Self-Fulfilling Debt Crises and Government Policy

Carlo Galli

Self-Fulfilling Debt Crises and Multiple Equilibria

Role for self-fulfilling beliefs in sovereign default models

- Motivated by emerging markets experience and Eurozone crisis
- Bond spreads high and volatile...
- ...but often disconnected to fundamentals and actual defaults
- EZ debt crisis: high spreads as bad equilibrium, motivation for OMT

Self-Fulfilling Debt Crises and Multiple Equilibria

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Link between spreads, gov't policy and fundamentals important

- Two-way empirical relationship between country spreads and business cycle
  [Neumeyer-Perri (2005), Uribe-Yue (2006)]
- Austerity policies *in response to* EZ crisis (Italy, Spain)
- Micro evidence of gov't spreads pass-through to investment, output
  [Arellano et al. (2017), Bocola (2016), Bottero et al. (2017)]

This Paper

Standard sovereign default model, with endogenous output

- Circular feedback: spreads $\Leftrightarrow$ govt debt $\Leftrightarrow$ domestic policy (gov't investment)
- Non-contractible gov't policy
- Austerity induced by debt crises can generate belief-driven equilibria

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Debt crisis mechanism

- confidence crisis $\Rightarrow$ higher spreads, costlier to borrow
- $\Rightarrow$ govt raises less funds, cuts down on consumption *and* investment instead
- $\Rightarrow$ growth $\downarrow$, future default incentives $\uparrow$ $\Rightarrow$ pessimistic expectations verified

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Model properties

- multiplicity mechanism: dynamic, real effect of spreads
- standard debt auction timing [Aguiar-Gopinath (2006), Arellano (2008)]
- debt overhang dynamics: $\uparrow$ debt may $\downarrow$ investment incentives
- crisis periods (bad eqm) may feature large & finite spreads, lower debt (consistent with Aguiar et al. (2016))

Outline

1. Stylised 2-period model
   - highlight multiplicity mechanism
   - characterize equilibria
   - (appendix) analytical proof for deterministic case

2. Infinite-horizon numerical example
   - show quantitative properties
   - static vs dynamic multiplicity

Government Problem

- Two periods, $t = 0, 1$
- Agents: risk-averse SOE government, continuum of risk-neutral lenders.
- Government born with $w(:= f(k_0) - b_0)$, solves

$$V(w) = \max_{c_0, c_1^R, c_1^D} U(c_0) + \int \max_{R,D} \left\{ U(c_1^R), U(c_1^D) \right\} dG(\gamma)$$

$$\text{s.t. } c_0 = w + qb - k$$

$$c_1^R = f(k) - b$$

$$c_1^D = f(k)\gamma$$

- Govt cannot commit to either k or repay
- If default, production loss $(1-\gamma)$, with $\gamma \sim G(0,1)$
- Repay iff default costs are high: $1 - \gamma \geq \frac{b}{f(k)}$
- Discount bonds, perfectly patient lenders $\Rightarrow$ risk-free debt price $= 1$

Timing in $t = 0$

1. Government chooses debt issuance b

2. Lenders pay price q, government raises qb resources

3. Consumption/Investment chosen **after** debt issuance, taking (q, b) as given
   - objective function for investment, given (w, q, b)

$$W(k; w, q, b) = u(w+qb-k)+\int \max_{R,D} \{u[f(k)-b], u[f(k)\gamma]\} \, dG(\gamma)$$

   - $k^*(w, q, b)$ unique solution to $\max_k W(k; w, q, b)$
   - consumption determined residually

Lenders' Problem

Lenders are atomistic, perfectly competitive $\Rightarrow$ make zero-profits in expectations

- must anticipate government's investment strategy k^*

Set of zero-profit prices at which lenders are willing to buy b

$$Q(w,b) = \left\{ q : q = \text{Prob}\left((1-\gamma) \geq \frac{b}{f[k^*(w,q,b)]} \right) \right\}$$

$\Rightarrow$ Calvo timing setup: repay if $\quad y' - b'R \geq \gamma y' \quad \Rightarrow \quad (1-\gamma) \geq \frac{b'R}{y'}$

Pricing equations review

$Q(w,b)$ may be a correspondence for some values of (w,b)

Equilibrium

Collection of

- government policies $b_i^*(w)$, $k_i^*(w)$, value functions $V_i(w)$
- creditors debt price schedules $q_i(w, b)$

such that

- $b_i^*(w)$ and $k_i^*(w)$ solve the government's problem and achieve $V_i(w)$, conditional on q_i
- given government policies, price functions $q_i(w, b)$ satisfie lenders' zero-profit condition *for all b*

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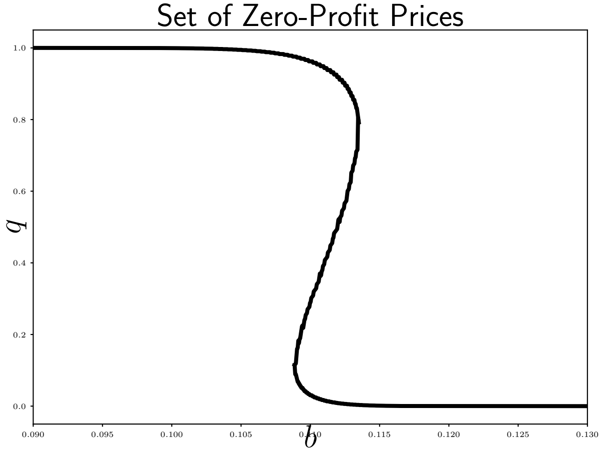
Now:

1. show conditions for existence of **multiple debt price schedules**
2. show conditions & states for **multiple equilibria**

When is $Q(w, b)$ a Correspondence?

