Gambling for Redemption and Self-Fulfilling Debt Crises

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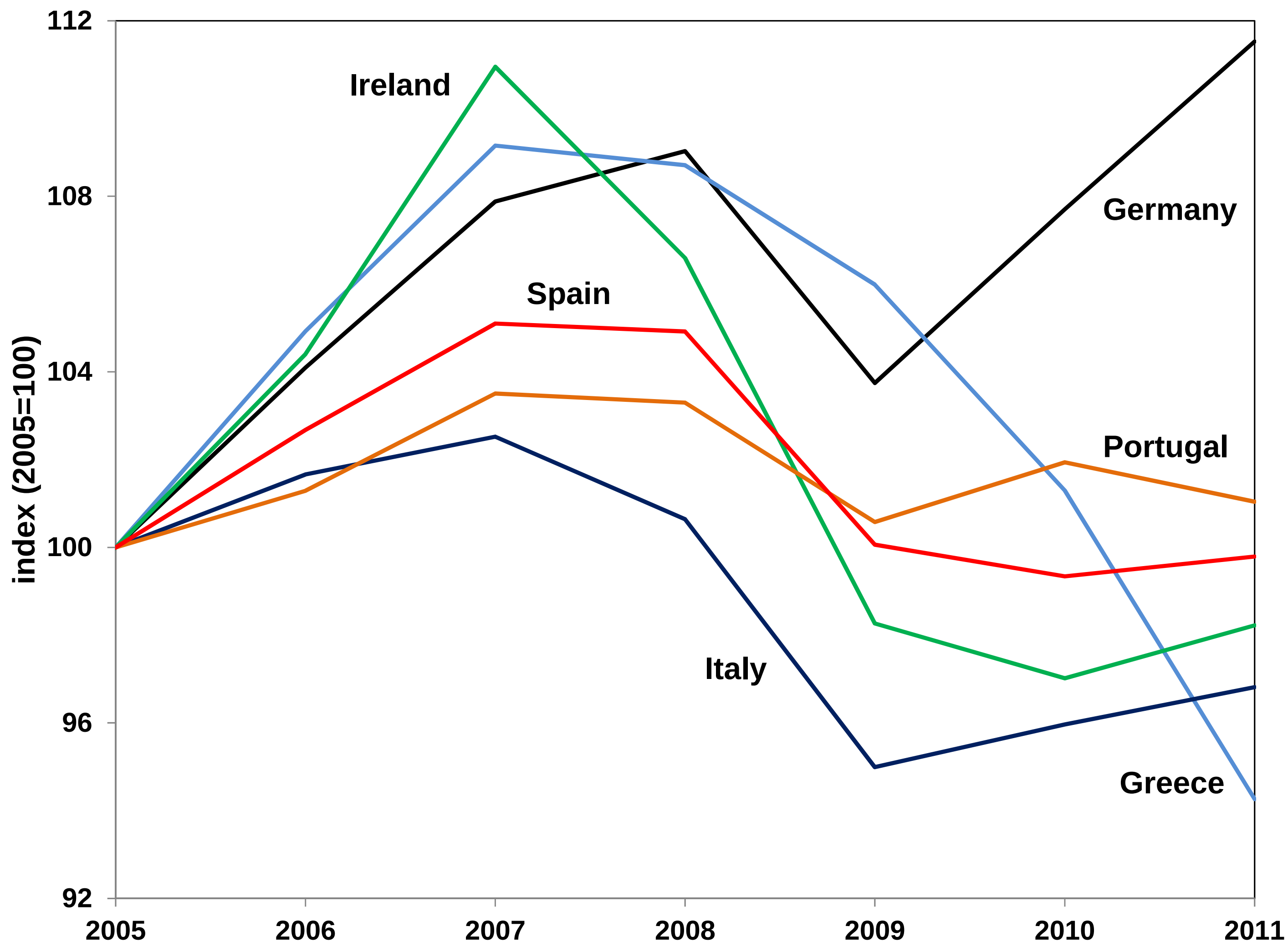
February 2012

