Gambling for Redemption and Self-Fulfilling Debt Crises

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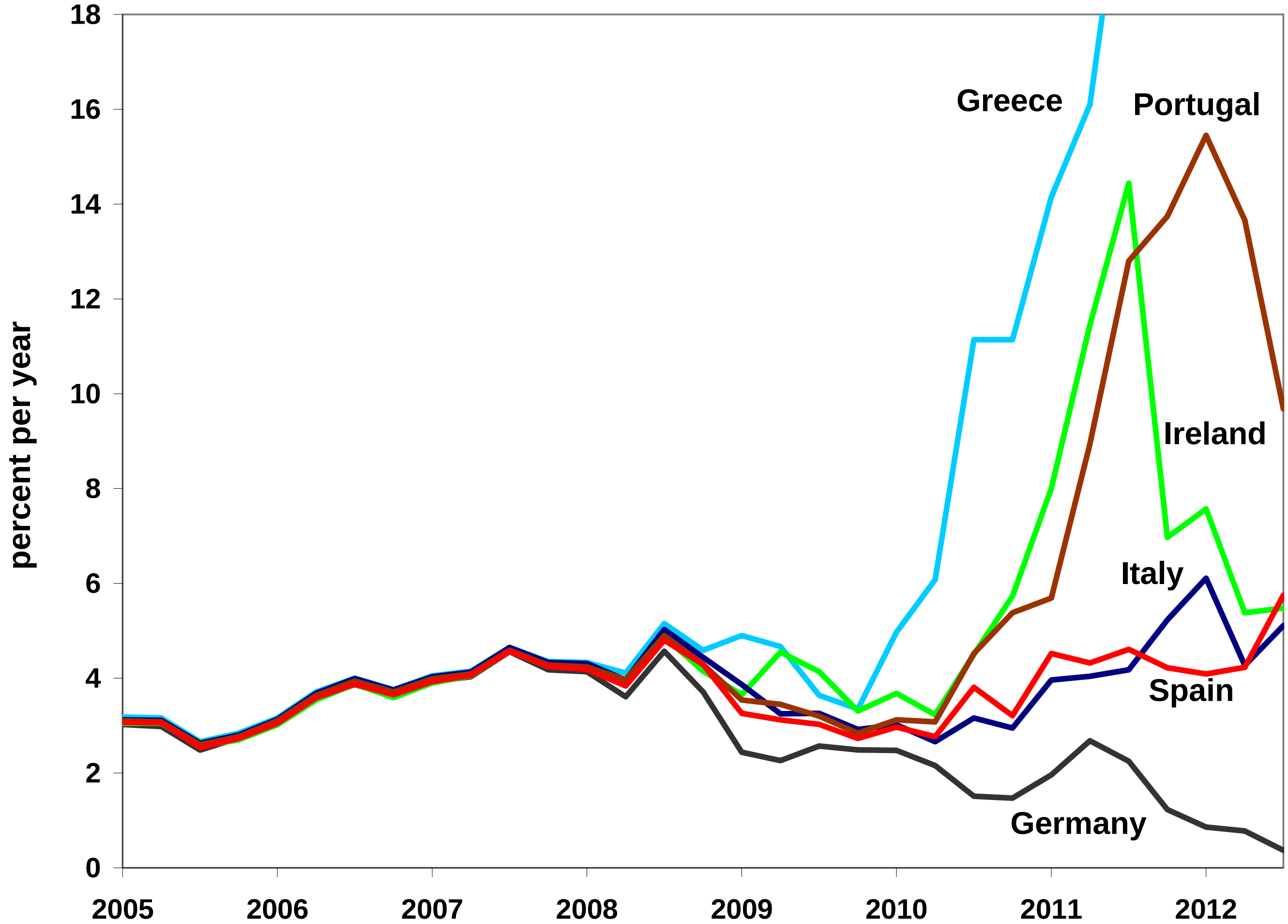
Jumps in spreads on yields on bonds of PIIGS governments (over yields on German bonds)



Yields on 5-year government bonds

Definition

Crisis: government forced to default because of inability to rollover debt.

Note 1: Paying high yields to place bonds is not a crisis.

Note 2: As of today, only Greece has suffered a crisis.

Theory of self-fulfilling debt crises (Cole-Kehoe)

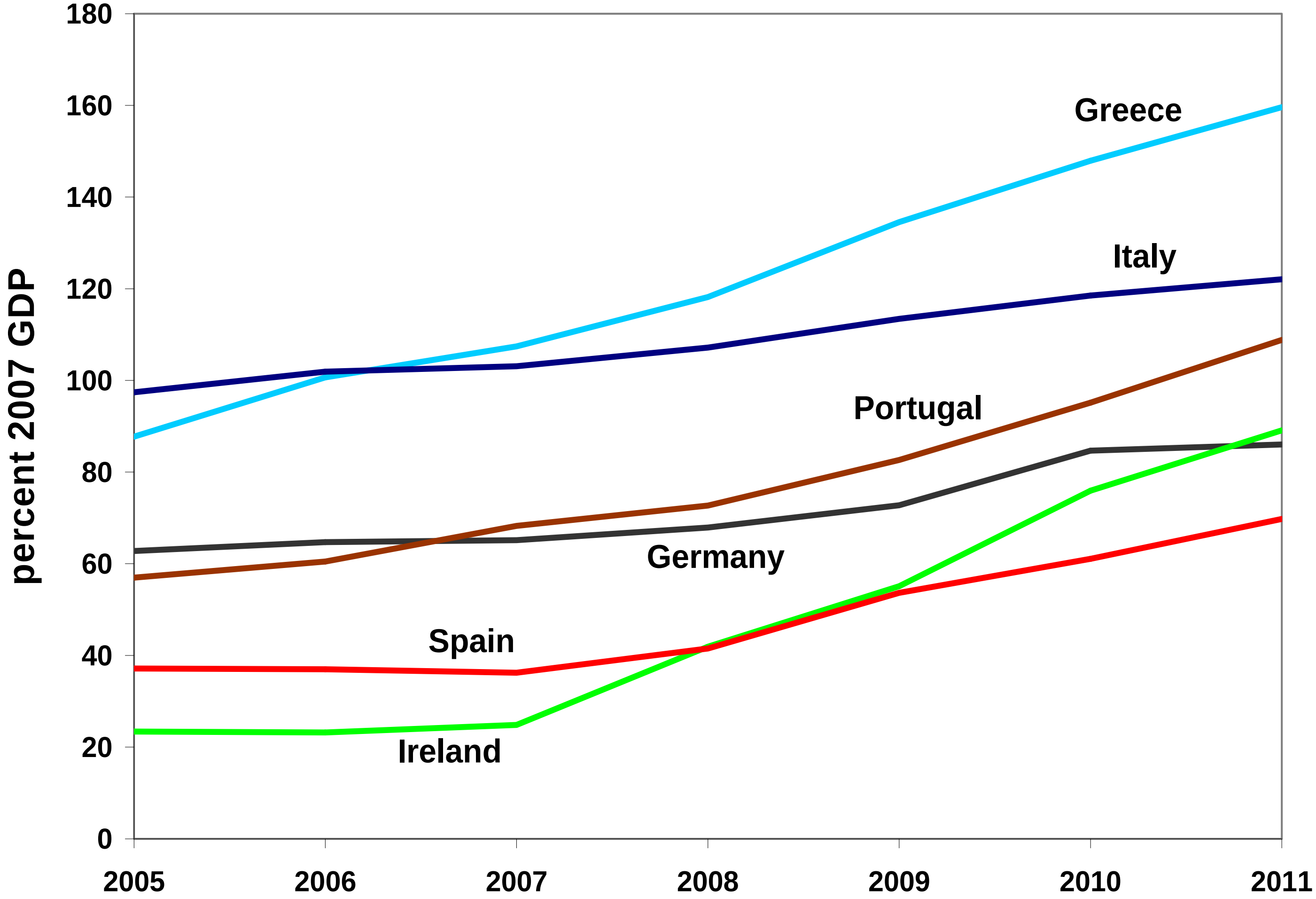
Spreads reflect probabilities of crises

For low enough levels of debt, no crisis is possible

For high enough levels of debt, default

For intermediate levels of debt (crisis zone) optimal policy is to run down debt

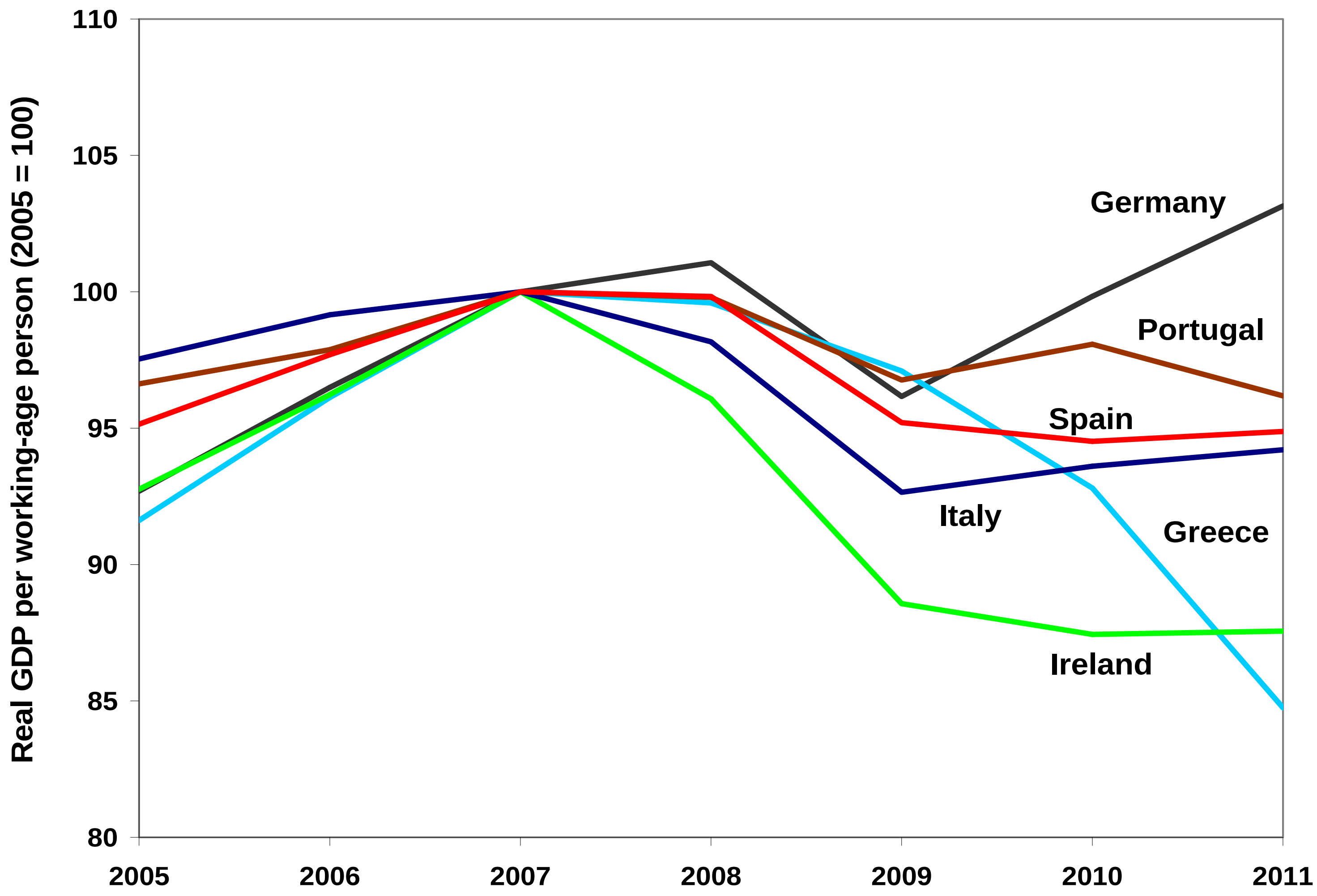
…but PIIGS ran up debt.