Given state w



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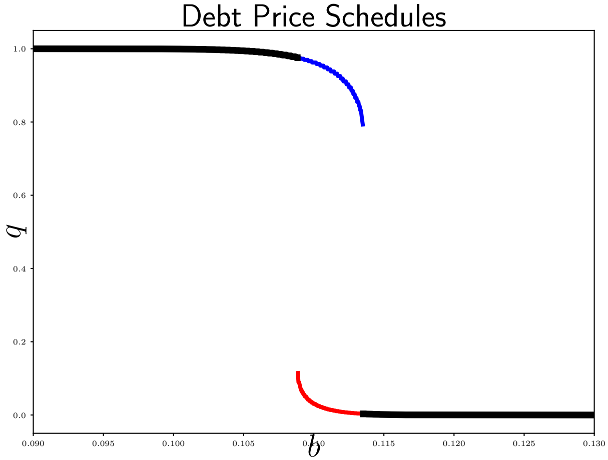
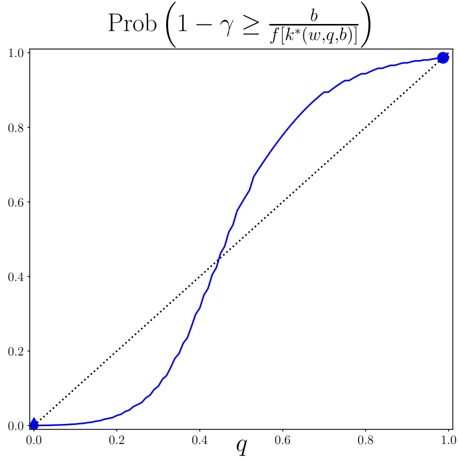
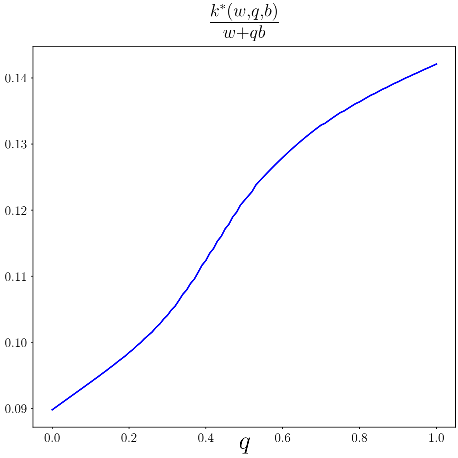


- ignore unstable part of schedule, split into single-valued fns $q_i(w, b)$
- assume government observes i before issuing debt
  - $\approx$ observing secondary market conditions

When is $Q(w, b)$ a Correspondence?

Fix w, b

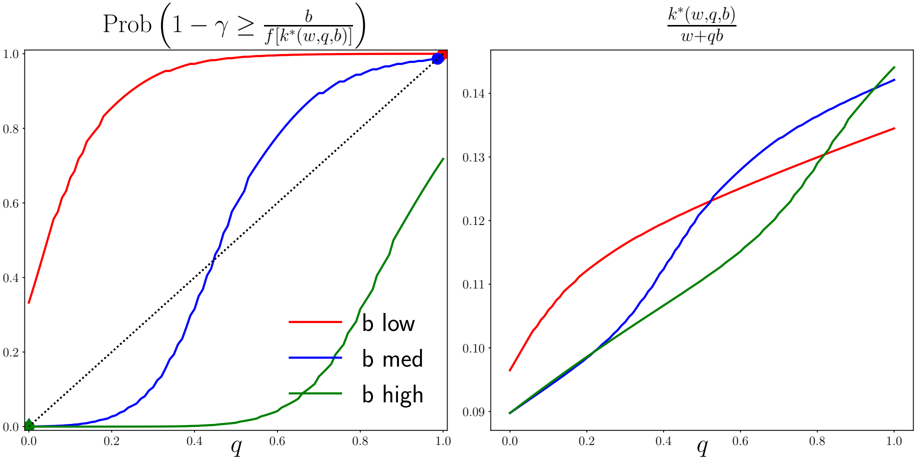




FOCs Comp. Statics Stdev

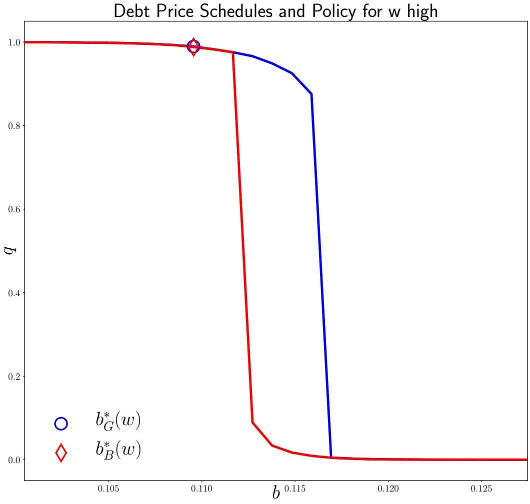
When is $Q(w, b)$ a Correspondence?

