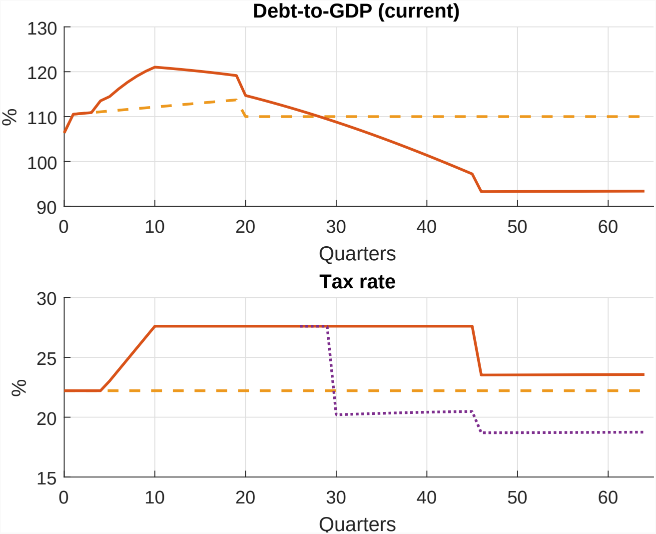


Paths of Deleveraging

- Public: Expected to reach 110%, delever until 90% in 10 years

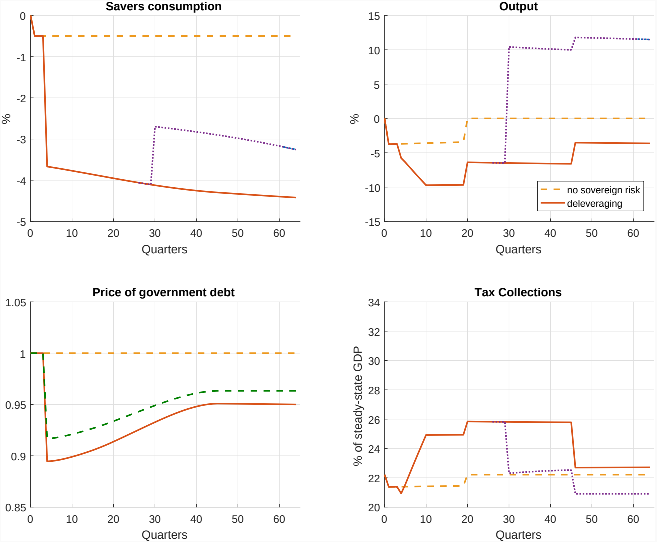


Early Deleveraging

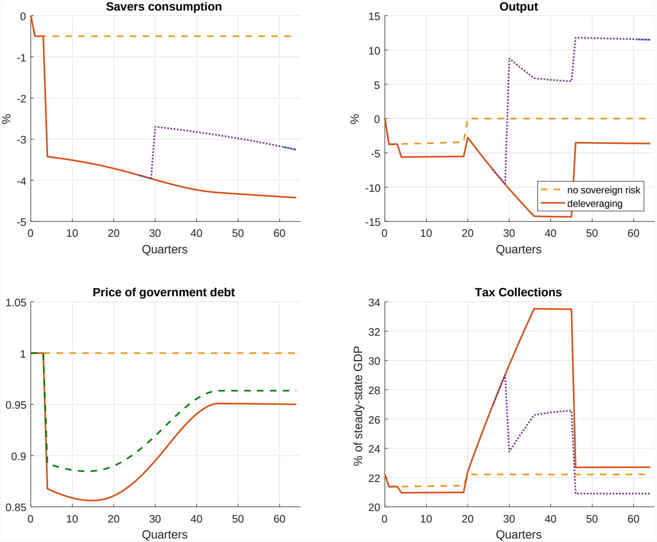


Yellow: no risk; Red: deleveraging

Early Deleveraging

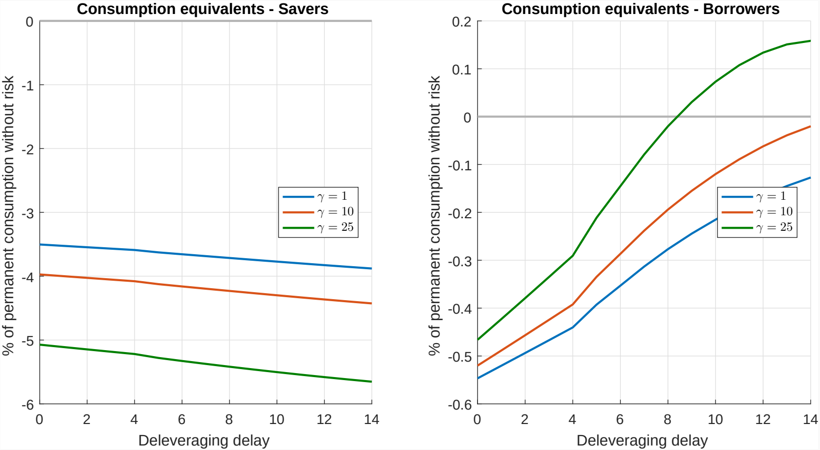


Late Deleveraging

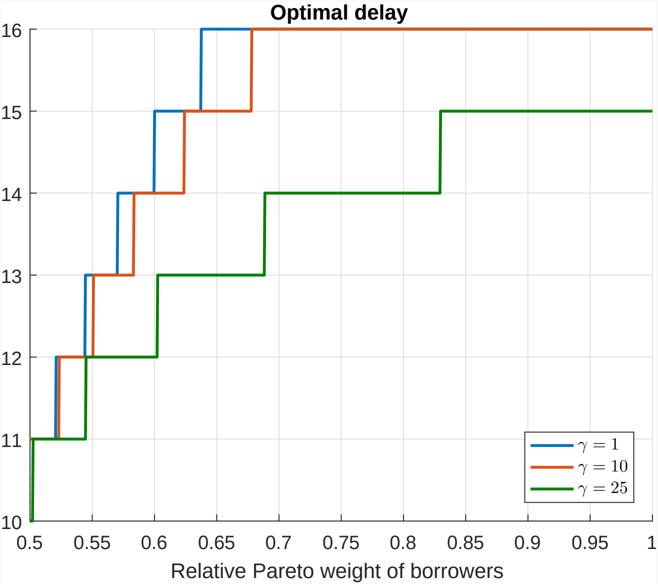


Tax rates

Borrowers and savers disagree

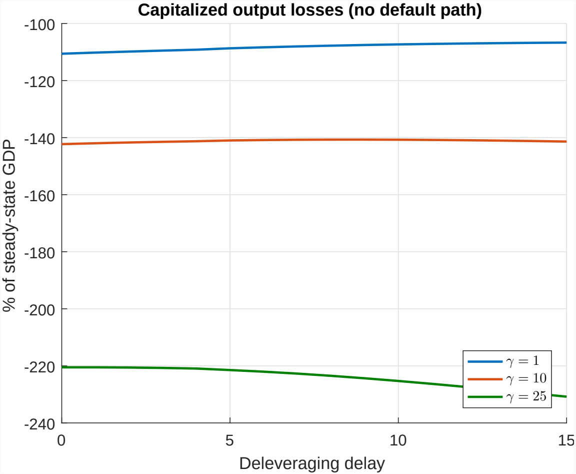


Optimal Delay



Output Losses and Delay

Risk aversion makes output losses **worse** and steeper

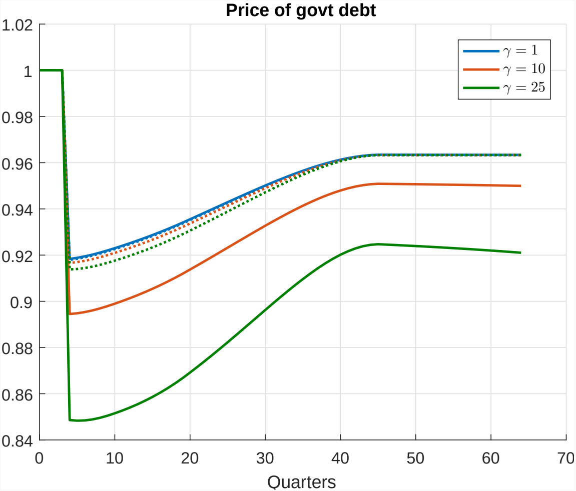


Capitalized output loss on the no-default path with the borrower's discount factor

Normal Times

Price of Debt

- Risk aversion has a big impact on **macro** quantities
- Only a **modest** impact on asset prices.



Concluding Remarks

- Quantitative model of default risk with non-Ricardian features
  - Framework to think about tradeoffs in sovereign deleveraging
  - Optimal delay: about 2 years in baseline crisis calibration
- Risk aversion has big impact on macro aggregates (and asset prices)
  - Agg demand externalities + sticky prices
  - Tallarini
- Disagreement about delay
  - Two periods gives artificial commitment power

Details on Backward Induction

1. After default
   - **One** path. No more risk so $q^\star = 1$ and constant $C_t^{s,\delta=1}$
   - Taxes from government BC

$$T_t^{\delta=1} + q^\star(1-\hbar)\left(B_t^g - (1-\rho)B_{t-1}^g\right) = G + (1-\hbar)\kappa B_{t-1}^g$$

   - Output from savers BC, $C_t^{b,\delta=1}$ from borrowers BC.