Government debt

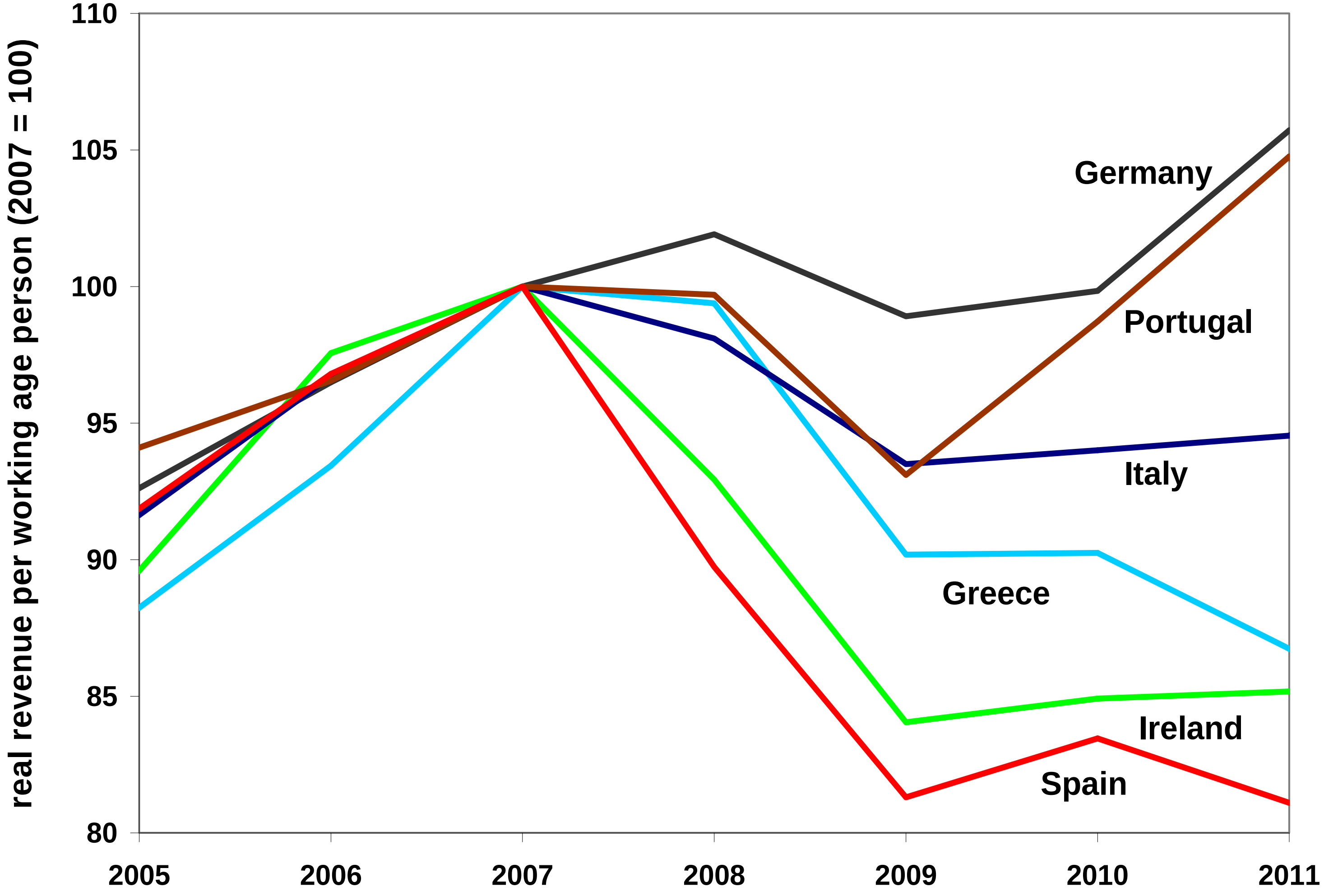
What is missing in Cole-Kehoe?

Severe recession in PIIGS, still ongoing



Real GDP

…government revenues also depressed.



Government revenues

This paper

Extends Cole-Kehoe to stochastic output.

Standard consumption smoothing argument (as in Aiyagari, Chaterjee et al, Arellano) can imply running up debt.

When running up debt is optimal, we call it "gambling for redemption."

Use model to evaluate impact of EU-IMF policy.

Two policy experiments

Lend at onset of crisis at interest rate above pre-crises level (Clinton’s bailout of Mexico in 1995).

Lend before onset of crisis at below-market interest rate (EU-IMF rescue packages and ECB lending policies in 2010–2012).

Main mechanism of our theory

Model characterizes two forces in opposite directions:

1. Run down debt (as in Cole-Kehoe)

2. Run up debt (consumption smoothing)

Which one dominates depends on parameter values and EU-IMF policies.

Run down debt

In crisis zone run down debt if:

- Interest rates are high.
- Costs of default are high.

Run up debt

In recession run up debt if:

- Interest rates are low.
- Costs of default are low.
- Recession is severe.
- Probability of recovery is high.

General model

Agents:

Government

International bankers, continuum [0,1]

Consumers, passive (no private capital)

Third party in policy experiments

General model

State of the economy: $s = (B, a, z_{-1}, \zeta)$

B: government debt

a: private sector, $a = 1$ normal, $a = 0$ recession

z_{-1}: previous default $z_{-1} = 1$ no, $z_{-1} = 0$ yes

ζ: realization of sunspot

GDP: $y(a,z) = A^{1-a} Z^{1-z} \overline{y}$

$1 > A > 0$, $1 > Z > 0$ parameters.

Model with no recovery (Cole-Kehoe)

State of the economy: $s = (B, 1, z_{-1}, \zeta)$

B: government debt

z_{-1}: previous default $z_{-1} = 1$ no, $z_{-1} = 0$ yes

ζ: realization of sunspot

GDP: $y(1, z) = Z^{1-z}\bar{y}$

$1 > Z > 0$ parameter.

Model without crises

State of the economy: $s = (B, a, 1, \cdot)$

B: government debt

a: private sector, $a = 1$ normal, $a = 0$ recession

GDP: $y(a,1) = A^{1-a}\bar{y}$

$1 > A > 0$ parameter.

General model

Before period 0, $a = 1$, $z = 1$.

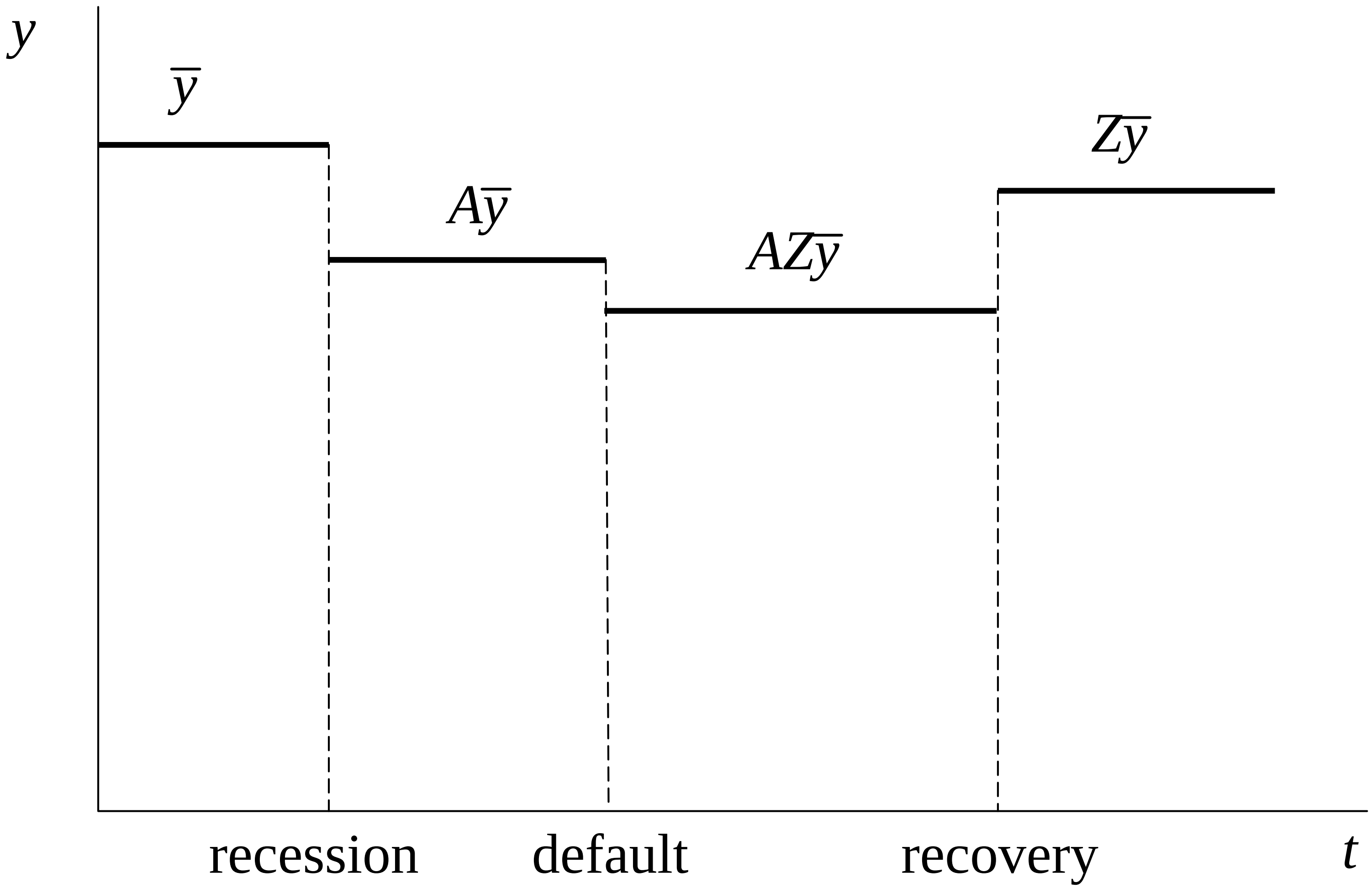
In $t = 0$, $a_0 = 0$ unexpectedly, GDP drops from $\bar{y}$ to $A\bar{y} < \bar{y}$.