Fix w, b



Equilibrium Policy: High Endowment

- There might exist multiple schedules...
- ...but does the government ever select them?



Equilibrium Policy: Low Endowment

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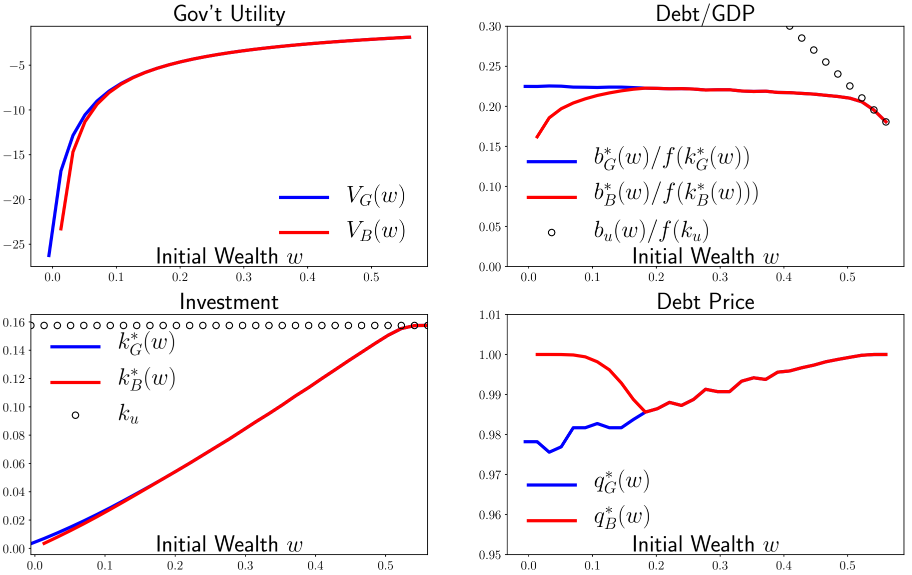
Equilibrium Policy

When govt policy is risk-free

- $f'(k_u) = 1$ (MPK = return on savings/cost of borrowing)
- $b_u(w) = \frac{f(k_{rf})+k_{rf}-w}{2}$ (when feasible, first-best)

Multiple Equilibria



Summing Up

Confidence crisis

- more expensive to borrow, tighter govt budget set
- cut borrowing, consumption & investment ($\approx$ raise taxes)
- debt/GDP$\downarrow$, but lower utility and depressed output

Here "austerity" is bad but necessary

- fiscal tightening to avoid high (extreme here) borrowing costs
- not desirable, but only alternative during crisis

Infinite Horizon Numerical Example

- 1 period = 1 quarter

- Default causes
  - random iid production loss γ, permanent
  - permanent exclusion from debt markets

- Qualitative predictions very similar to 2-period model

Value Functions

Start-of-period value function:

$$V(k,b,\gamma) = \max_{R,D}\{V^R[f(k)-b], V^D(k,\gamma)\}$$

Repay value function:

$$V^R[\underbrace{f(k)-b}_{:=w}] = \max_{k',b'} \; u[w + q(w,b')b' - k'] + \beta \sum_{\gamma} P(\gamma) V(k',b',\gamma)$$

Default value function:

$$V^D(k,\gamma) = \max_{k'} \; u[\gamma f(k) - k'] + \beta V^D(k',\gamma)$$

Debt price correspondence

$$Q(w,b') = \left\{ q : q = \frac{1}{R} \sum_{\gamma} P(\gamma) \mathbb{1}\left[V^R[f(k^*) - b'] \geq V^D(k^*,\gamma) \right] \right\}$$