Prelude to the 2010–2012 European debt crises:

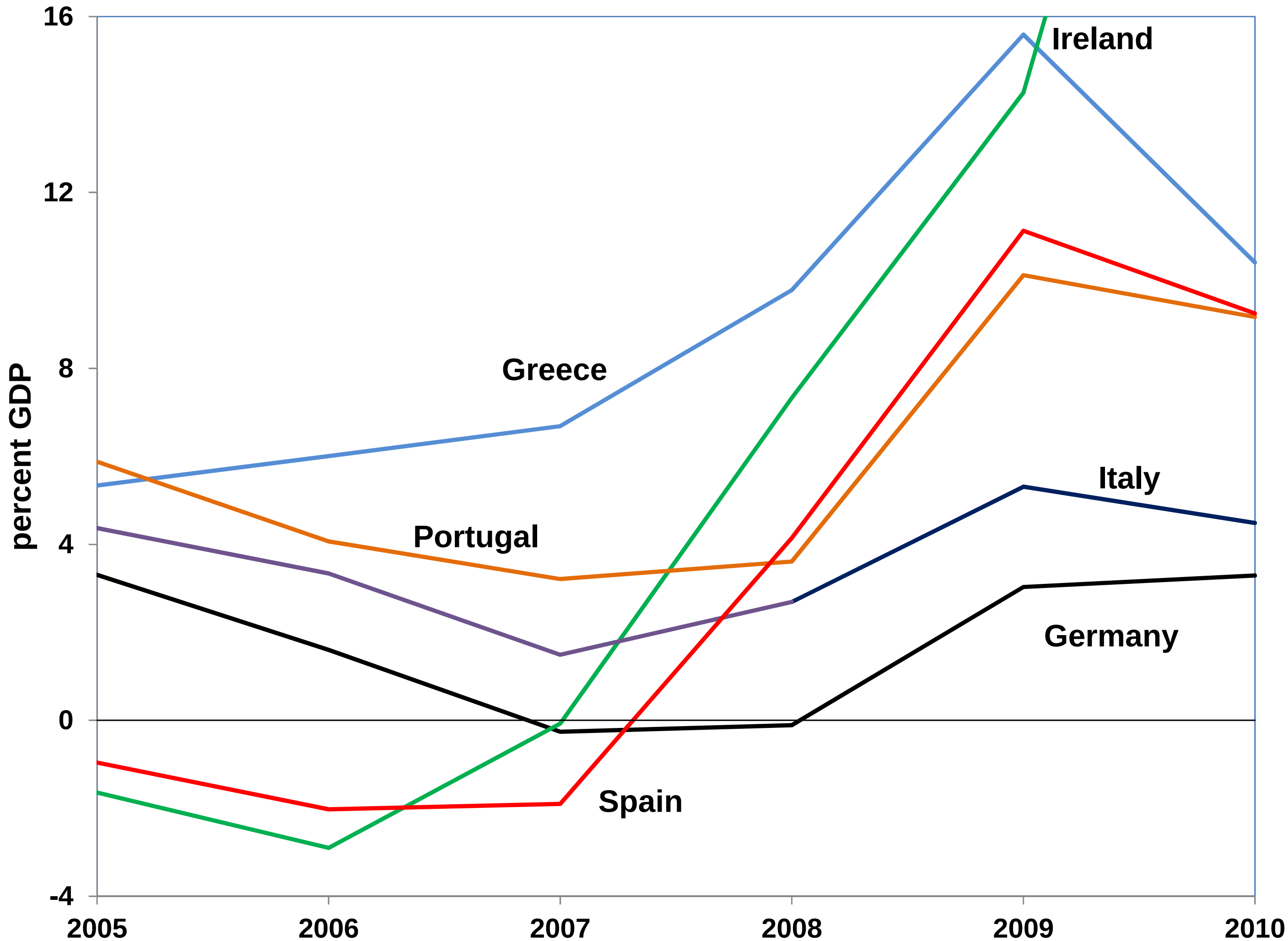
The 2008–2009 recession led to sharp drops in fiscal revenues.