In $t = 1, 2, ...,$ a_t becomes 1 with probability p.

$1 - A$ is severity of recession. Once $a_t = 1$, it is 1 forever.

$1 - Z$ is default penalty. Once $z_t = 0$, it is 0 forever.

A possible time path for GDP



Sunspot

Coordination device for international bankers' expectations.

$\zeta_t \sim U[0,1]$

B_t outside crisis zone: if ζ_t is irrelevant

B_t inside crisis zone: if $\zeta_t \geq 1 - \pi$ bankers expect a crisis (π arbitrary)

Government's problem

Depends on timing, equilibrium conditions, to be described.

Government tax revenue is $\theta y(a,z)$, tax rate θ is fixed.

Choose c, g, B', z to solve:

$$V(s) = \max \ u(c,g) + \beta EV(s')$$

$$\text{s.t. } c = (1-\theta)y(a,z)$$

$$g + zB = \theta y(a,z) + q(B',s)B'$$

$$z = 0 \text{ if } z_{-1} = 0.$$

International bankers

Continuum [0,1] of risk-neutral agents with deep pockets

First order condition and perfect foresight condition:

$$q(B',s) = \beta \times Ez(B',s',q(B',s')).$$

bond price = risk-free price × probability of repayment

Timing

a_t, ζ_t realized, $s_t = (B_t, a_t, z_{t-1}, \zeta_t)$

$\downarrow$

government offers B_{t+1}

$\downarrow$

bankers choose to buy B_{t+1} or not, q_t determined

$\downarrow$

government chooses z_t, which determines y_t, c_t, and g_t

Notes

Time-consistency problem: when offering B_{t+1} for sale, government cannot commit to repay B_t

Perfect foresight: bankers do not lend if they know the government will default.

Bond price depends on B_{t+1}; crisis depends on B_t.

Recursive equilibrium

Value function for government $V(s)$ and policy functions

$B'(s)$ and $z(B',s,q)$ and $g(B',s,q)$,

and a bond price function $q(B',s)$

such that:

1. Beginning of period: Given $z(B',s,q)$, $g(B',s,q)$, $q(B',s)$ government chooses B' to solve:

$$V(s) = \max u(c,g) + \beta EV(s')$$

$$\text{s.t. } c = (1-\theta)y(a, z(B',s,q(B',s))$$

$$g(B',s,q(B',s)) + z(B',s,q(B',s))B = \theta y(a,z) + q(B',s)B'$$

2. Bond market equilibrium:

$$q(B'(s),s) = \beta Ez(B'(s),s',q(B'(s),s')).$$

3. End of period: Given $V(B', a', z, \zeta')$ and $B' = B'(s)$ and $q = q(B'(s), s)$, government chooses z and g to solve:

$$\max u(c, g) + \beta EV(B', a', z, \zeta')$$

$$\text{s.t. } c = (1-\theta) y(a, z)$$

$$g + zB = \theta y(a, z) + qB'$$

$$z = 0 \text{ or } z = 1$$

$$z = 0 \text{ if } z_{-1} = 0.$$

Characterization of government's optimal debt policy

Four cutoff levels of debt: $\bar{b}(a)$, $\bar{B}(a)$, $a = 0,1$:

- If $B \leq \bar{b}(a)$, repay
- If $\bar{b}(a) < B \leq \bar{B}(a)$, default if $\zeta > 1 - \pi$
- If $B > \bar{B}(a)$, default

We can show:

$\overline{b}(0) < \overline{b}(1)$, $\overline{b}(0) < \overline{B}(0)$, $\overline{b}(1) < \overline{B}(1)$, and $\overline{B}(0) < \overline{B}(1)$.

$\overline{b}(1)$, $\overline{B}(0)$?

Most interesting case:

$$\overline{b}(0) < \overline{b}(1) < \overline{B}(0) < \overline{B}(1).$$

Other cases (catastrophic recessions):

$$\overline{b}(0) < \overline{B}(0) < \overline{b}(1) < \overline{B}(1)$$

$$\overline{b}(0) < \overline{b}(1) = \overline{B}(0) < \overline{B}(1).$$

Characterization of equilibrium prices

After default bankers do not lend: $q(B',(B,a,0,\zeta))=0$.

During a crisis bankers do not lend: If $B>\overline{b}(a)$ and $\zeta \geq 1-\pi$, $q(B',(B,a,1,\zeta))=0$

Otherwise, q depends only on B'.

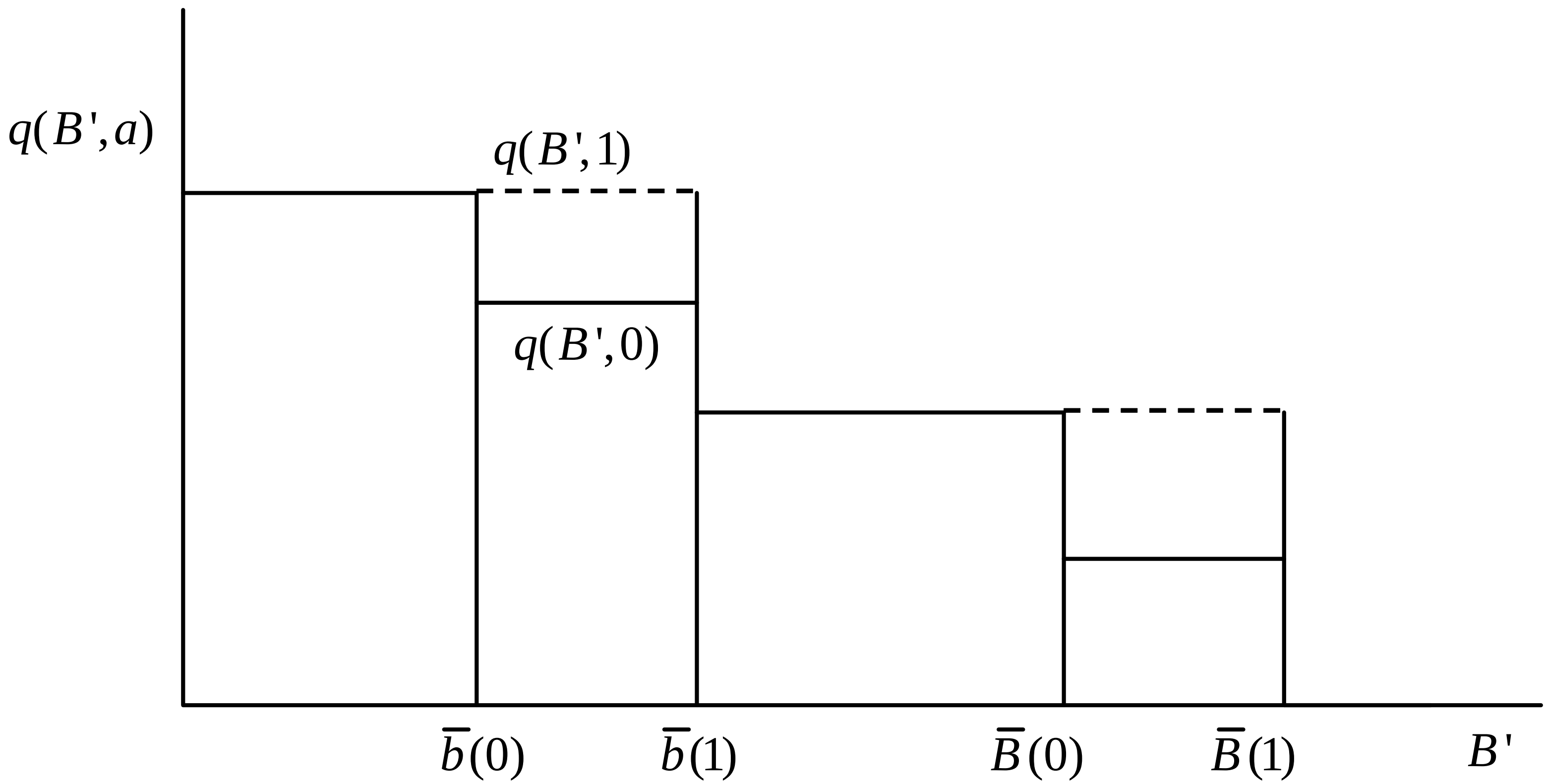
In normal times (as in Cole-Kehoe):

$$q(B',(B,1,1,\zeta)) = \begin{cases} \beta & \text{if } B' \le \bar{b}(1) \\ \beta(1-\pi) & \text{if } \bar{b}(1) < B' \le \bar{B}(1) \\ 0 & \text{if } \bar{B}(1) < B' \end{cases}$$

In a recession (for the most interesting case):

$$q(B',(B,0,1,\zeta)) = \begin{cases} \beta & \text{if } B' \le \bar{b}(0) \\ \beta\left(p+(1-p)(1-\pi)\right) & \text{if } \bar{b}(0) < B' \le \bar{b}(1) \\ \beta(1-\pi) & \text{if } \bar{b}(1) < B' \le \bar{B}(0) \\ \beta p(1-\pi) & \text{if } \bar{B}(0) < B' \le \bar{B}(1) \\ 0 & \text{if } \bar{B}(1) < B' \end{cases}$$

Bond prices as function of debt and a



Characterization of optimal debt policy

Two special cases with analytical results:

- $p = 0$ (no gambling for redemption)
- $\pi = 0$ (no crises)

General model with numerical experiments:

- $V(s)$ has kinks and $B'(s)$ is discontinuous because of discontinuity of $q(B', s)$.
- $V(s)$ is discontinuous because government cannot commit not to default.