2. Before default
   - 2 equations involving **sdf**: risk-free debt and government debt

$$\beta = (1-\pi_t)M_{t+1}^{\delta=0} + \pi_t M_{t+1}^{\delta=1}$$

$$q_t^{\delta=0} = (1-\pi_t)M_{t+1}^{\delta=0}\left(\kappa + (1-\rho)q_{t+1}^{\delta=0}\right) + \pi_t M_{t+1}^{\delta=1}(1-\hbar)\left(\kappa + (1-\rho)q^\star\right)$$

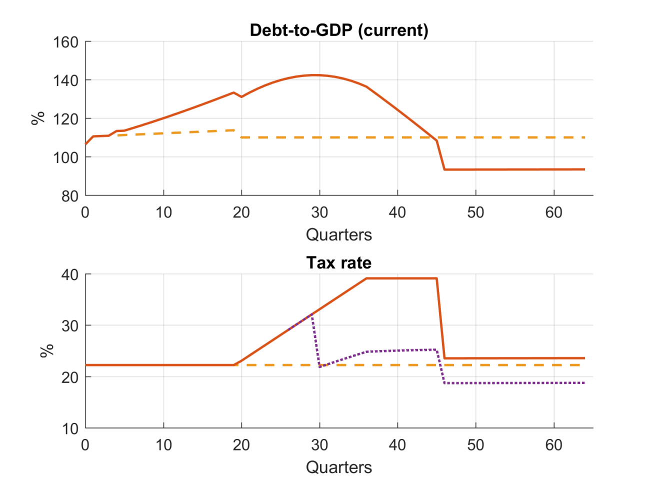
Back

Details on Backward Induction

- Given the price of debt $q_t^{\delta=0}$
- If B_t^g is known, plug in govt BC for taxes
  - Otherwise, tax rate $\frac{T_t^{\delta=0}}{Y_t^{\delta=0}}$ is known. **Guess** B_t^g and loop until taxes and output match target rate.
- With taxes, get **output** from savers BC
- Consumption of borrowers from borrowers BC or market clearing.
- Outer loop with **shooting** on
  - B_T^g for the no deleveraging simulation
  - τ^H for the deleveraging simulation

Back

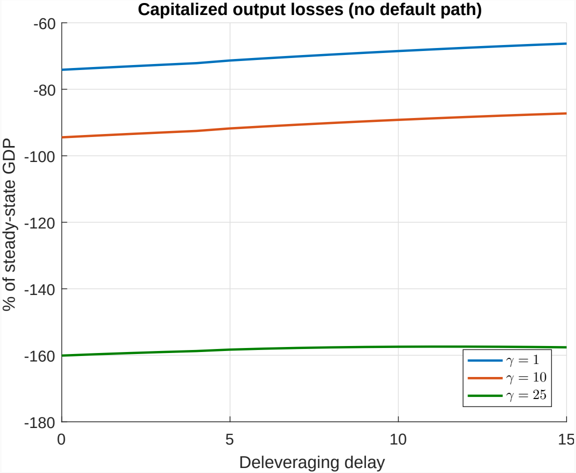
Late Deleveraging



Back

Output Losses and Delay

In normal times ($\pi^{\text{normal}} = \frac{1}{3}\pi^{\text{crisis}}$), delaying is better for output



Capitalized output loss on the no-default path with the borrower's discount factor

Back

Calibration

Parameter	Description	Value	Target
β	Savers' discount	0.995	2% annual interest
β_b	Borrower's discount	0.972	12% annual interest
χ	Proportion of borrowers	0.5	Standard
φ	Inverse Frisch elasticity	1	Standard
G	Government consumption	$20\% \times \bar{Y}$	Italy 1999-2008.
C	Steady-state consumption	1	Normalization
ψ	Inter-temporal substitution	1	Standard
γ	Coefficient of risk aversion	10	Standard for asset pricing moments
α	Consumption share in utility function	0.40	$W = 1$ (normalization)
κ_n	Labor endowment	2.78	Work week of 36 hours

Back

Calibration

Parameter	Description	Value	Target
ρ	Persistence of public debt	5%	Duration of Italian debt 2010
$\hbar$	Haircut	50%	Greek default
Δ	Deadweight loss after default	10%	
θ	Hazard of low productivity state	1/10 per year	
B^g_T	Final public debt	$4 \cdot \bar{Y} \cdot 90\%$	Italy in Great Recession
B^h_0	Initial private debt	$4 \cdot \bar{Y} \cdot 80\%$	Italy in Great Recession
B^h_T	Final private debt	$4 \cdot \bar{Y} \cdot 70\%$	Italy in Great Recession
T_h	Length of private deleveraging	20	Italy in Great Recession

Back