Slow moving debt crises (2019)

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Motivation

Features of recent crises:

- No obvious change in fundamentals.
- Unexpected sharp increase in spreads.
- Gradual, but faster accumulation of debt despite fiscal efforts.
- Treasury auctions keep going.

Recent example: Italy, Spain, and Portugal in late 2010.

Motivation

Multiple Equilibrium Story

- **Self fulfilling high interest rates:**

  Increase in spreads → faster debt accumulation

  Higher debt → higher probability of default

- Two way feedback: multiplicity.
  - Bad equilibrium: high debt.
  - Good equilibrium: low debt.
- Crisis: switch from a good to a bad equilibrium path.

Motivation

- When a crisis occurs: bond prices jump in response to changes in future default probabilities.
  - **Rollover crisis:** run on the country's debt leading to a failed bond auction and immediate default.
  - **Slow moving crisis:**
    Crisis here does not trigger immediate default
    Makes probability of future default higher
    Debt continues increasing
- Multiple equilibria arise due to a coordination problem across investors in sovereign debt markets.

Objective and contributions

Objective:

- Build a dynamic model that formalizes the multiple-equilibria view of debt crises.
- Explore how the initial debt level, the fiscal policy regime, and the maturity of debt affect the vulnerability to debt crises.

Related literature:

- Calvo (1988): extend to a dynamic approach.
- Cole and Kehoe (2000), Eaton and Gersovitz (2016): rollover crises.
- Sovereign debt default, like Arellano (2008): they make specific timing assumptions to have unique equilibrium.
- Leeper (1991), Bohn (2005), Gosh et al. (2011): fiscal rules.

Outline

1. Model 1: discrete, finite time model
   - Equilibrium construction: short term debt
   - Multiplicity
2. Model 2: Infinite, continuous time. Long term debt
   - Debt dynamics
   - Numerical example: Markov Equilibria
   - Numerical example: Slow moving debt crisis

Model

- Discrete time.
- Exogenous state s_t, node $s^t = (s_0, ..., s_t)$, probability $p(s^t)$.
- Simplification: all uncertainty is resolved at some $T < \infty \rightarrow$ allows to solve the model by backward induction.
- 2 agents:
  1. Government
  2. Continuum of risk neutral investors, discount factor $\beta = \frac{1}{1+r}$.

Model

Government:

- Issues noncontingent bonds with geometrically decreasing coupons: $\kappa, (1-\delta)\kappa, (1-\delta)^2\kappa, \ldots$ with $\delta \in (0,1)$

- $\kappa = \delta + r > 0 \rightarrow$ the bond price is 1 when the risk of default is zero at all future dates.

- Sequence of primary fiscal surpluses $\{z_t\}$

- Fiscal rule: $z_t = h(b_t, s^t)$.
  - h weakly increasing in b_t
  - **Fiscal fatigue:** fiscal rule bounded above: $z_t \leq \bar{z} < \infty$.

Model

- Government budget constraint without default:

$$z_t + q_t \cdot (b_{t+1} - (1-\delta)b_t) = \kappa b_t \tag{1}$$

Where q_t is the price of a newly issued bond.

- The government honors its debts ($\chi_t = 1$) whenever possible.

- Recovery value: $v_t = v\left(b_t, s^t\right) \geq 0$, bounded above.

- Bond prices at date t satisfy rational expectations:

$$q_t = \beta E\left[\chi_{t+1}\left(\kappa + (1-\delta)q_{t+1}\right) + \left(1 - \chi_{t+1}\right)\frac{v_{t+1}}{b_{t+1}}|s^t\right] \tag{2}$$

Equilibrium definition

An equilibrium is a sequence of bond price functions $Q\left(b_{t+1}, s^t\right)$, debt issuance functions $B\left(b_t, s^t\right)$, repayment indicators $X\left(b_t, s^t\right)$ such that:

1. If the GBC can be satisfied for one or more values of b_{t+1}, then $B\left(b_t, s^t\right)$ is selected among these values.
2. If the GBC is not satisfied for any b_{t+1}, default follows and $X\left(b_t, s^{t+1}\right)$ is set to 0.
3. The bond price functions satisfy rational expectations (2).

Equilibrium construction

Assume short term debt: $\delta = 1$.