.

Self-fulfilling liquidity crises, no gambling

$p = 0$, also limiting case where $a = 0$ and $p = 0$: Replace $\overline{y}$ with $A\overline{y}$.

Cole-Kehoe without private capital.

Start by assuming that $\pi = 0$.

When $s = (B, a, z_{-1}, \zeta) = (B, 1, 1, \zeta)$,

$$V(B,1,1,\zeta) = \frac{u((1-\theta)\bar{y}, \theta\bar{y} - (1-\beta)B)}{1-\beta}.$$

When default has occurred, $s = (B, a, z_{-1}, \zeta) = (B, 1, 0, \zeta)$,

$$V(B,1,0,\zeta) = \frac{u((1-\theta)Z\bar{y}, \theta Z\bar{y})}{1-\beta}.$$

$\bar{b}(1)$:

Utility of repaying even if bankers do not lend:

$$u((1-\theta)\bar{y},\theta\bar{y}-B)+\frac{\beta u((1-\theta)\bar{y},\theta\bar{y})}{1-\beta}$$

Utility of defaulting if bankers do not lend:

$$\frac{u((1-\theta)Z\bar{y},\theta Z\bar{y})}{1-\beta}.$$

$\bar{b}(1)$ is determined by

$$u((1-\theta)\bar{y},\theta\bar{y}-\bar{b}(1))+\frac{\beta u((1-\theta)\bar{y},\theta\bar{y})}{1-\beta}=\frac{u((1-\theta)Z\bar{y},\theta Z\bar{y})}{1-\beta}$$

Determination of $\overline{B}(1)$ requires optimal policy.

If $B_0 > \overline{b}(1)$ and the government decides to reduce B to $\overline{b}(1)$ in T periods, $T = 1, 2, ..., \infty$. First-order conditions imply

$$g_t = g^T(B_0).$$

$$g^T(B_0) = \theta\overline{y} - \frac{1-\beta(1-\pi)}{1-(\beta(1-\pi))^T}\left(B_0 - (\beta(1-\pi))^{T-1}\beta\overline{b}(1)\right).$$

$$g^\infty(B_0) = \lim_{T\to\infty} g^T(B_0) = \theta\overline{y} - (1-\beta(1-\pi))B_0.$$

Compute $V^T(B_0)$:

$$V^T(B_0) = \frac{1-(\beta(1-\pi))^T}{1+\beta(1-\pi)} u((1-\theta)\overline{y}, g^T(B_0))$$

$$+\frac{1-(\beta(1-\pi))^{T-1}}{1+\beta(1-\pi)} \frac{\beta\pi u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta}$$

$$+(\beta(1-\pi))^{T-2} \frac{\beta u((1-\theta)\overline{y}, \theta\overline{y}-(1-\beta)\overline{b}(1))}{1-\beta}$$

To find $\overline{B}(1)$, we solve

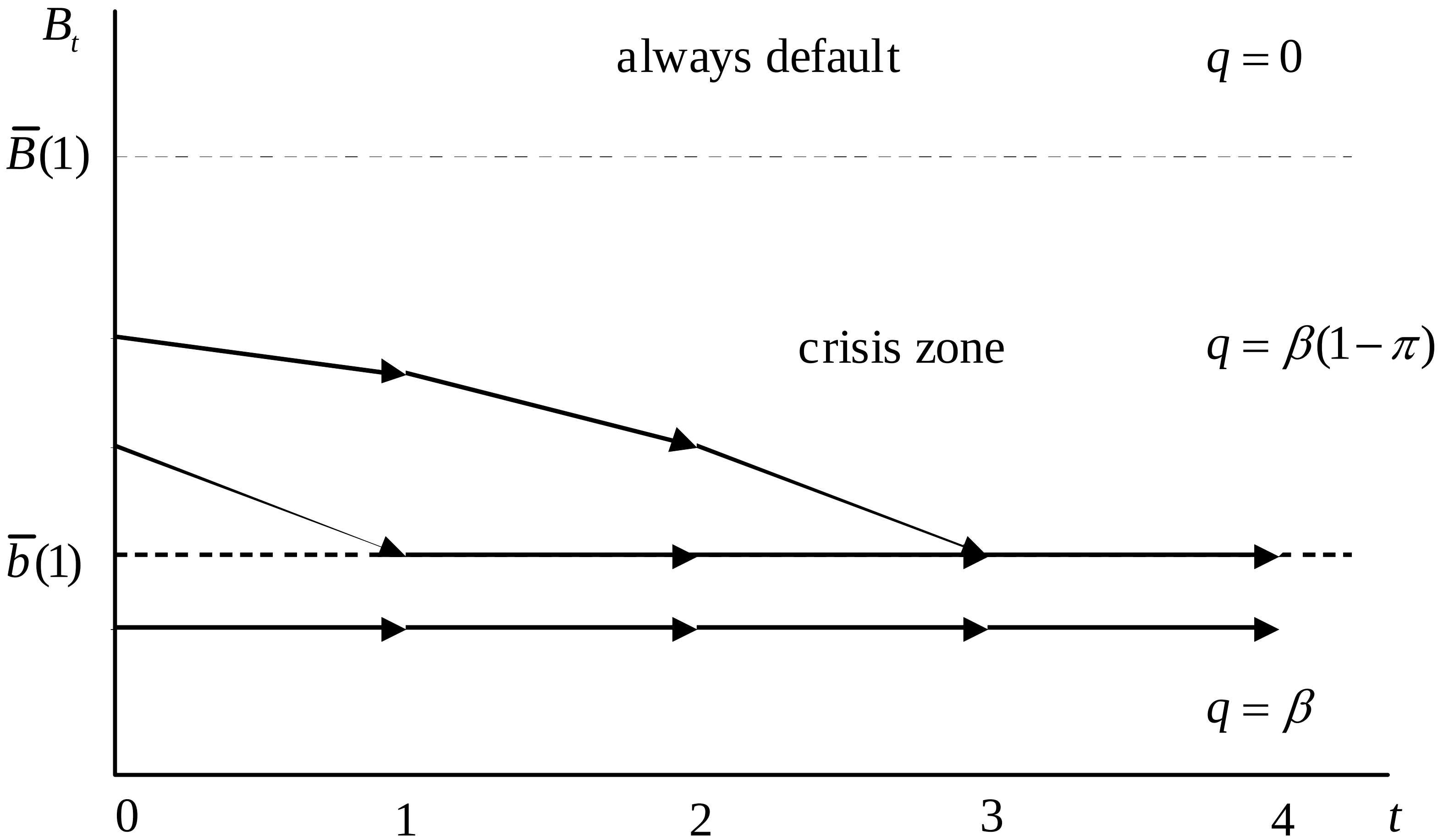
$$\max\left[V^1(\overline{B}(1)), V^2(\overline{B}(1)), \ldots, V^\infty(\overline{B}(1))\right]$$

$$= u((1-\theta)Z\overline{y}, \theta Z\overline{y} + \beta(1-\pi)\overline{B}(1)) + \frac{\beta u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta}.$$

$$V(B,1,1,\zeta) =$$

$$\begin{cases} \dfrac{u((1-\theta)\overline{y}, Z\overline{y})}{1-\beta} & \text{if } B \le \overline{b}(1) \\ \max\left[V^1(B), V^2(B), \ldots, V^\infty(B)\right] & \text{if } \overline{b}(1) < B \le \overline{B}(1),\ \zeta \le 1-\pi \\ \dfrac{u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta} & \text{if } \overline{b}(1) < B \le \overline{B}(1),\ 1-\pi < \zeta \\ \dfrac{u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta} & \text{if } \overline{B}(1) < B \end{cases}$$

Equilibrium with self-fulfilling crises, no crises

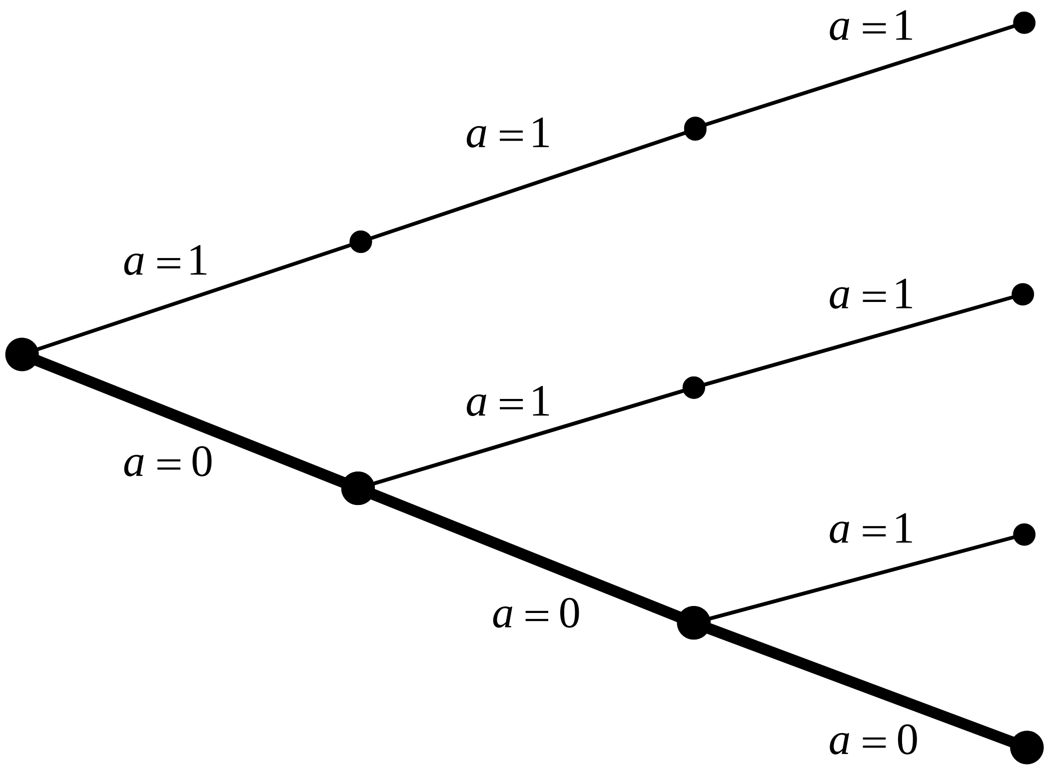


Consumption smoothing without self-fulfilling crises

$a = 0$ and $\pi = 0$.

