The Macroeconomics of Imperfect Capital Markets

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Lecture 14: Sovereign Risk

Introduction

Intertemporal budget constraint of government:

$$\underbrace{R_b b}_{\text{repayment}} + \underbrace{g}_{\text{spending}} = \underbrace{x}_{\text{taxes}} + \underbrace{b'}_{\text{new borrowing}}$$

- is at the basic level an accounting identity
- is at the center of fierce political debates
- is subject to much "fiscal illusion"
- provides a reality check to fiscal plans

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Intertemporal budget constraint of government:

$$\underbrace{R_b b}_{\text{repayment}} + \underbrace{g}_{\text{spending}} = \underbrace{x}_{\text{taxes}} + \underbrace{b'}_{\text{new borrowing}}$$

To ensure the identity holds, government can

- adjust spending
- adjust tax revenue
- adjust new borrowing
  or
- adjust repayment
  - via repudiation
  - via inflation

Introduction

Problem of Time-Inconsistency:

- government cannot commit to future policy
  - political pressure
  - democratic process
    (ultimately non-commitment of voters)

$\longrightarrow$ focus on "time-consistent" equilibria

$\longrightarrow$ such equilibria may exhibit multiplicity:

- good equilibrium: repayment is expected $\longrightarrow$ low interest rate
- bad equilibrium: repudiation is expected $\longrightarrow$ high interest rate

Limited Commitment in Sovereign Borrowing

Main difference to private debt: enforcement mechanism

- Borrowing in countries with good legal institutions:
  - contracts are enforced by government authorities
  - default is incentive-compatible only when borrower has negative net worth
- Borrowing relationships across sovereign nations:
  - no central authority that enforces contracts
  - severe moral hazard problem: incentive to repay much weaker than in domestic borrowing relationship
  - penalties to default are limited to:
    - seizure of external assets (usually very small)
    - exclusion from future borrowing (usually hard to coordinate)
    - sanctions on trade and financial flows (usually inexistant)
    - military invasions (nowadays used almost exclusively for oil)

Reputational Models of Sovereign Debt

Basic assumptions:

- cost of default = loss of reputation, which entails future exclusion from credit markets
- borrowers default whenever it is to their benefit

Main results:

- benefits of default grow in size of debt
- costs of market exclusion depend on output variability
- borrowers can obtain funds up to a credit ceiling
- international borrowing can only be used for intertemporal smoothing

Eaton and Gersovitz (1981): Intuition

Competitive Equilibrium with Potential Repudiation:

- lenders set credit ceiling of $\overline{b}$
- borrowers have credit demand b^*
- equilibrium $b = \min\left\{\overline{b}, b^*\right\}$

Credit ceiling depends on:

- value of continuing access to credit markets:
  - level of output
  - growth rate
  - volatility of output
- penalty in case of default:
  - level of retaliatory actions

Model Setup

Notation:

- output $y_t \sim G(y_t)$, borrowing b_t, repayment p_t
- output is not storable $\rightarrow$ consumption $c_t = y_t + b_t - p_t$
- debt due is $d_{t+1} = R(b_t)$, e.g. $d_{t+1} = (1+r) b_t$ in no-default case
- penalty in case of default is P_t and exclusion from future borrowing (grim trigger strategy)

Behavior of Agents:

- maximize utility $\max E\left[\Sigma_t \beta^t U(c_t)\right]$
- choose $b_t \in B_t$ ... set of loan amounts offered
- decide on repayment $p_t \in \{0, d_t\}$

$$
\begin{aligned}
V^D(y_t) &= E\left[\Sigma_\tau U(y_\tau - P_\tau)\right] \\
V^R(y_t, d_t) &= \sup_{b_t \in B_t} \Big\{ U(y_t + b_t - d_t) + \\
&\quad + \beta E \max\left[V^R(y_{t+1}, d_{t+1}), V^D(y_{t+1})\right] \Big\}
\end{aligned}
$$

Default Decision

Default if and only if

$$V^D(y_t) > V^R(y_t, d_t)$$

Probability of default $\lambda(d_t) = \Pr\left(\left\{V_t^D > V_t^R\right\}\right)$

Theorem (Default probability)

The probability of default increases monotonically with debt service obligations

Lending behavior:

- lenders competitive and risk-neutral
- zero profit condition implies repayment function $R^*(b_t)$ s.t.

$$\left\{1 - \lambda\left[R^*(b_t)\right]\right\} R^*(b_t) = (1+r) b_t$$

Equilibrium Under Potential Repudiation

Determination of amount lent:

- Expected repayment to lenders: $\left[1-\lambda\left(d_{t+1}\right)\right] d_{t+1}$
- Define $\overline{d}_{t+1}=\inf\left\{d: 1-\lambda\left(d_{t+1}\right)-\lambda'\left(d_{t+1}\right) d_{t+1}=0\right\}$
- Beyond $\overline{d}_{t+1}$ an increase in loan size reduces expected repayment
- Zero profit condition yields $\overline{b}_t\left(1+r\right)=\left[1-\lambda\left(\overline{d}_{t+1}\right)\right]\overline{d}_{t+1}$
  $\longrightarrow$ Credit rationing whenever $b_t^*>\overline{b}_t$