The recovery has been very slow. In fact, it has been nonexistent in some countries.



Real GDP per working-age (15–64) person

There was a sharp increase in government debt compared to GDP.



Net government borrowing

This left some European governments vulnerable to financial crises.

Self-fulfilling debt crises:

Suppose that international investors expect a sovereign government to default on its debt.

Then these investors are willing to pay little for new issuances of government debt. This makes default more attractive for the government.

$$q = \beta(1 - \pi\alpha)$$

q price of bond
β discount factor (≈ 0.98 for 1-year bonds)
π probability of a default
α recovery rate in a default ($1 - \alpha$ is the "haircut")

$1/q - 1$ is the implicit interest rate ("yield") on the bond.

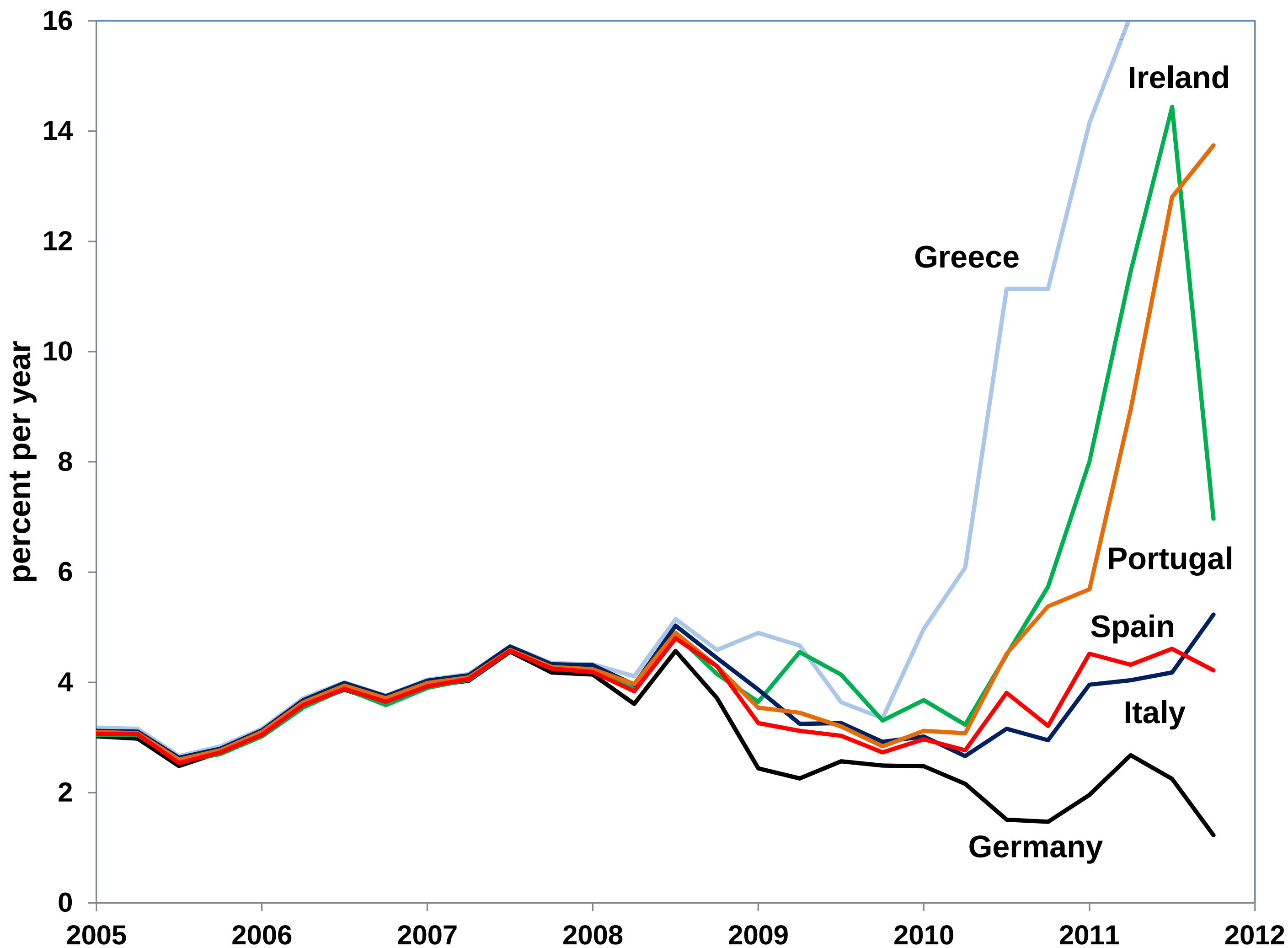
Example:

Greece July 2011

$$\beta = 0.98$$
$$\pi = 0.5$$
$$\alpha = 0.5$$

$$q = 0.98 \times (1 - 0.5 \times 0.5) = 0.735$$
$$\frac{1}{q} - 1 = \frac{1}{0.735} - 1 = 0.3605$$

In fact, Greek bonds had yields of 36.6 percent in July 2011.

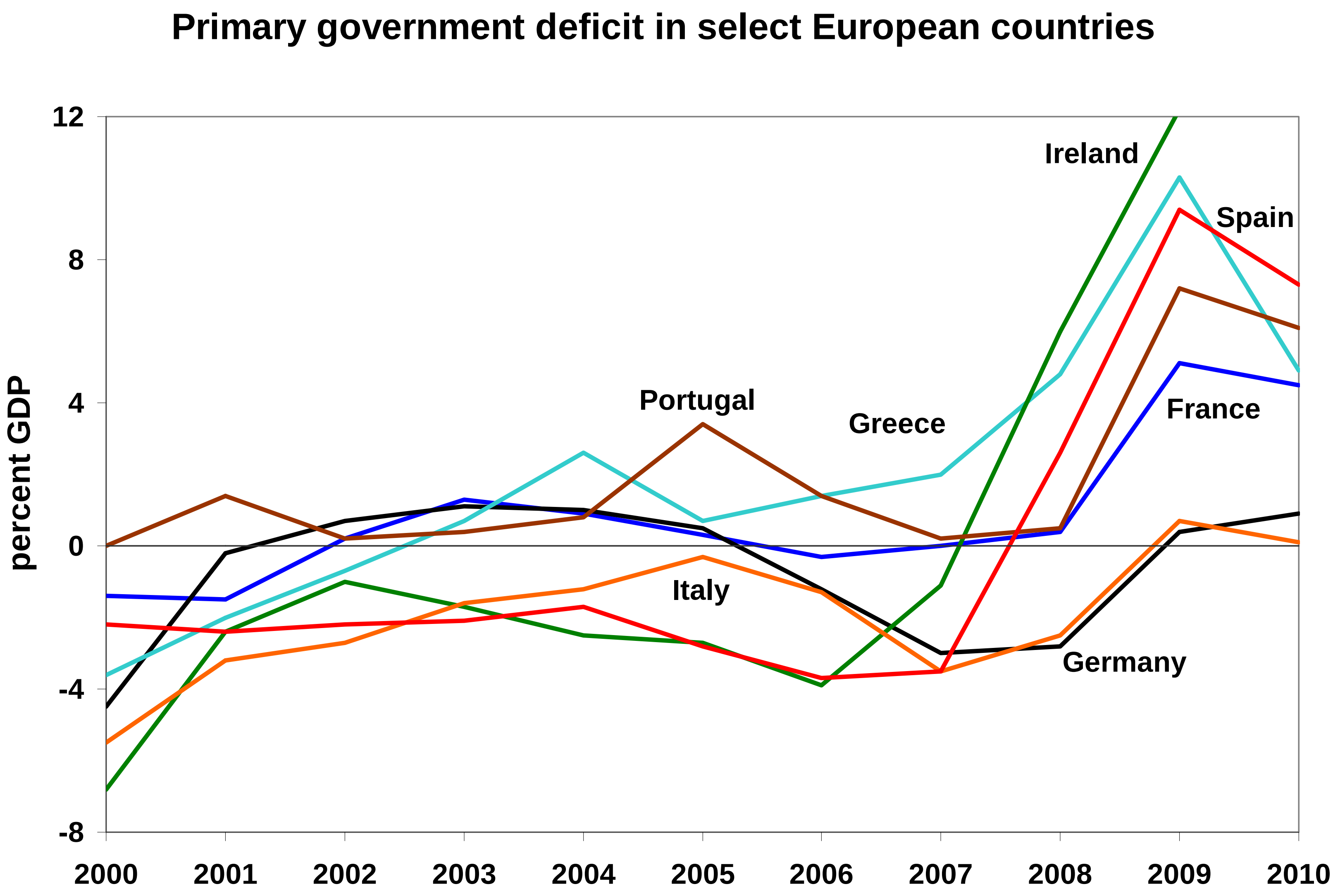


Yields on 5-year government bonds

If a government is vulnerable to a debt crisis, it has the incentive to run down its debt because:

Interest rates are high.

Defaults are costly.


Primary government deficit in select European countries
percent GDP
12
8
4
0
-4
-8
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Ireland
Spain
Portugal
Greece
France
Italy
Germany

Countervailing incentive:

If the government expects that there is some probability of a recovery in the private economy and in tax revenues, it can gamble for redemption.

A martigale gambling strategy.

Cutting government expenditures is painful. If the government expects that, with some probability, the private economy will recover in the near future, it will cut spending slowly and run up its debt.

The government has an incentive to gamble for redemption to the extent to which:

Interest rates are low.

Cost of sovereign default are low.

The various rescue packages put together by the European Union (Merkel and Sarkorzy) for countries like Greece have not taken into account the incentives that these packages provide the governments of these countries.

Crises in Europe have been ungoing for more than a year, since May 2010. It seems that they will be going on into 2012 (2013?).

This contrasts with U.S. President Bill Clinton’s 31 January 1995 rescue package for Mexico, which put an immediate end to the financial crisis there.

Contribution

We develop a model in which a government faced with the possibility of a self-fulfilling crisis on its sovereign debt can choose to run down the debt or to run up the debt.

We can then analyze how optimal government policy changes as external conditions change.