Private sector is in a recession and faces the possibility p of recovering in every period.

Uncertainty tree with recession path highlighted

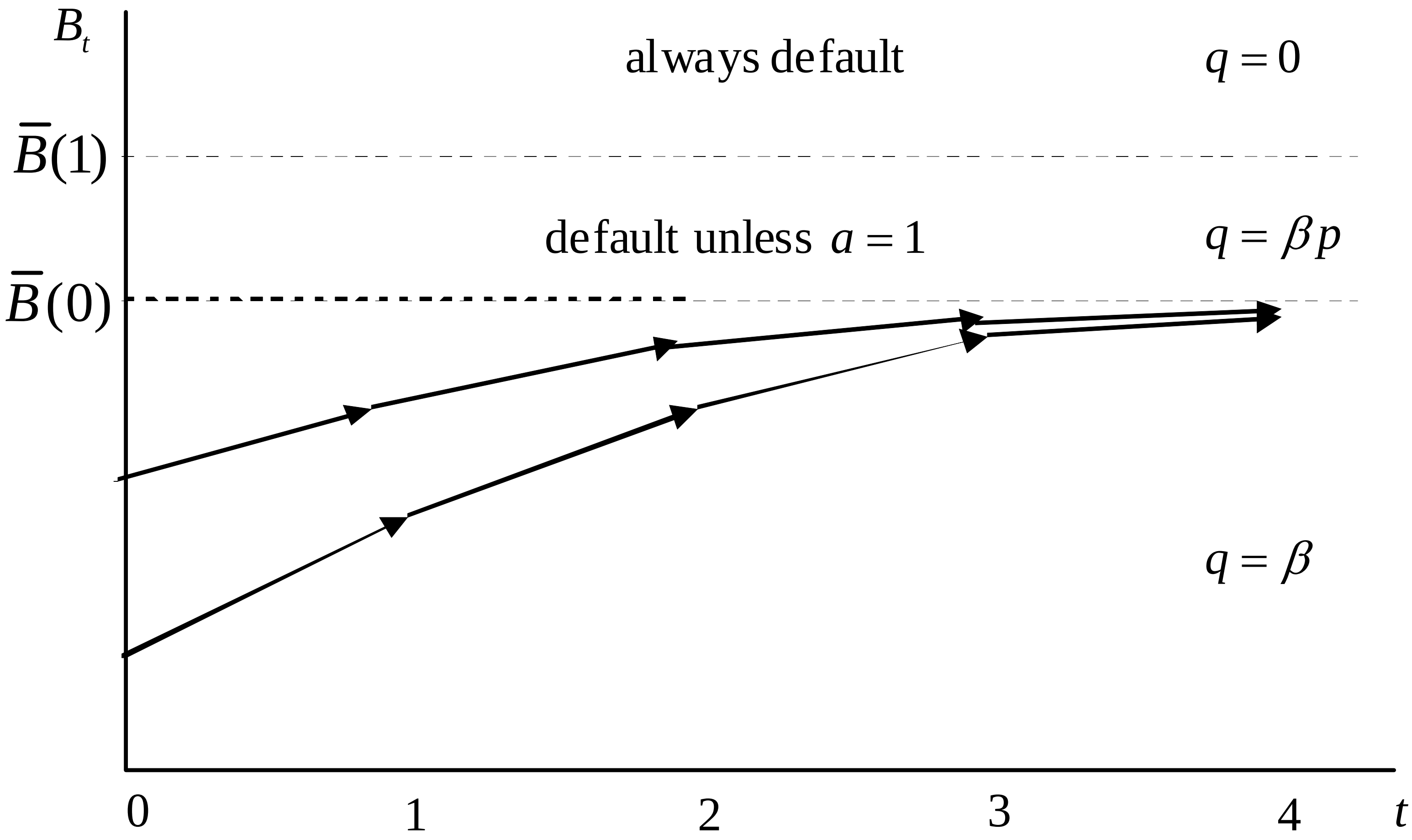


Two cases:

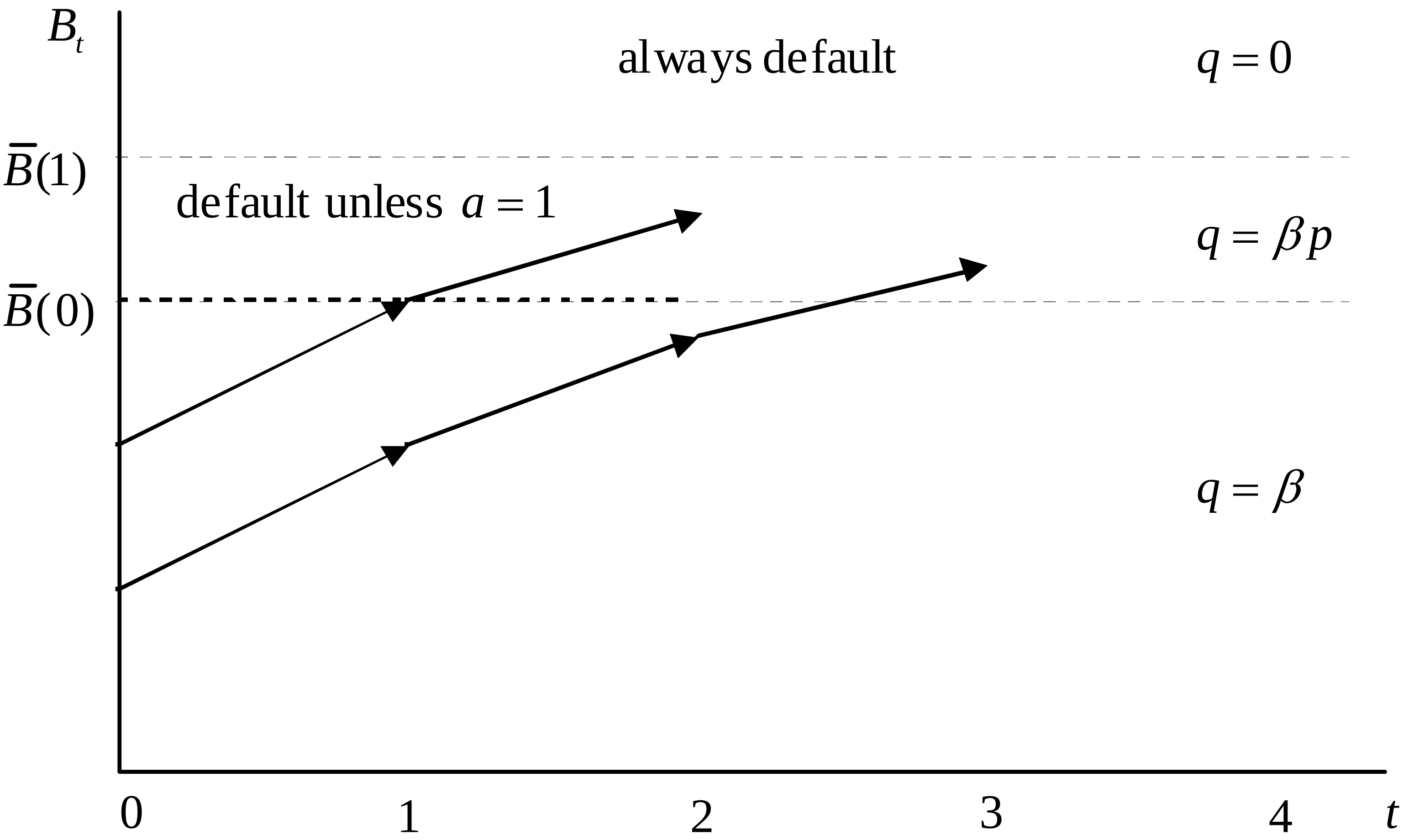
- Government chooses to never violate the constraint $B \le \bar{B}(0)$ and debt converges to $\bar{B}(0)$ if $a = 0$ sufficiently long.

- Government chooses to default at T if $a = 0$ sufficiently long.