Theorem (Loan availability)

The set of available loans is bounded in $B_t=\left[0,\overline{b}_t\right]$ *for some* $\overline{b}_t<\infty$

Theorem (Loan supply)

The repayment function $R^*\left(b_t\right)$ *is increasing and convex over* $\left[0,\overline{b}_t\right]$

Note: follows from increasing $\lambda\left(d_t\right)$

Occurance of Rationing

Unconstrained optimal level of borrowing:

$$b_t^* = \arg\max_{b_t} U\left(y_t + b_t - d_t\right) + \beta E \max\left[V^R\left(y_{t+1}, R^*\left(b_t\right)\right), V^D\left(y_{t+1}\right)\right]$$

Actual level of borrowing:

$$b_t = \min\left\{\overline{b}_t, b_t^*\right\}$$

Link to Stiglitz-Weiss (1981):

- interest rate acts as an incentive device:
  probability to repay depends on interest rate
- price cannot efficiently allocate resources and incentive effects together
  $\longrightarrow$ non-price allocation mechanism occurs: rationing

Deterministic Example of Eaton and Gersovitz (1981)

Basic assumptions:

- output oscillates by $\pm\sigma$ above/below trend
- all international borrowing/lending is to smooth this shock

Observations:

- default never occurs in deterministic model
- depending on discount rate, growth rate, interest rate: borrowing in bad periods *or* saving in good periods
- desired credit b_t^* and credit ceiling $\overline{b}_t$ are higher the greater the standard deviation of the output shock
- credit ceiling rises in size of the default penalty

Critique of Reputational Models of Sovereign Debt

Bulow and Rogoff (AER, 1989a):
Sovereign Debt: Is to Forgive to Forget?

Claim: loss of reputation after default does not preclude country from accumulating savings to smooth consumption (e.g. gold, reserves, etc.)

But: country will be subject to a cash-in-advance constraint to protect counterparty from default risk

Basic Intuition: whenever PDV(repayments) > 0,

- country can default
- invest the saved repayments in contingent assets with same payoff profile to obtain smoothing benefits
- but save on repayment

$\longrightarrow$ agent is unambiguously better off

Extenstion to reputation contracts with punishment:
default if PDV(repayments) - PDV(punishments) ≥ 0

General Reputation Models

Cole and Kehoe (1997):
Reviving Reputation Models of International Debt

Separate Bulow and Rogoff (1989)'s argument into two:

1. good reputation for repayment cannot support sovereign lending
2. lending must therefore be supported by sanctions

BUT: one does not necessarily imply the other

Reputation model in Bulow and Rogoff (1989) is "partial":

- reputation only linked to borrowing relationship

General model of reputation:

- includes all relationships of a country
- allows for potential spillovers between these relationships
- debt repayment salvages reputation in other relationships, e.g. trade

Cole and Kehoe (1997)

Two kinds of relationships with reputation:

1. Transient benefits:
   - net benefits eventually diminish along equilibrium path
   - examples:
     - debt relationship (once we save enough, we don't need it anymore!)
     - access to common pool of exhaustible resources

   $\longrightarrow$ unique equilibrium: no debt
2. Enduring benefits
   - large and long-lasting, for example
     - constant per-period benefits from trade
     - access to stream of innovations

   $\longrightarrow$ positive level of debt can be supported

Duality:

What is the difference between "reputation with enduring benefit" and "punishment"?

Bulow and Rogoff: Recontracting of Sovereign Debt

Bulow and Rogoff (JPE, 1989b):
A Constant Recontracting Model of Sovereign Debt

Motivation:

- reputation is an unsatisfactory incentive for repayment
- focus on threat of sanctions as an incentive
- possibility to renegotiate debts is at the center stage

Difficulties:

- sanctions are off-equilibrium strategy
- hard to estimate empirically

Bulow and Rogoff (1989): Model Setup

Consumer behavior:

$$\max E\left\{\sum_i \frac{C^D_{t+hi} + C^F_{t+hi}}{(1+\delta h)^i}\right\}$$

h ... time interval between periods
C^D_t, C^F_t are consumption of domestic good D, foreign good F

Technology: exogenous production $\overline{y}h$ of good D, which can be

- consumed
- exported: quantity T_t yields $T_t P$ units of F, where $P > 1$
- stored at a "deterioration rate" of γ such that

$$S_{t+h} = (1-\gamma h)\, S_t + \overline{y}h - C^D_t - T_t$$

in default: lenders impose sanctions that cost fraction β of exports

Sovereign Borrowing Relationship

Current account balance:

$$C_t^F = T_t P\left(1 - \beta X_t\right) - R_t$$

where X_t indicator for default, R_t is size of repayments

Behavior of banks:

- if borrowers default, seize fraction $\alpha \leq \beta$ of exports
- competitiveness yields zero profit condition:

$$E\left\{\sum_i \frac{R_{hi} + \alpha T_{hi} X_{hi}}{(1+rh)^i}\right\} = 0$$

Incentive Compatibility Constraint

Punishment device for default: seize fraction β of export revenue:

- if $\beta P > P - 1$: autarky is optimal
- if $\beta P < P - 1$: exporting and letting creditors seize β is optimal

Definition (Incentive compatibility constraint, no bargaining)

The country's credit limit is given by

$$\mathfrak{K} \leq \min\left\{\beta P, P - 1\right\} \cdot \frac{\overline{y}}{r}$$

Note:

- if bank could make a take-it-or-leave-it offer, this would be the equilibrium
- in practice: this is not time-consistent $\longrightarrow$ non-credible threat

$\Rightarrow$ Country and lender will engage in bargaining

Bargaining Game

Bargaining game:

- Borrowers cannot commit to future payments
  $\longrightarrow$ only current payment can be contracted
- Since $\delta > r$, country never pre-pays for future benefit

$\Rightarrow$ **Basic question:** How much do I have to pay today so that banks let me trade free of sanctions for this period?
Banks and borrower make alternating offers over distribution q of wealth:

$$\begin{array}{rccc} \text{banks receive} & q_t P & (\overline{y}h + S_t) \\ \text{borrower receives} & (1 - q_t) P & (\overline{y}h + S_t) \end{array}$$

Nash Bargaining Solution

Nash Bargaining Solution following Rubinstein (1982):

$$q^{\text{Nash}} = \frac{\gamma + \delta}{2\gamma + \delta + r}$$

Maximum level of repayments:

$$R = \min \left\{ \frac{\gamma + \delta}{2\gamma + \delta + r}, \beta, \frac{P-1}{P} \right\} \cdot P\overline{y}$$

$\longrightarrow$ Three different repayment regimes

Regions of Repayments

3 Different Repayment Regimes:

1. Bargaining region:
   - country receives $P\overline{y}\frac{\gamma+r}{2\gamma+\delta+r}$
   - banks receive $P\overline{y}\frac{\gamma+\delta}{2\gamma+\delta+r}$
2. Autarky-constrained region:
   - arises if gains from trade are relatively small
   - banks make offer for repayment of $(P-1)\,\overline{y}-\varepsilon$
   - banks' recovery of debt very sensitive to fluctuations in P
3. Punishment-constrained region:
   - arises if punishment relatively small
   - banks make offer for repayment of $\beta P\overline{y}-\varepsilon$
   - NOTE: ability to punish does not affect equilibrium outside this area

Maximum Sustainable Debt Level

Maximum sustainable debt level $\mathfrak{R}$ = NPV(repayments):

$$\mathfrak{R} = \min\left\{\frac{\gamma+\delta}{2\gamma+\delta+r}, \beta, \frac{P-1}{P}\right\} \cdot \frac{P\overline{y}}{r}$$

(any loan beyond this amount would never be repaid)

NOTE: since $\delta > r$, country will immediately jump to $\mathfrak{R}$ and make repayments forever after

Effects of higher interest rates on $\mathfrak{R}$:

- higher discount rate applied to calculate NPV(repayments)
- banks become more impatient bargainers

$\longrightarrow$ equilibrium with lower debt ceiling

Involvement of Creditor Country Government

If gains from trade are important for creditor country:

- Banks and borrowers rationally anticipate bailout payments
- Credit limit $\mathfrak{R}$ is increased
- Bailout constitutes transfer from taxpayers in creditor country to borrowing country (banks earn zero profits!)
- Creditor country government would like to commit not to make payments, but commitment often not credible
- Forms of side payments:
  - write-down of official debts
  - extension of new loans by government
  - funding for multilateral institutions
  - tax breaks for banks that suffer losses

Atkeson (1991): Moral Hazard and Repudiation

Atkeson (Econometrica, 1991): International Lending with Moral Hazard and Risk of Repudiation

Common stylized facts about emerging market economies:
Indebted countries who are hit by an adverse shock

- lose access to international capital markets
- are asked to repay existing loans

$\longrightarrow$ current account reversals, financial crises

Contrast: complete market models:

- countries should be able to insure costlessly
- perfectly smooth consumption

Atkeson (1991): Moral Hazard and Repudiation

Atkeson's Solution:
Observed pattern of international capital flows results from optimal contract under 2 imperfections:

1. Moral hazard:
   - lenders cannot observe if loans were invested or consumed
   - low output is signal that past investment was low
   - optimal contract specifies repayment in low states
   - this imposes fall in consumption and investment as a penalty
     $\longrightarrow$ moral hazard problem solved
2. Risk of repudiation:
   - limits the size of repayments that can be demanded
   - imposes limit on maximum amount of debt provided

Quantitative models of emerging market borrowing

Main issues in the quantitative analysis of EM borrowing:

Joint analysis of:

- high debt levels
- equilibrium default
- volatile interest rates
- pro-cyclical capital flows
- large economic fluctuations

Quantitative analysis of emerging market borrowing

Cristina Arellano (2008): Default Risk and Income Fluctuations:

Main difficulty: *Why does default occur in recessions?*

- in Eaton-Gersovitz: highest incentives for default in good times
- here: uncontingent bonds imply debt rises during recession, up to a point where debt service causes net capital outflows
- outflows are more costly in recession
  $\longrightarrow$ higher incentive to default
  $\longrightarrow$ higher interest rates
- quantitative specification requires higher [exogenous] default cost in boom times:

$$c^D = \max\{y, \hat{y}\}$$

Quantitative analysis of emerging market borrowing

Vivian Yue (2006): Sovereign Default and Debt Renegotiation:

Main insight: *Debt renegotiation increases sustainble debt levels*

- recovery rates based on Nash bargaining (Bulow-Rogoff...)
- in lower states of nature: lower recovery
  $\longrightarrow$ higher default risk
- recovery rate is an additional market clearing instrument
- increases counter-cyclicality of default risk and interest rates

Calvo (1988): Servicing the Public Debt

Calvo (AER, 1988): Servicing the Public Debt: The Role of Expectations

Model Setup:

- two time periods: $t = 0, 1$
- two types of agents: consumers and government

Government:

- in period 0, government borrows b and promises to repay $R_b b$
- in period 1, government repudiates a proportion $\theta \in [0, 1]$ and incurs at deadweight cost $\alpha < 1$ per unit repudiated
- outside option to invest in capital k at fixed rate of return R

$$\rightarrow \quad (1 - \theta) R_b = R$$

- budget constraint of the government:

$$x = (1 - \theta) b R_b + g + \alpha \theta b R_b \qquad \text{(Gvt.BC)}$$

Calvo (1988)

Consumer budget constraint:

$$c = y - z(x) + kR + (1-\theta)\, bR_b - x \qquad \text{(C.BC)}$$

where $z(x)$ is a convex deadweight loss from taxation

from (Gvt.BC), the repudiated debt satisfies

$$\theta bR_b = \frac{bR_b + g - x}{1-\alpha}$$

In period 1**,** a time-consistent government takes bR_b as given

Maximizing consumption c w.r.t. x gives

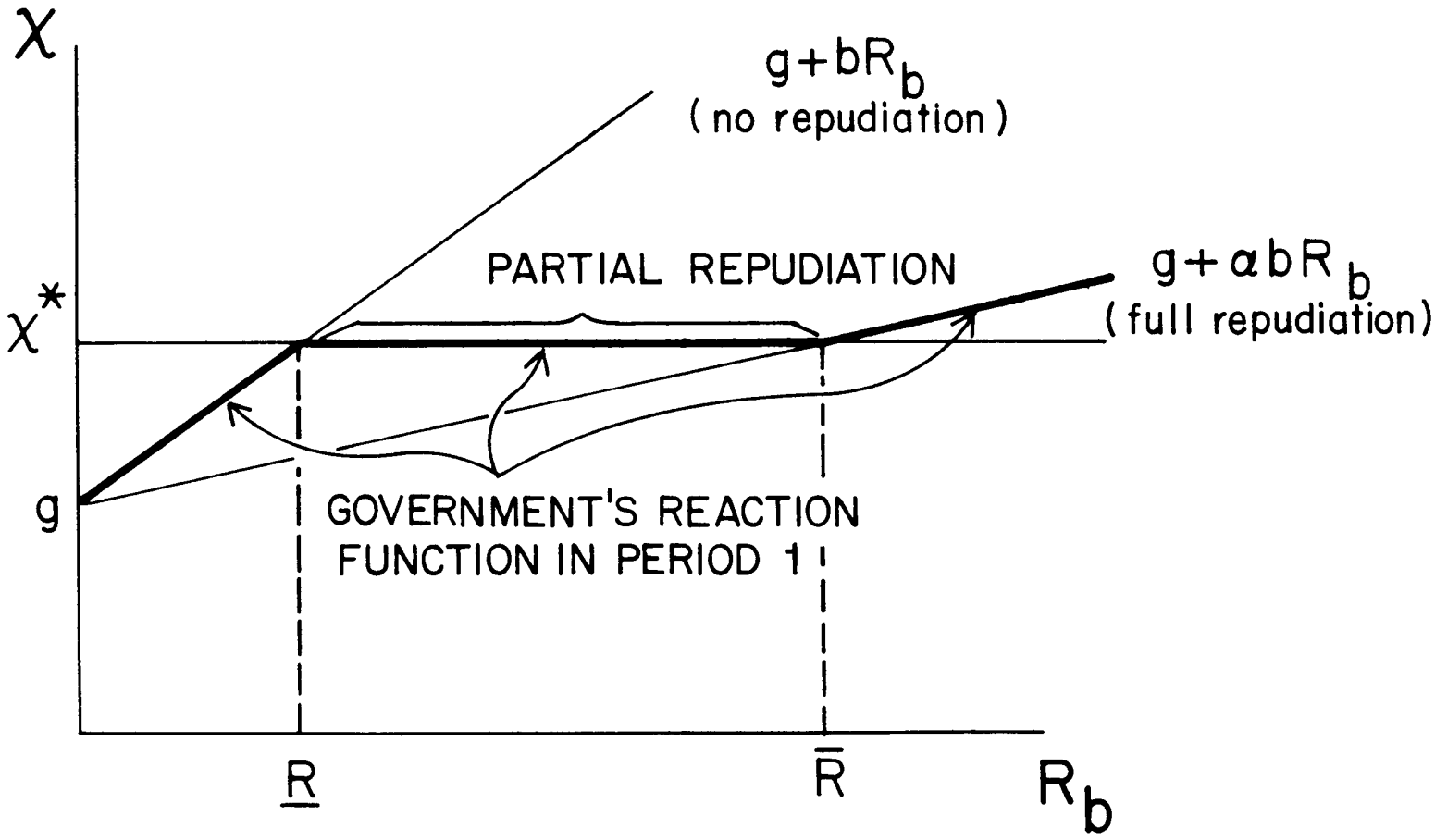
$$FOC(x): \quad z'(x) = \frac{\alpha}{1-\alpha} \quad \rightarrow \quad \text{defines unconstrained } x^*$$