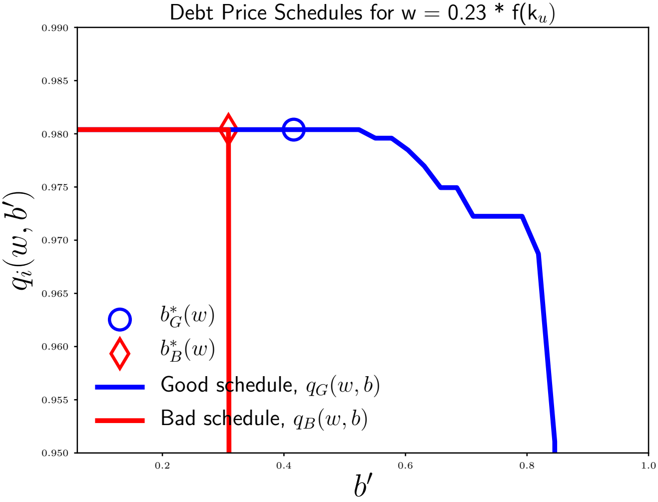
$$k^* := k^*(w,q,b')$$

Params Optimality Conditions

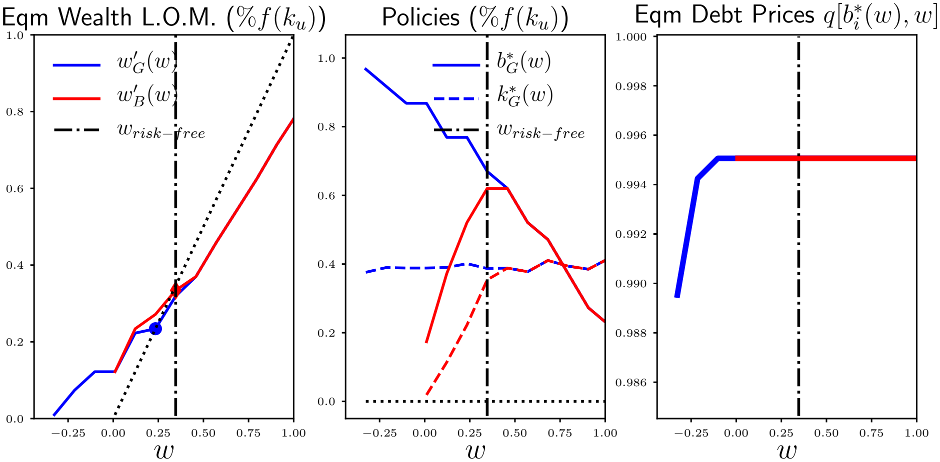
- Debt price schedule is still a correspondence
- To coordinate lenders' beliefs, iid sunspot

$$i = \begin{cases} G \quad \text{w.p. } \pi \quad \rightarrow \quad V_G[f(k) - b], Q_G(w, b') \\ B \quad \text{w.p. } 1-\pi \quad \rightarrow \quad V_B[f(k) - b], Q_B(w, b') \end{cases}$$

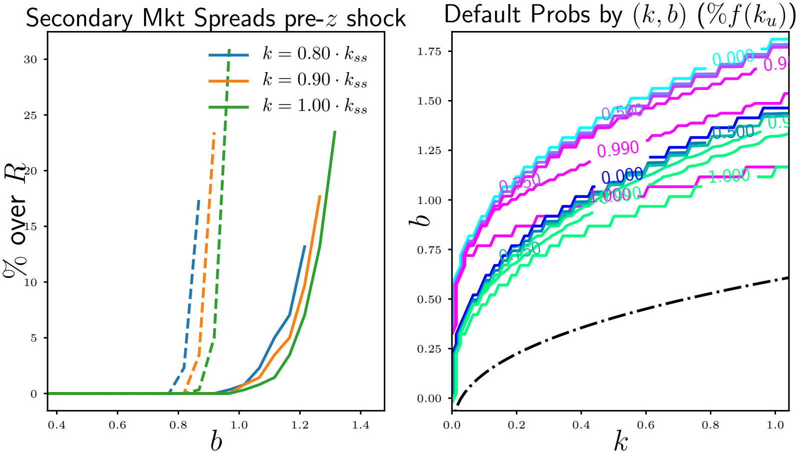
Debt Price Function Example



Policies and Equilibrium Prices



"Secondary Mkt" Spreads and Default Probabilities



What about "dynamic" multiplicity?

So far, "static" multiplicity: given $E[V(k', b', \gamma)]$, self-confirming beliefs over k' today

- Limitation? In bad eqm no risky borrowing, "endogenous austerity"

Dynamic, circular mechanism typical of sovereign default models:

- $V^R \rightarrow$ default cutoff $\hat{b}(k, \gamma)$ via $V^R[f(k) - \hat{b}] = V^D[\gamma f(k)]$
- cutoff $\hat{b}(k, \gamma) \rightarrow$ price fn $Q(w, b')$
- price fn $Q(w, b') \rightarrow V^R$

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- cutoff $\hat{b}(k, \gamma) \to$ price fn $Q(w, b')$
- price fn $Q(w, b') \to V^R$

Is mechanism strong enough to generate multiple $(V^R, \hat{b}, Q)$ triplets?

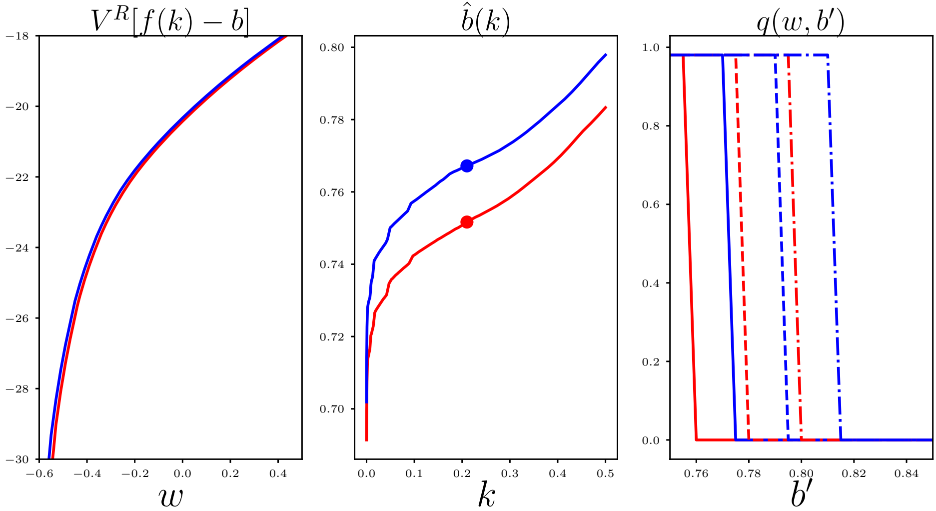
- No, in canonical Eaton-Gersovitz models (Auclert-Rognlie (2016))
- Answer seems different here with endogenous income