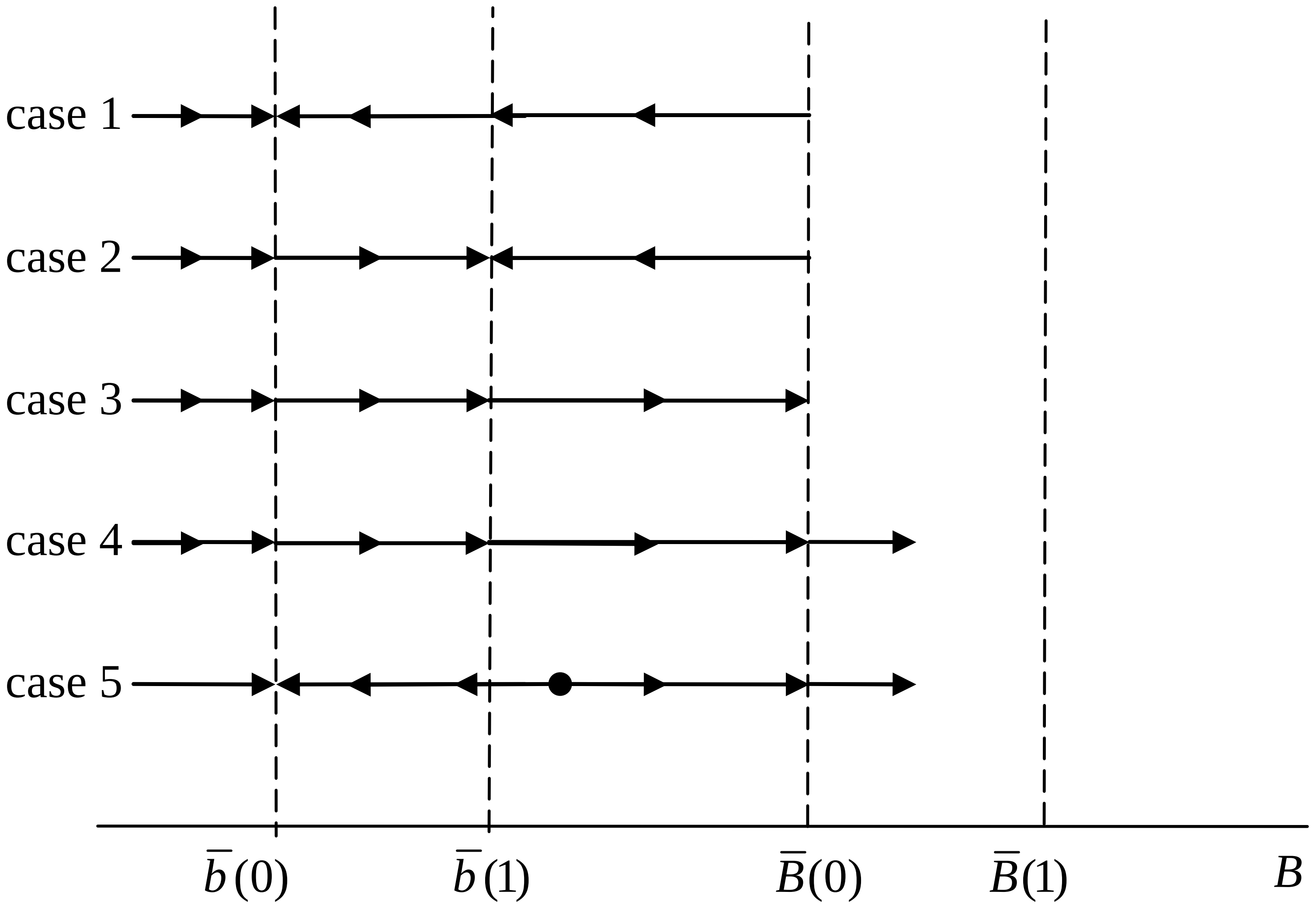
Equilibrium with no default



Equilibrium with eventual default



Some possible phase diagrams in general model



Crucial parameters: p, π, A and Z.

p small means that we are in case 1.

p large and $1-A$ small means that we are in case 2.

π small and $1-Z$ large mean that we are in case 3.

π small and $1-Z$ small mean that we are in case 4.

Case 5 is an intermediate possibility.

Quantitative analysis in a numerical model

$$u(c,g) = \frac{c^{\rho}}{\rho} + \gamma \frac{(g-\bar{g})^{\rho}}{\rho} \text{ where } \rho = -1$$

Parameter	Value
A	0.90
Z	0.95
p	0.20
β	0.96
π	0.03
γ	0.50
θ	0.4041
$\bar{y}$	100
$\bar{g}$	28

Parameters are such that, if $B = 10$, in the initial steady state $g = 40$.

We work with one-year bonds.

Maturity structure makes a difference, not just average maturity!

Suppose that every period, the government sells 310 of bonds, divided between 300 1-year bonds and 10 30-year bonds. Then the government has total debt of

$$300 + (30)10 = 600$$

Notice that the average maturity is

$$\frac{300(30 + 29 + ... + 1) / 30 + 300}{600} = \frac{150(30) + 300}{600} = 8.$$

Every period the fraction of debt that becomes due is

$$\frac{310}{600} = 0.5167.$$

Suppose, in contrast, the government sells 40 15-year bonds every period. Then the government has debt of