x satisfies the govt. budget constraint, i.e. $\theta \in [0,1]$, if

$$g + \alpha bR_b \leq x \leq g + bR_b$$

Calvo (1988)

Period 1 Reaction Function:



Choice of best response x as a function of R_b

$\longrightarrow$ optimal repudiation is increasing function of R_b

Calvo (1988)

Period 0 Equilibrium:
consistency condition combining govt. budget constraint and investor participation constraint $(1-\theta) R_b = R$:

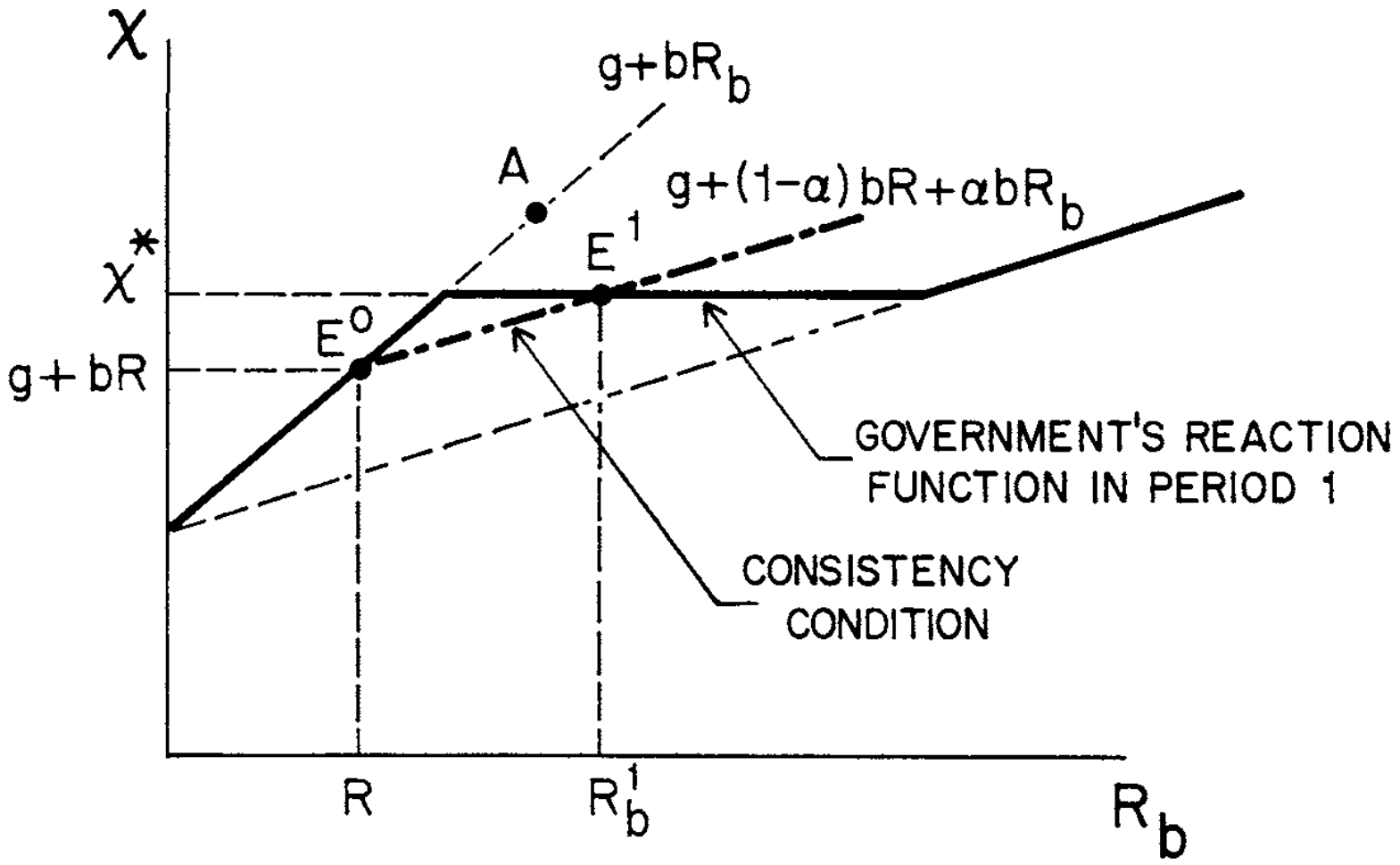
$$x = g + (1-\alpha) bR + \alpha bR_b$$

$\longrightarrow$ defines feasible combinations of (x, R_b)

3 Possibilites:
if $x^* > g + bR$: two equilibria
if $x^* = g + bR$: unique equilibrium with $R_b = R = \underline{R}$
if $x^* < g + bR$: no debt issuance possible

Calvo (1988)

Determination of Equilibrium in Period 0:



Calvo (1988)

Total Consumption:

$$c = y - z(x) + (k + b) R - x$$

Case of Multiple Equilibria:
in good equilibrium: no repudiation, $R_b = R$, $x = g + bR$
in bad equilibrium: partial repudation, $R_b > R$, $x = x^*$
$\longrightarrow$ welfare-inferior

Note: x^* is an increasing function of α
$\longrightarrow$ for low α, no debt can be sustained