Different beliefs on continuation values

$\to$ parallel debt schedules

$\to$ more realistic equilibrium prices?

Deterministic Example: Dynamic Multiplicity



Conclusion

- Real, dynamic effect of spreads in standard sovereign default model
- Two-way feedback between spreads, policy and real activity
  $\Rightarrow$ beliefs iteract with both debt *and* domestic policy

Extensions

- add private sector and govt taxation $\rightarrow$ feedback spreads-govt-pvt sector
- dynamic multiplicity in infinite horizon

Appendix

Related Literature

Problems tackled separately in the literature:

- Quantitative literature (debt policy only [Aguiar-Gopinath(2006), Arellano(2008)], reform effort [Mueller et al.(2016), Marimon et al.(2017)], investment [Bai-Zhang(2012), Gordon-Guerron(2017)]
  - (fundamentals, policy) $\rightarrow$ spreads
- Lending channel [Bocola (2016), Arellano et al. (2017), Ari (2017), Balke (2017), Bottero et al. (2017)]
  - spreads $\rightarrow$ fundamentals (via banking sector)
- Austerity policies [Arellano-Bai (2016), Conesa-Kehoe-Ruhl (2017)]
  - spreads $\rightarrow$ fundamentals (via tax policy)
- Self-fulfilling debt crises literature [Calvo (1988), Cole-Kehoe (2000), Lorenzoni-Werning (2014), Aguiar et al. (2016), Ayres et al. (2018)]
  - spreads $\leftrightarrow$ debt policy (no fundamentals)

Back

Pricing Equations Review

PR $:=$ **Probability of Repayment**

Eaton-Gersovitz tradition (Aguiar-Gopinath (2006), Arellano (2008))

- issue b', get price q, repay tmr if $y' - b' \geq h(y') \quad \Rightarrow \quad q = \mathrm{PR}_{y'}[b']$
  - off-equilibrium, adjust c

Government as price-taker (Lorenzoni-Werning (2014))

- given q, issue b', repay if $y' - b' \geq h(y') \quad \Rightarrow \quad q = \mathrm{PR}_{y'}[b'(q)]$
  - off-equilibrium, adjust b'

Calvo (1988) timing

- issue b' at interest rate $1/q$, repay if $y' - b'\frac{1}{q} \geq h(y') \quad \Rightarrow \quad q = \mathrm{PR}_{y'}[b'\frac{1}{q}]$

If output is endogenous: $y' = \mathcal{H}(q, b', \cdot) \leftrightarrow$ This paper: $y' = f[k^*(w, q, b')]$

- issue b', get q, debt price $q = \mathrm{PR}_{y'}[b', \mathcal{H}(q, b', \cdot)]$
  - same timing/commitment of Eaton-Gersovitz framework
  - $\mathcal{H}$ can be many things

Back

First-Order Conditions

- Govt repays iff $\gamma \leq \hat{\gamma} := 1 - \frac{b}{f(k)}$
- Define debt price schedule as $q_i(w, b)$
- Capital FOC:

$$u'(c_0) = \beta f'(k) \left[G(\hat{\gamma}) u'(c_R) + \int_{\hat{\gamma}} \gamma u'(c_D) dG(\gamma) \right]$$

- Debt FOC:

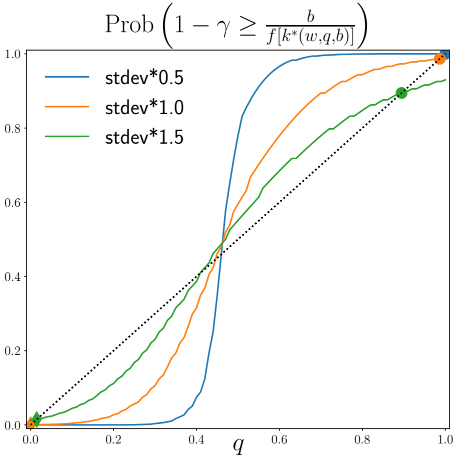
$$u'(c_0) = \beta \frac{1}{q_i(w, b) + \frac{\partial q_i(w,b)}{\partial b} b} G(\hat{\gamma}) u'(c_R)$$