$$(15)40 = 600,$$

and the average maturity is

$$\frac{15 + 14 + ... + 1}{2} = 8,$$

but every period the fraction of debt that becomes due is

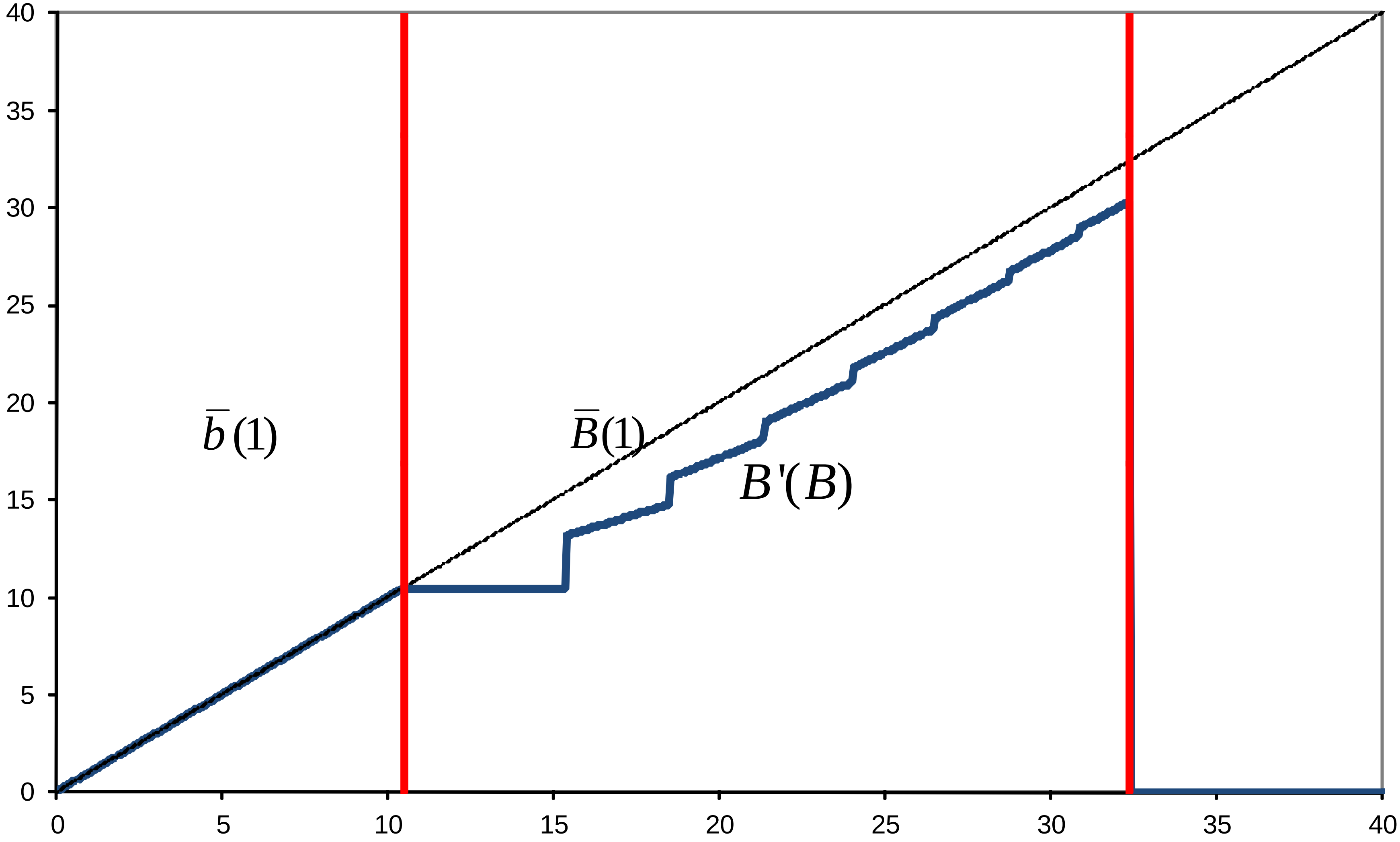
$$\frac{40}{600} = 0.0667.$$

Maturity of debt in 2010

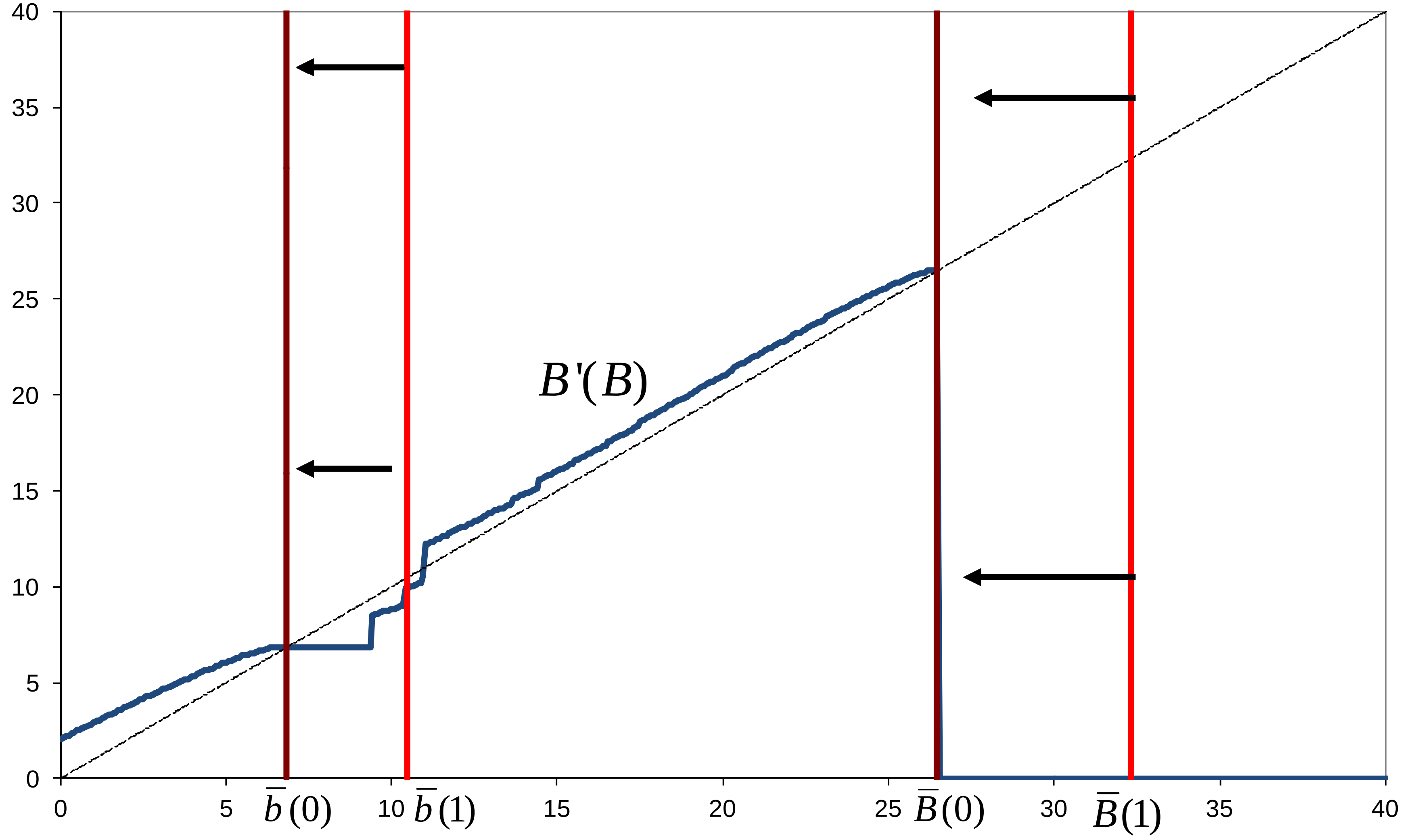
	Weighted average years until maturity	Percent debt with one year or less maturity at issuance
Germany	6.8	7.2
Greece	7.1	11.9
Ireland	6.4	0.0
Italy	7.1	19.2
Portugal	6.0	12.6
Spain	6.8	16.1

Think of results in terms of debt needing refinancing every year — say one-sixth, as in Spain.

Results: The benchmark economy in normal times



Then, a recession hits…



Policy implications

Policy 1: Lend at onset of crisis at interest rate above pre-crises level

Providing credit at interest rate higher than

$$\frac{1}{\beta(1-\pi)}-1$$

prevents crisis, but leaves incentives to run down debt.

Bill Clinton's 1995 loan package for Mexico

Policy 2: Lend before onset of crisis at interest rate below pre-crises level

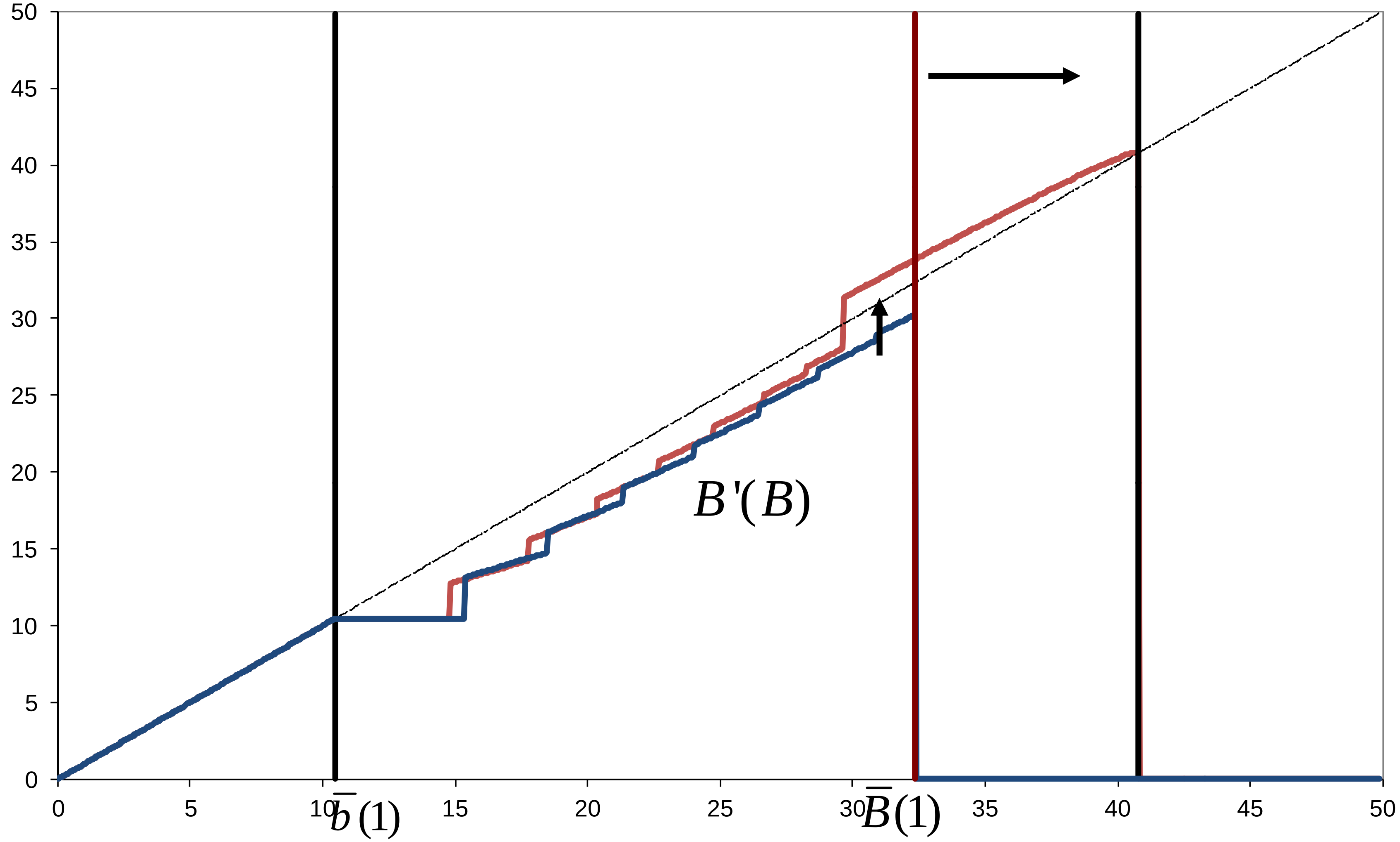
Providing credit at interest rate lower than

$$\frac{1}{\beta(1-\pi)}-1 \quad \text{or} \quad \frac{1}{\beta(p+(1-p)(1-\pi))}-1$$

provides incentive to gamble for redemption.

EU-IMF 2010 rescue package for Greece

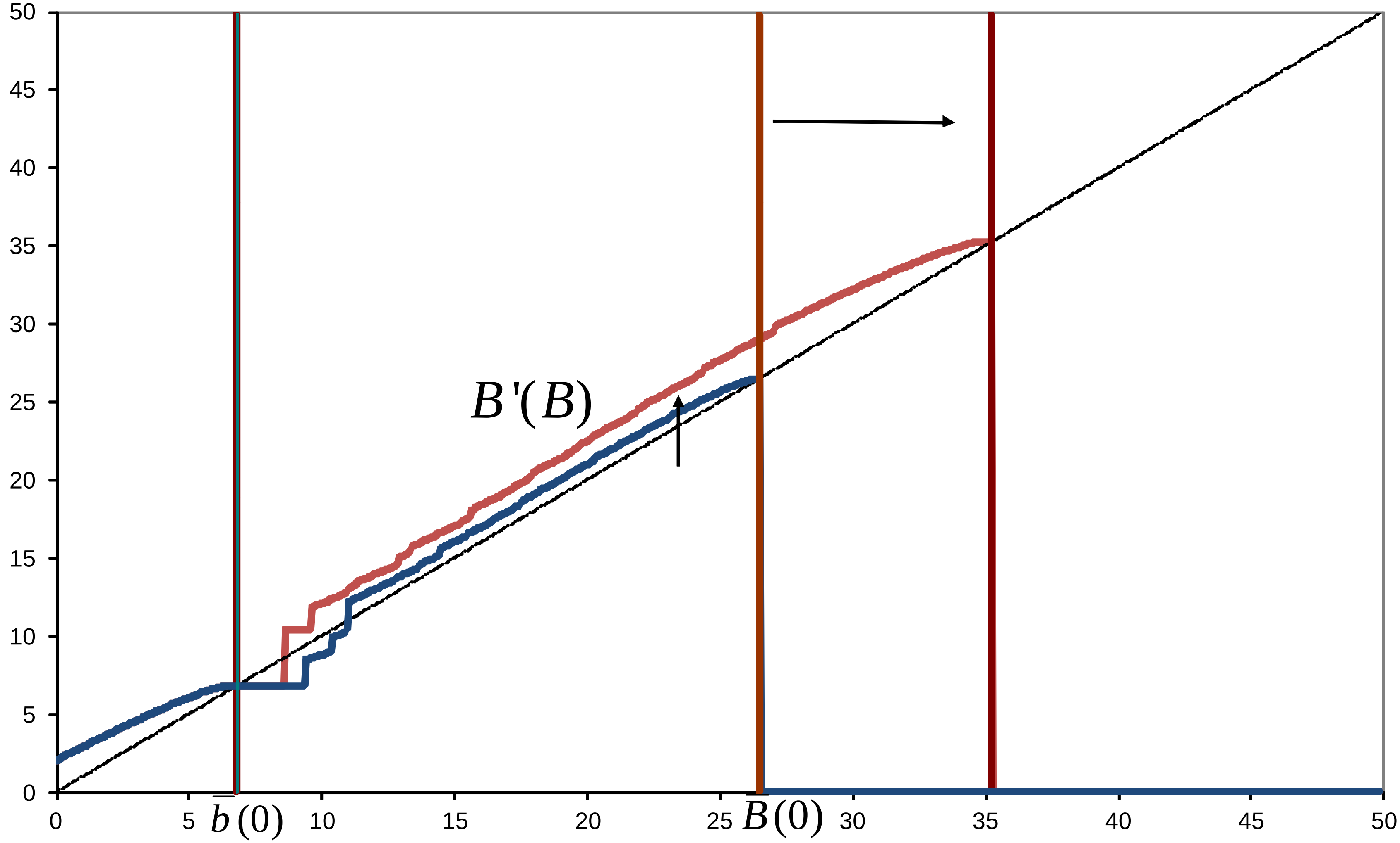
Policy 2: third party lends at $r = 0.04$ in normal times



The upper threshold goes up.