Number of possible explanations of the sovereign debt in Europe:

- Low interest rates following the implementation of the European Monetary Union led some European countries to over borrow during the expansionary period before 2008 (Portugal).

- Some European countries employed fraudulent accounting practices to appear to be in line with the Maastricht Accords (Greece, Italy).

- Some European countries took on debt from their banking systems that were left fragile following the turndown in the real estate market in 2008–2009 (Ireland).

These explanations make some sense for individual countries but do not explain why countries continued to borrow even as the crisis continued.

General model

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

B: government debt

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

z_{-1}: whether or not default has occurred: $z_{-1} = 1$ no, $z_{-1} = 0$ yes

ζ: value of the sunspot variable

GDP

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

where $1 > A, Z > 0$.

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

Period 0, a unexpectedly becomes $a_0 = 0$

GDP drops from $y = \overline{y}$ to $y = A\overline{y} < \overline{y}$.

In every period t, $t = 1, 2, \ldots$, a_t becomes 1 with probability p, $1 > p > 0$.

Once $a_t = 1$, it stays equal to 1 forever.

Drop in GDP by factor Z is default penalty. Once $z_t = 0$, it stays equal to 0 forever.

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

To keep things simple, assume that the tax rate θ is fixed.

Government's problem is to choose c, g, B', z to solve

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

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

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

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

Here $z = 1$ is the decision not to default, and $z = 0$ is the decision to default.