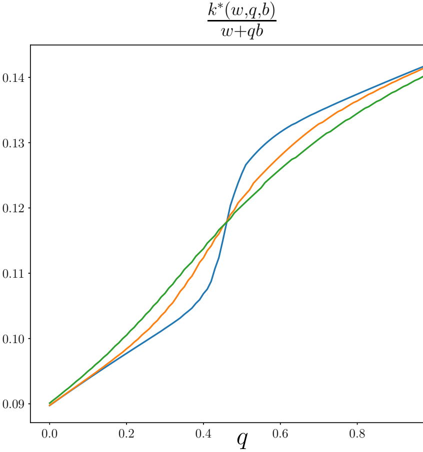
- When debt is risk-free:

$$q_i(w, b') + \frac{\partial q_i(w, b')}{\partial b'} b' = \frac{1}{R} \quad \text{and} \quad G(\hat{\gamma}) = 1 \quad \Rightarrow \quad \begin{cases} f'(k) = R \\ u'(c_0) = \beta R u'(c \end{cases}$$

Back

When is $Q(w, b)$ a Correspondence?





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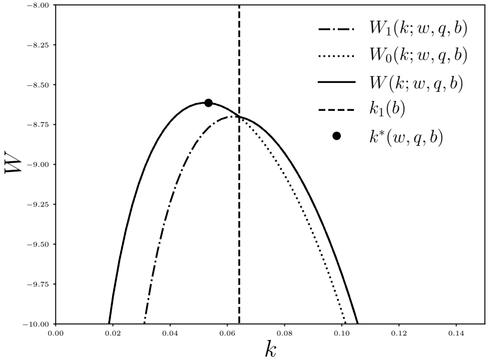
Investment Objective Fn

- Examine the investment decision, keeping everything else (w, q, b) fixed

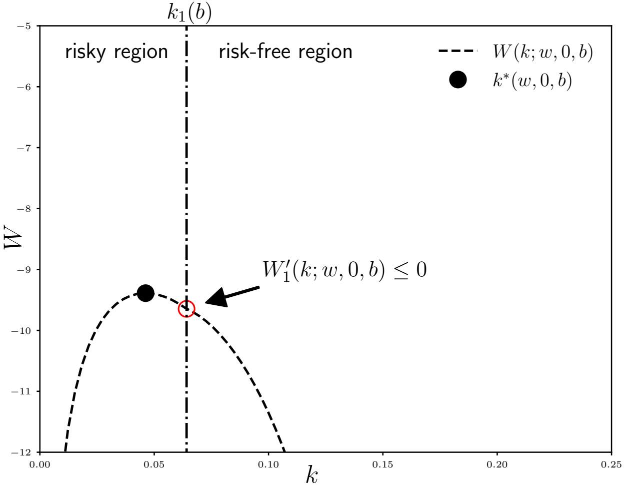
$$W(k; w, q, b) = u(w + qb - k) + \max\{u[f(k) - b], u[f(k)\gamma]\}$$

- $k_1(b) :=$ lowest k s.t. govt repays b
- $W_p(k; w, q, b)$ is obj. fn. assuming govt will repay w.p. p



When is $Q(w, b)$ a Correspondence? Sufficient Conditions

$$k^*(w, 0, b) < k_1(b) \quad \Leftrightarrow \quad 0 \in Q(w, b) \quad \Leftarrow W_1'(k_1(b); w, 0, b) \leq 0$$



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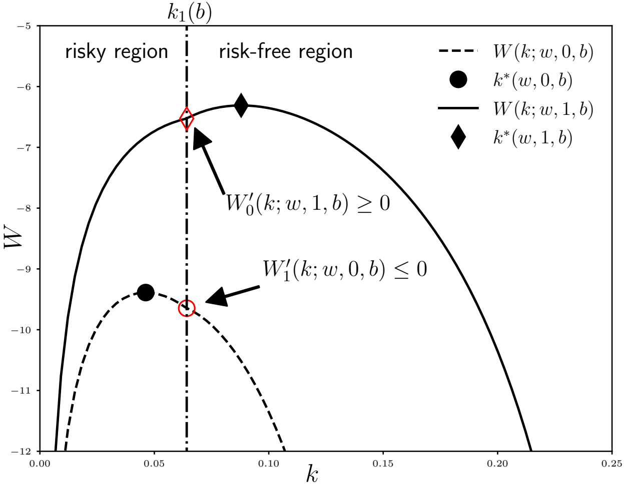
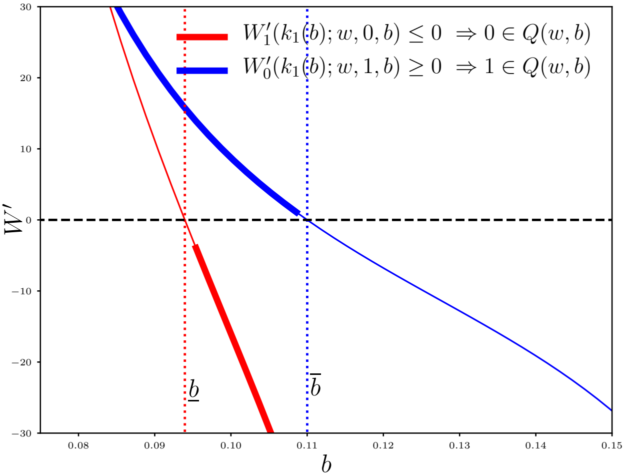
$$k^*(w, 1, b) \geq k_1(b) \quad \Leftrightarrow \quad 1 \in Q(w, b) \quad \Leftarrow W_0'(k_1(b); w, 1, b) \geq 0$$