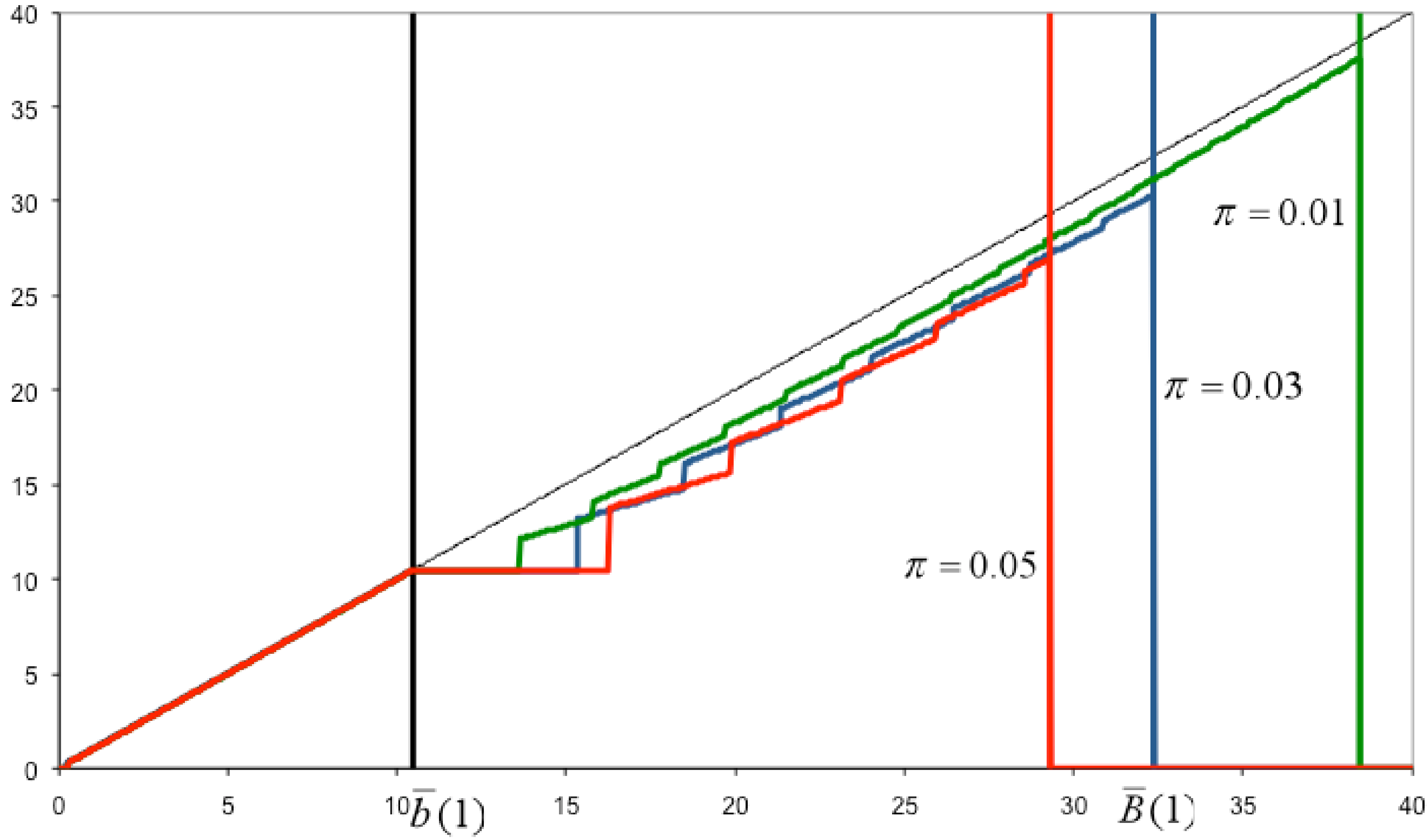
Debt can go up even in normal times.

…and in a recession…

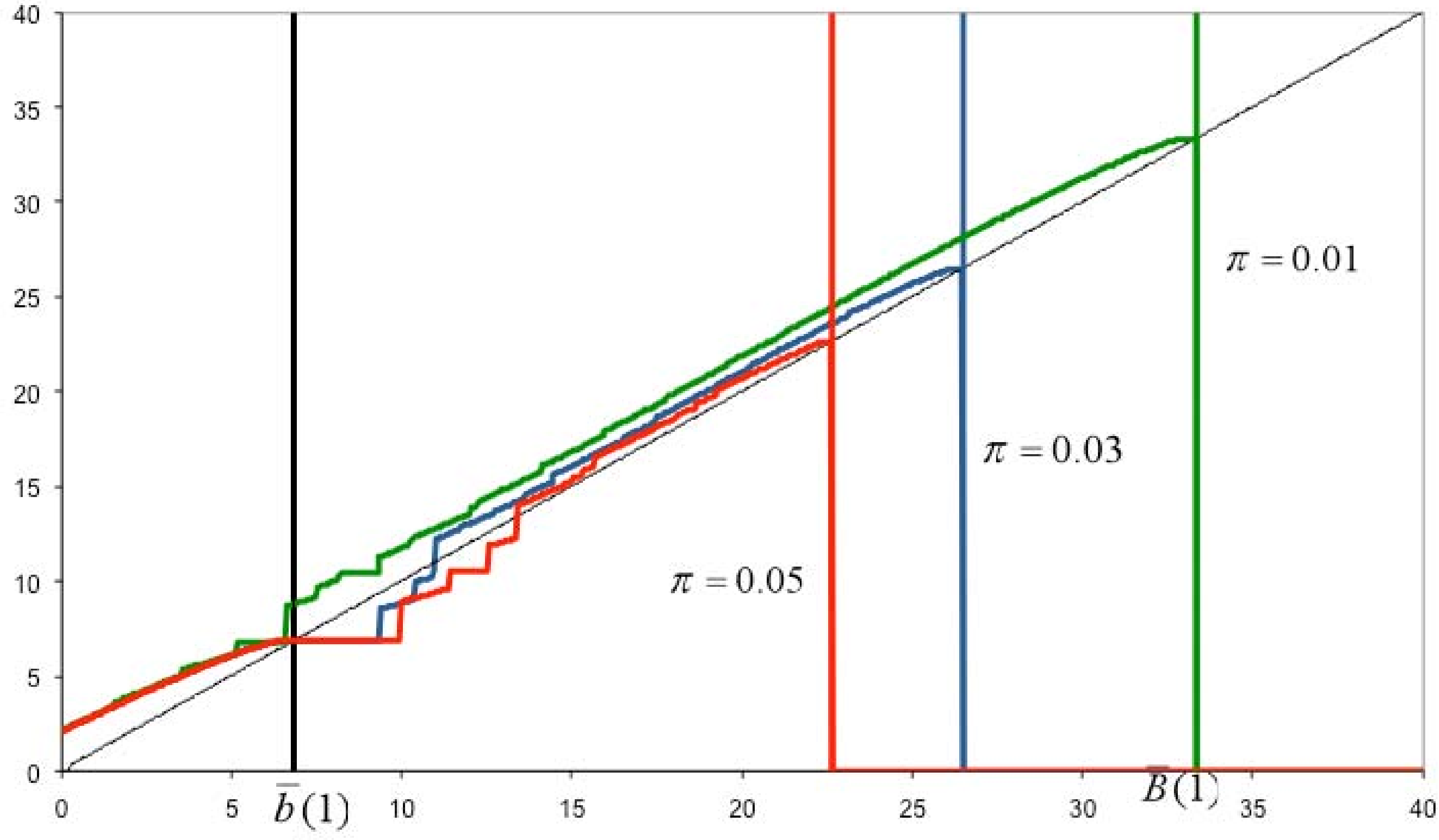


More gambling for redemption.

Sensitivity analysis: the impact of π in normal times



Sensitivity analysis: the impact of π in recession



Extensions:

Keynesian features

Panglossian borrowers *á la* Krugman (1998)

Keynesian features

Government expenditures are close substitutes for private consumption expenditures:

$$u(c,g) = -(c + g - \overline{c} - \overline{g})^{-1}.$$

Probability of recovery $p(g)$ varies positively with government expenditures:

$$p'(g) > 0.$$

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Keynesian features make gambling for redemption more attractive!

Panglossian borrowers

Krugman (1998), Cohen and Villemot (2010)

The government is overly optimistic about the probability of a recovery:

$$p^g > p$$

where p is the probability that international lenders assign to a recovery.

Proposition: Suppose that

$$q(B',s) = \beta\left(p + (1-p)(1-\pi)\right)$$

or

$$q(B',s) = \beta p(1-\pi).$$

Then holding p^g fixed and lowering p results in lower $B'(B,s)$.

Similarly, holding p fixed and increasing p^g results in lower $B'(B,s)$.

We could also analyze the case where the government is overly optimistic about the probability of a self-fulfilling crisis:

$$\pi^g < \pi$$

and obtain similar results.

Bottomline:

Optimistic governments feel the market charges too much of a premium and hence want to reduce debt.

Pessimistic governments (or governments with private information about the low probability of recovery) want to increase debt.

Time varying risk premia

Two different probabilities of a self-fulfilling crisis, $\pi_2 > \pi_1$, transitions follow a Markov process:

$$\begin{bmatrix} \mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22} \end{bmatrix}.$$

A country can be repaying its debts when faced with π_1, then make the transition to π_2 and be forced to default.

Concluding remarks

Quantitative model provides:

- Plausible explanation for the observed behavior of PIIGS.
- Plausible explanation for impact of rescue packages and subsidized loans.

Why Greece and not Belgium?

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Why Greece and not Belgium?

Why the Eurozone and not the United States?