Policy functions

- At T the process s_t stops, and the fiscal surplus is constant at: $z_T = h\left(b_T, s^T\right)$.

$$\chi_T = \begin{cases} 1, & \text{if } z_T \geq rb_T \\ 0, & 0.w \end{cases}$$

Equilibrium construction

At $t < T$,

- Bond price for every possible value b_{t+1}:

$$Q_t(b_{t+1}, s^t) \equiv \beta E \left[X_{t+1}(b_{t+1}, s^{t+1})\kappa + (1 - X_{t+1}(b_{t+1}, s^{t+1})) \frac{v(.)}{b_{t+1}} | s^t \right]$$

- *Maximum debt revenue:*

$$m_t \left(b_t, s^t \right) \equiv \max_b \left\{ Q_t \left(b, s^t \right) b \right\}$$

- Default policy:

$$\chi_t = \begin{cases} 1, & \text{if } h \left(b_t, s^t \right) + m_t \left(b_t, s^t \right) \geq \kappa b_t \\ 0, & 0.w \end{cases}$$

- If $\chi_t = 1$, select a b_{t+1} that satisfies the GBC, call it $B_{t+1} \left(b_t, s^t \right)$:

$$h \left(b_t, s^t \right) + Q_t \left(b_{t+1}, s^t \right) b_{t+1} = \kappa b_t$$

Multiplicity

Multiple equilibria: GBC admits multiple solutions for some s^t and b_t:

$$\underbrace{Q_t\left(b_{t+1}, s^t\right) b_{t+1}}_{\text{Laffer curve}} = \underbrace{(1+r)b_t - z_t}_{\text{Government financing needs}}$$

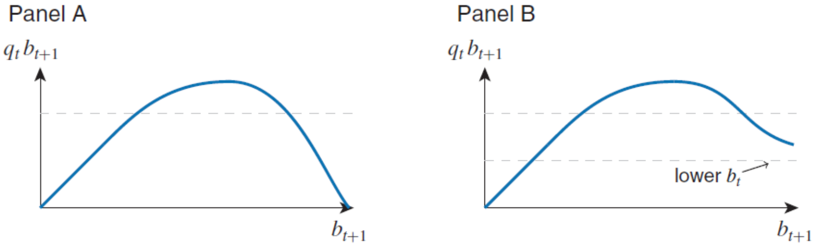


FIGURE 1. DEBT LAFFER CURVE: ZERO RECOVERY (PANEL A) AND POSITIVE RECOVERY (PANEL B)

Multiplicity

Proposition

Consider the model with short-term debt ($\delta = 1$).
With zero recovery, if there is an equilibrium for a positive value of $(1+r)b_t - z_t$, then there are always at least two equilibria.
With positive recovery, if $(1+r)b_t - z_t$ is low enough, the equilibrium is unique.

- Equilibrium points where the Laffer curve is locally decreasing are "unstable".
- If the Laffer curve is single-picked, there is 1 stable equilibrium, 1 unstable equilibrium.
- There can be a third equilibrium: rollover-crises.

Continuous time model

- Infinite, continuous time.
- Resolution of uncertainty happens with Poisson probability: λ, at some $T < \infty$.
- Before the resolution of uncertainty: $z = h(b)$, bounded above.
- At T, Z is drawn from F(Z) and the primary surplus is constant: $z = rZ$.

  1. If $Z \geq b$: default is avoided and the bond price equals 1.
  2. If $Z < b$: bondholders obtain the recovery rate ϕZ, with $\phi < 1$.

- The bond price immediately before the resolution of uncertainty is:

$$q = \Psi(b) \equiv 1 - F(b) + \frac{\phi}{b} \int_0^b Z dF(Z)$$

Continuous time model

Before the Poisson event, 2 ordinary differential equations:

- Government budget constraint:

$$z + q(\dot{b} + \delta b) = \kappa b$$

- Bond pricing condition:

$$rq = \kappa - \delta q + \lambda(\Psi(b) - q) + \dot{q}$$

Equilibrium characterization

- Objective: construct a Markov equilibrium in which, before the resolution of uncertainty, the bond price is a function of the stock of bonds, denoted by $Q(b)$.
- 2 steps:
  - Characterize solutions to the ODEs in (q, b), given appropriate boundary conditions.
  - Use these solutions to construct the function $Q(b)$.
- Two boundary conditions are possible:
  1. Convergence to a stable steady state
  2. Convergence to default before the Poisson event