$\longrightarrow$ costly α makes bad equilibrium more costly, but it still exists

Possible solution: refuse to sell bonds at $R_b > R$

Calvo (1988)

Money and Nominal Debt:
we can interpret inflation as partial repudiation

- redefine $R_b = 1 + i$
- denote price levels as P_0 and P_1 and $\pi = \frac{P_1 - P_0}{P_0}$
- real return is $P_0 / P_1 \cdot R_b = (1 - \theta) R_b$ so $\theta = \frac{\pi}{1+\pi}$
- money demand: $M/P = \kappa \longrightarrow$ seigniorage revenue $\kappa\theta$

Government budget constraint:

$$x = (1 - \theta) bR_b + g - \kappa\theta$$

Consumption, reduced by convex inflation cost $\mathfrak{R}(\theta)$:

$$c = y - z(x) + kR + (1 - \theta) bR_b - x - \kappa\theta - \mathfrak{R}(\theta)$$

Calvo (1988)

First-Best Equilibrium (under commitment):

$$\min_{\theta} z\left(g + bR - \kappa\theta\right) + \mathfrak{R}\left(\theta\right)$$

$\longrightarrow$ defines θ^{fb} via FOC $z'\left(x\right)\kappa = \mathfrak{R}'\left(\theta\right)$

Note: consumption is lower the higher inflation

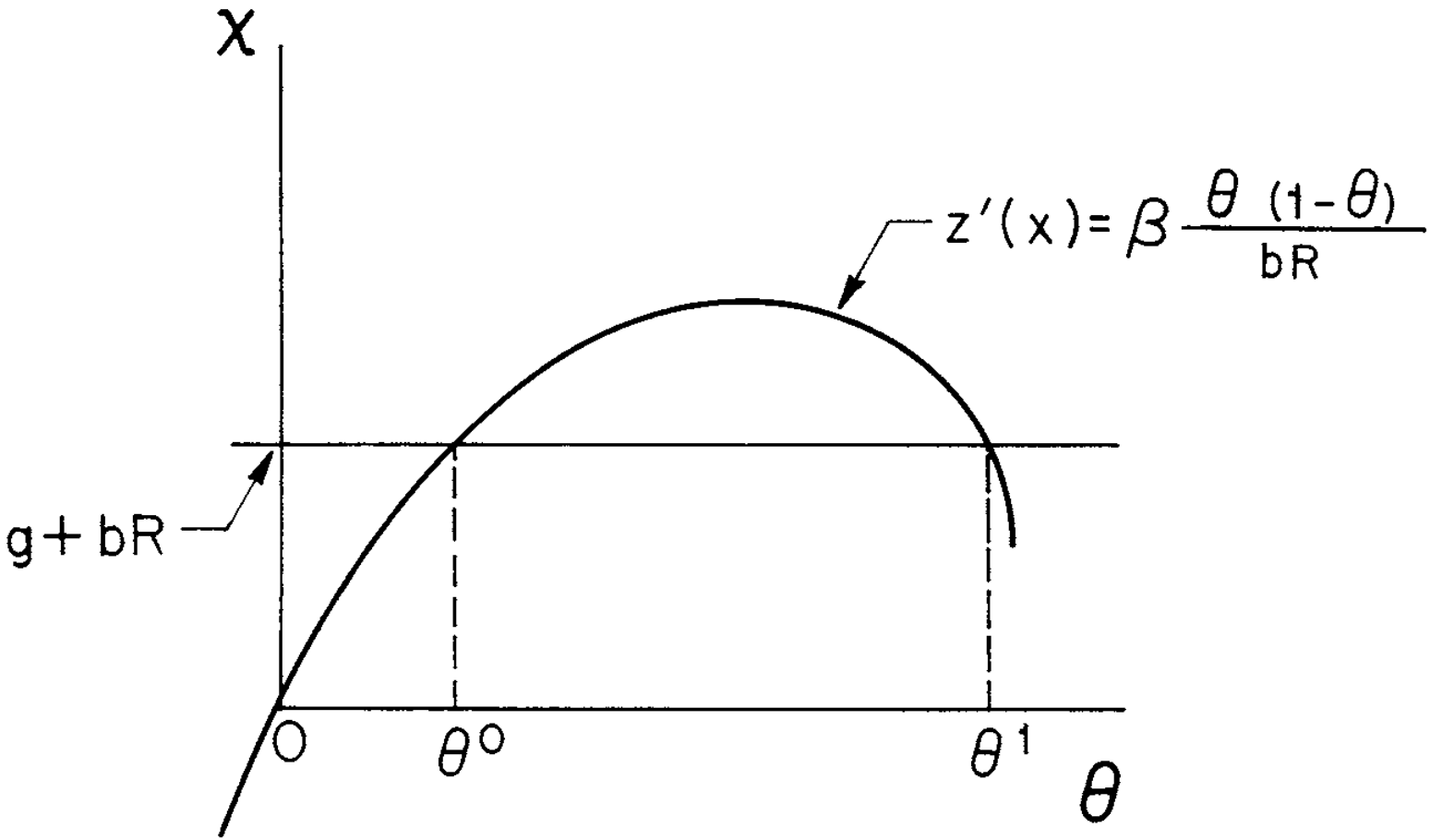
Second-Best Equilibrium (time-consistent – optimizing in pd 1):