When is $Q(w, b)$ a Correspondence? Characterization

- For each state w, characterize debt levels such that $(0, 1) \in Q(w, b)$
- for all $b \in [\underline{b}(w), \overline{b}(w)]$, there are multiple zero-profit prices

ZP condition graph



Sufficient Condition

Proposition

Given state w, if

$$\frac{u'\Big(w + \underline{b}(w) - k_1[\underline{b}(w)]\Big)}{u'\Big(w - k_1[\underline{b}(w)]\Big)} \leq \gamma$$

then

$$\underline{b}(w) \leq \overline{b}(w) \quad \textit{and} \quad (0,1) \in Q(w,b) \quad \forall b \in [\underline{b}(w), \overline{b}(w)]$$

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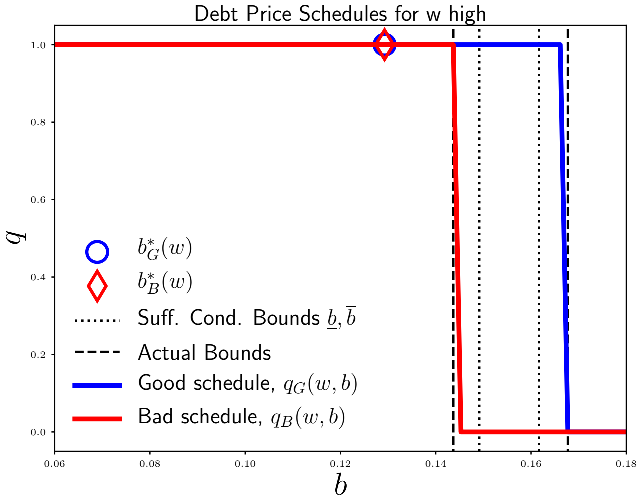
In words, there exist multiple zero-profit prices if k^*

- implies default when $q = 0$
  - low auction revenues, high $u'(c_0)$ $\rightarrow$ MC(risk-free k)>> MB(risk-free k)
- is risk-free when $q = 1$
  - high auction revenues, low $u'(c_0)$ $\rightarrow$ MC(default k)<< MB(default k)

Equilibrium Policy: High Endowment

- There might exist multiple schedules...
- ...but does the government ever select them?



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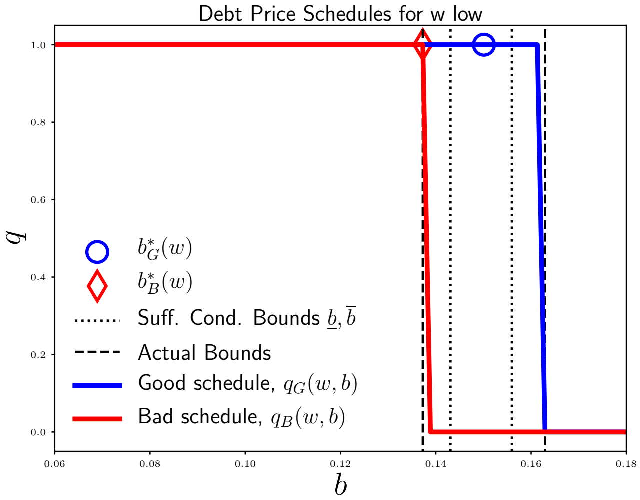


Unconstrained Risk-Free Policy

When govt policy is risk-free

- $f'(k_u) = 1$ (MPK = return on savings/cost of borrowing)
- $b_u(w) = \frac{f(k_{rf}) + k_{rf} - w}{2}$ (when feasible, Pareto-efficient)

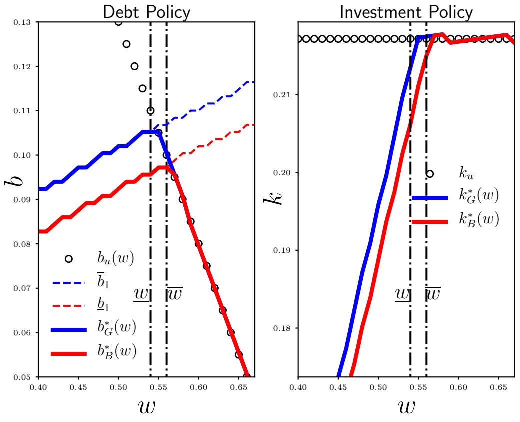
If $1 \notin Q(w, b_u(w))$, policy is not feasible!