Equilibrium characterization: boundary conditions

1. **Convergence to a steady state:**

   The locus $\dot{q} = 0$ is given by:

   $$q = \frac{\kappa + \lambda \Psi(b)}{r + \delta + \lambda}$$

   The locus $\dot{b} = 0$ is given by:

   $$q = \frac{\kappa b - h(b)}{\delta b}$$

2. **Convergence to default before resolution of uncertainty**
   Follow a path leading to certain default at some finite date $\hat{t}$.
   This can happen only if: $q = 0$, with recovery value $v = qb = \hat{v} > 0$
   $\rightarrow$ solve the ODEs in (q,v) with terminal conditions $(0, \hat{v})$.

Numerical example

- Italy 2011. b and z are ratios over GDP.
- Fiscal rule: $z = \min\{\alpha_0 + \alpha_1 b, \bar{z}\}$
  From OLS: $\alpha_0 = -0.13$, $\alpha_1 = 0.135$, $\bar{z} = 6\%$.
  Data: debt-to-GDP ratio and primary surplus in Italy (1988–2012).
- $\delta = 1/7$: match average maturity of 7 years.
- $r = 2\%$, $\phi = 0.5$ and Z is normally distributed.
- $\lambda = 0.1$.

Numerical example: boundary conditions

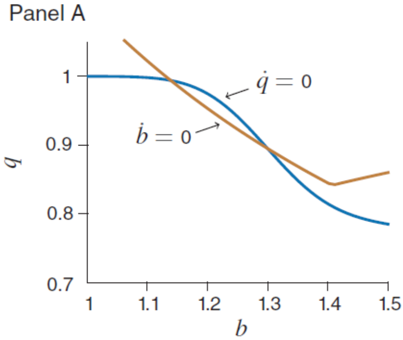


FIGURE 5. CONTINUOUS TIME MODEL: PHASE DIAGRAM

Numerical example: Markov Equilibria

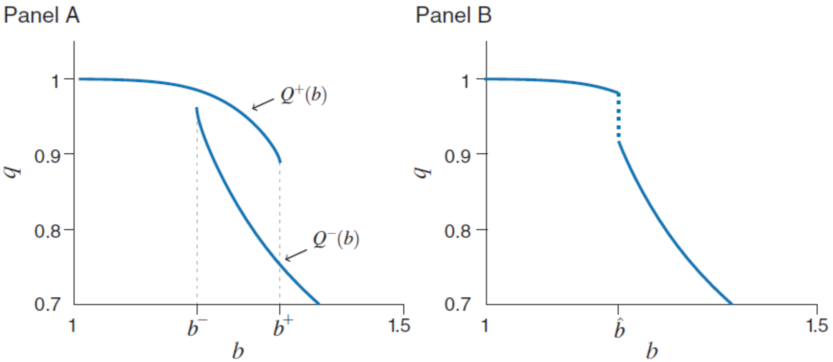


Figure 6. Continuous Time Model: Constructing a Markov Equilibrium

proposition

Numerical example: unique Markov Equilibrium

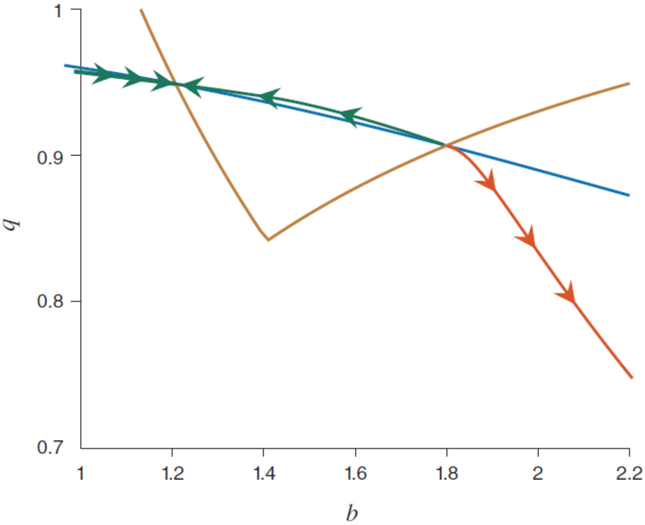
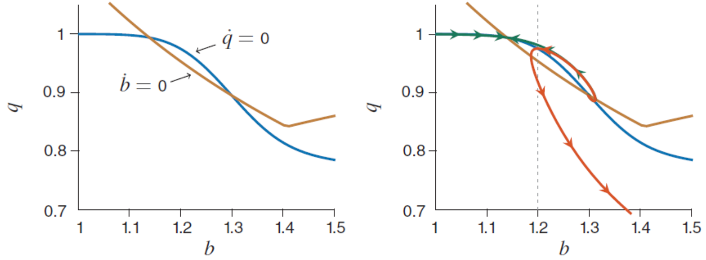
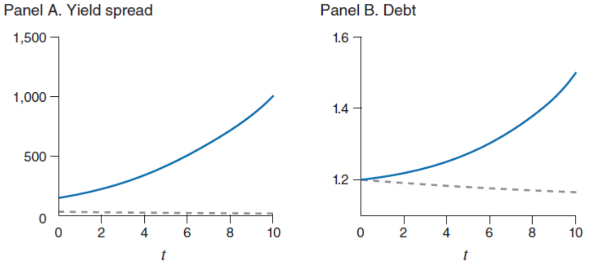


FIGURE 7. AN EXAMPLE OF UNIQUENESS