$$\min z\left(g + b\left(1-\theta\right)R_b - \kappa\theta\right) + \mathfrak{R}\left(\theta\right)$$
$$FOC\left(x\right): \; z'\left(x\right)\left(bR_b + \kappa\right) = \mathfrak{R}'\left(\theta\right)$$

$\longrightarrow$ defines $\theta^{sb} > \theta^{fb}$ which satisfies $\partial\theta^{sb}/\partial(bR_b) > 0$ and $\partial\theta^{sb}/\partial g > 0$

Calvo (1988)

Multiple Equilibria in Monetary Example:



Jeanne (2012): Fiscal Challenges

Fiscal Challenges to Monetary Dominance in the Euro Area

Two (caricature) views on European debt crisis:

1. "Northern View:" interest rate spreads on Southern debt
   - reflect default risk
   - are desirable to provide incentives for consolidation
2. "Southern View:" interest rate spreads on Southern debt
   - reflect self-fulfilling bad equilibrium
   - could easily be avoided by lender-of-last-resort
     $\longrightarrow$ actually emergency lending only off equilibrium

Contribution:

- "Southern View" ignores non-zero possibility of default
- "Northern View" ignores difficulty of adjustment with excessive spreads $\longrightarrow$ incentives may actually weaken

Jeanne (2012): Fiscal Challenges

Background (Sargent and Wallace, 1981):

Monetary dominance:

- monetary authorities control inflation (leader)
- fiscal authorities take seigniorage as given and implement feasible fiscal path to ensure solvency (follower)

Fiscal dominance:

- fiscal authorites choose spending path (leader)
- monetary authorities provide seigniorage revenue to ensure solvency (follower)

Jeanne (2012): Fiscal Challenges

Model Setup:

- 2 periods $t = 1, 2$ (short & long term)
- central bank targets $\pi = 0$
- fiscal authority needs to roll over debt d_1 at $t = 1$

$$(1 + i)\, d_1 = d_2$$

- government budget constraint at $t = 2$ is

$$\underbrace{(1 - h)}_{\text{possible haircut}} \; r d_2 = \underbrace{b}_{\text{fiscal balance}} + \underbrace{s(\pi)}_{\text{seigniorage}}$$

  where r is risk-less real interest rate

- fiscal balance b needs to adjust to debt to avoid haircut/inflation

Jeanne (2012): Fiscal Challenges

Possibility of Debt Crises:

- probability $P(b)$ that fiscal authorities fail to do so satisfies $P(\underline{b}) = 0$, $P(\bar{b}) = 1$ and $P'(b) > 0$ in between
- two adjustment possibilities:
  - probability μ: default/haircut: $1 - h = b/rd_2$
  - probability $1 - \mu$: inflation: $s(\pi) = rd_2 - b$