- $\Rightarrow$ depends on schedule
- if so, govt is borrowing constrained
- borrowing constraint depends on schedule

Multiple Equilibria

$[\underline{w}, \overline{w}]$ where $k_u, b_u(w)$

- are feasible under q_G
- are not feasible under $q_B \Rightarrow$ constrained policy (borrow less, invest less)



Optimality Conditions (Infinite Horizon Model)

Let $\hat{\gamma} := \hat{\gamma}(k', b')$

Capital FOC

$$u'[w+q_i(w,b')b'-k'] = \beta f'(k)\left[G(\hat{\gamma})u'[f(k)-b] + \int_{\hat{\gamma}} \gamma u'[\gamma' f(k) - k']dG(\gamma)\right]$$

Debt FOC

$$u'[w+q_i(w,b')b'-k'] = \beta \frac{1}{q_i(w,b') + \frac{\partial q_i(w,b')}{\partial b'} b'} G(\hat{\gamma})u'[f(k)-b]$$

With risk-free debt

$$q_i(w,b') + \frac{\partial q_i(w,b')}{\partial b'} b' = \frac{1}{R} \quad \Rightarrow \quad f'(k_u) = R$$

Back

Parametrization

Parameter		Value
Capital share of output	α	0.4
CRRA risk aversion parameter	σ	2
Government discount factor	β	0.89
Risk-free rate (annual)	R	2%
Sunspot probability	π	0.75
Default cost distribution	γ	$N(0.8, 0.05)$

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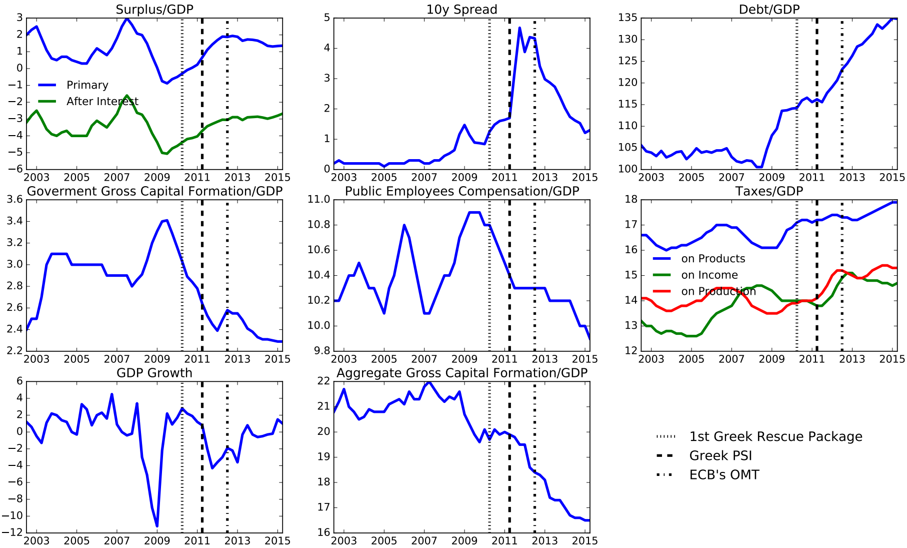
Italy


Surplus/GDP
Primary
After Interest
10y Spread
Debt/GDP
Goverment Gross Capital Formation/GDP
Public Employees Compensation/GDP
Taxes/GDP
on Products
on Income
on Production
GDP Growth
Aggregate Gross Capital Formation/GDP
1st Greek Rescue Package
Greek PSI
ECB's OMT

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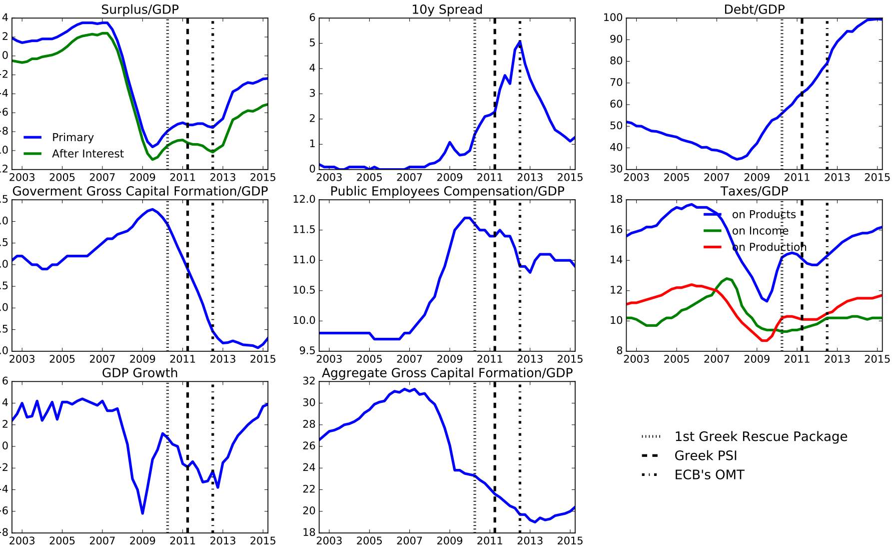
Spain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Some EZ Debt Crisis Quotes

Italian Government Press Release on “Salva Italia” measures, 4/12/2011

> *“These urgent measures were necessary to face a serious financial crisis that has hit [...] sovereign bond markets, Italy included.”*

Italian PM Mario Monti, 29/12/2011

> *“Our economic fundamentals do no justify such a high government bond spread.”*

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