Numerical example: Slow moving crisis

Italy 2011: $b_0 = 1.2$





Multiplicity: sensitivity

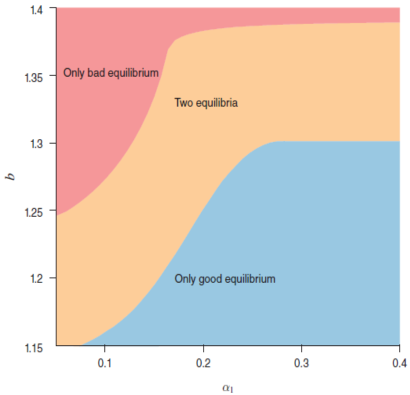


Figure 1: Fiscal policy

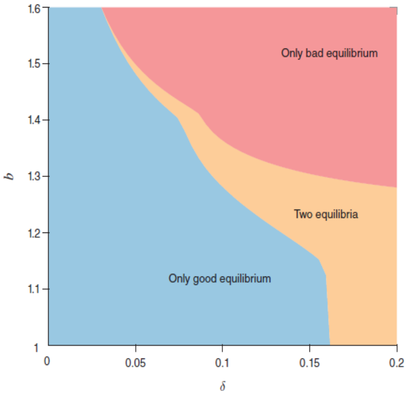


Figure 2: Maturity

Conclusions and policy implications

- Countries may become entrapped in self-fulfilling, slow moving debt crises.
- A sufficiently aggressive fiscal policy rule and longer debt maturities can help prevent them.

Policy implications:

- A *lender of last resort* can eliminate the bad equilibrium: committing to purchase bonds at a price above the bad equilibrium price. Example: "whatever it takes" announcement.
- Delaying an intervention is dangerous, as debt will keep increasing and eventually cross the threshold after which intervening is no longer costless.

Multiple Markov Equilibria

Proposition (Markov Equilibria)

Suppose there is a stable steady state (b_L, q_L) and an unstable steady state (b_H, q_H) , with $b_L < b_H$. Then there are two functions $Q^- : [b^-, \infty) \to \mathbb{R}_+$ and $Q^+ : (-\infty, b^+] \to \mathbb{R}_+$ with $b^- \leq b^H \leq b^+$, $Q^-(b) < Q^+(b)$ for $b \in [b^-, b^+]$. For any threshold $\hat{b} \in \left[b^-, \bar{b}^+\right]$ there is a Markov equilibrium with

$$Q(b) = \begin{cases} Q^+(b) & \text{for } b \leq \hat{b} \\ Q^-(b) & \text{for } b > \hat{b} \end{cases}$$

Debt dynamics satisfy $\dot{b} < 0$ for $b < \hat{b}$ and $\dot{b} > 0$ for $b > \hat{b}$.

back