  $\longrightarrow \mu$ is a measure of monetary credibility

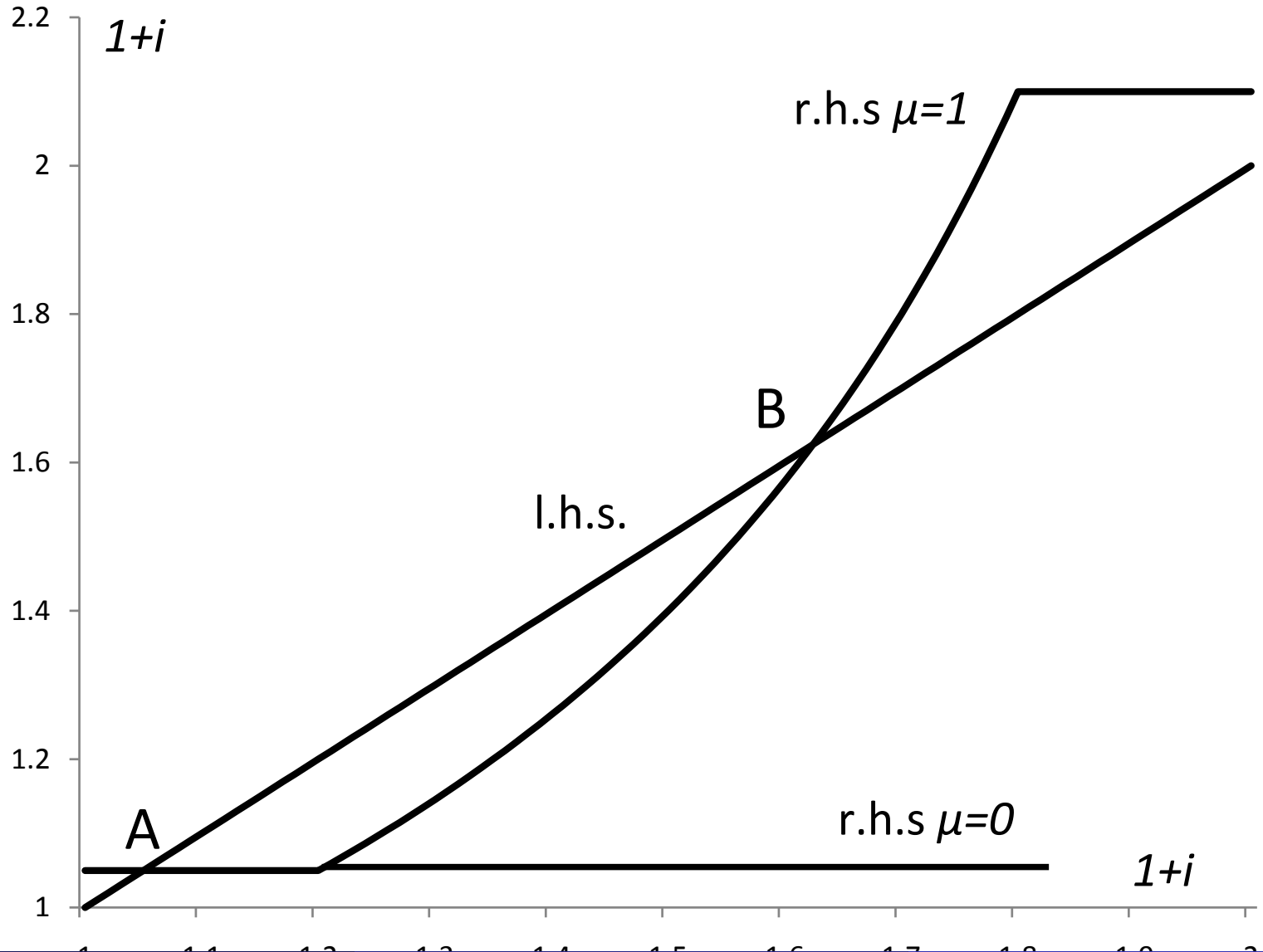
- participation constraint of investors:

$$(1+i)\left[1 - \mu h P(b)\right] = 1 + r \quad \text{or} \quad 1 + i = \frac{1+r}{1 - \mu h P\left(r(1+i)\, d_1\right)}$$

  $\longrightarrow$ both sides of equation are increasing in i
  $\longrightarrow$ possibility of Calvo-style multiple equilibria

Jeanne (2012): Fiscal Challenges

Multiple Equilibria:



Jeanne (2012): Fiscal Challenges

Possibility of Debt Crises:

- if $P(rd_1) = 0$ then committing to $\mu = 0$ (lending-of-last-resort) rules out default and will be off-equilibrium
  $\longrightarrow$ no monetization needs to occur

- if $P(rd_1) > 0$ then
  - if μ is high (hard monetary dominance):
    it is impossible to roll over debt at $t = 1$
    $\longrightarrow$ immediate default, no possibility of fiscal adjustment
  - if μ takes on intermediate values: some adjustment, some inflation risk
    BUT: locally, higher μ makes inflation more likely
    (greater interest rate implies more debt)
  - if μ is low: there is still risk that inflation will result

  $\longrightarrow$ parameter μ determines trade-off between default/inflation
  $\longrightarrow$ in terms of welfare, intermediate values preferable