Some possibilities for $u(c, g)$ are

$$u(c, g) = (1-\gamma)\log c + \gamma \log g$$

$$u(c, g) = (1-\gamma)\log c + \gamma \log(g - \overline{g})$$

$$u(c, g) = \log(c + g - \overline{c} - \overline{g}),$$

or even more curvature than that of natural logarithm.

Sunspot

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

If $\zeta_t > 1-\pi$, bankers expect there to be a crisis and do not lend to the government if such a crisis would be self-fulfilling.

Probability of a self-fulfilling crisis π is arbitrary, $1 \geq \pi \geq 0$, if the level of debt is high enough for such a crisis to be possible.

Timing within each period:

1. ζ_t is realized, $s_t = (B_t, a_t, z_{t-1}, \zeta_t)$, and government chooses B_{t+1}.
2. Each bankers chooses b_{t+1}. (In equilibrium, $b_{t+1} = B_{t+1}$.)
3. Government chooses default decision z_t, which determines y_t, c_t, and g_t.

Notes:

The equilibrium is 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 and ζ_t.

International bankers

$$W(b,B',s;p,\pi)=\max x+\beta EW((b',B'',s';p,\pi)$$

$$x+q(B',s;p,\pi)b'=w+z(B',s,q;p,\pi)b$$

$$x\geq 0,\ b\leq A.$$

$b\leq A$ eliminates Ponzi scheme's but A is large enough to not otherwise bind.

Endowment of consumption good w is large enough to rule out corner solutions in equilibrium.

First order condition and perfect foresight condition:

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

Recursive equilibrium

Value function for government $V(s)$ and policy functions $B'(s)$ and $z(B',s,q;p,\pi)$ and $g(B',s,q;p,\pi)$,

value function for bankers $W(b,B',s;p,\pi)$

bond price function $q(B',s;p,\pi)$.

Bankers' problem:

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

Government's problem at the beginning of the period: Choose B' to solve

$$V(B, a, z_{-1}, \zeta; p, \pi) = \max u(c, g) + \beta E V(B', a', z, \zeta'; p, \pi)$$

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

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

Government's problem at the end of the period: Choose z and g to solve

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

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

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

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

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

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

If $B \le \bar{b}(a;p,\pi)$, government repays even if bankers do not lend, it defaults if $B > \bar{b}(a;p,\pi)$.

If $B \le \bar{B}(a;p,\pi)$, government repays if bankers lend, it defaults if $B > \bar{B}(a;p,\pi)$.

Assumption that a government is permanently excluded from borrowing after default.

Once default has occurred, bankers do not lend:

$$q(B',(B,a,0,\zeta);p,\pi)=0.$$

During a crisis, bankers do not lend: If $B>\bar{b}(a;p,\pi)$ and $\zeta>1-\pi$,

$$q(B',(B,a,1,\zeta);p,\pi)=0$$

This is how q depends on (B,a,z_{-1},ζ) and the (perfect foresight) expectations of z. Otherwise, q depends on B' and the expectations of a' and z'.

$\bar{b}(0; p,\pi) < \bar{b}(1; p,\pi)$, $\bar{b}(0; p,\pi) < \bar{B}(0; p,\pi)$, $\bar{b}(1; p,\pi) < \bar{B}(1; p,\pi)$, and $\bar{B}(0; p,\pi) < \bar{B}(1; p,\pi)$.

More interesting case:

$$\bar{b}(0; p,\pi) < \bar{b}(1; p,\pi) < \bar{B}(0; p,\pi) < \bar{B}(1; p,\pi).$$

Other cases:

$$\bar{b}(0; p,\pi) < \bar{B}(0; p,\pi) < \bar{b}(1; p,\pi) < \bar{B}(1; p,\pi)$$

$$\bar{b}(0; p,\pi) < \bar{B}(0; p,\pi) = \bar{b}(1; p,\pi) < \bar{B}(1; p,\pi).$$

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

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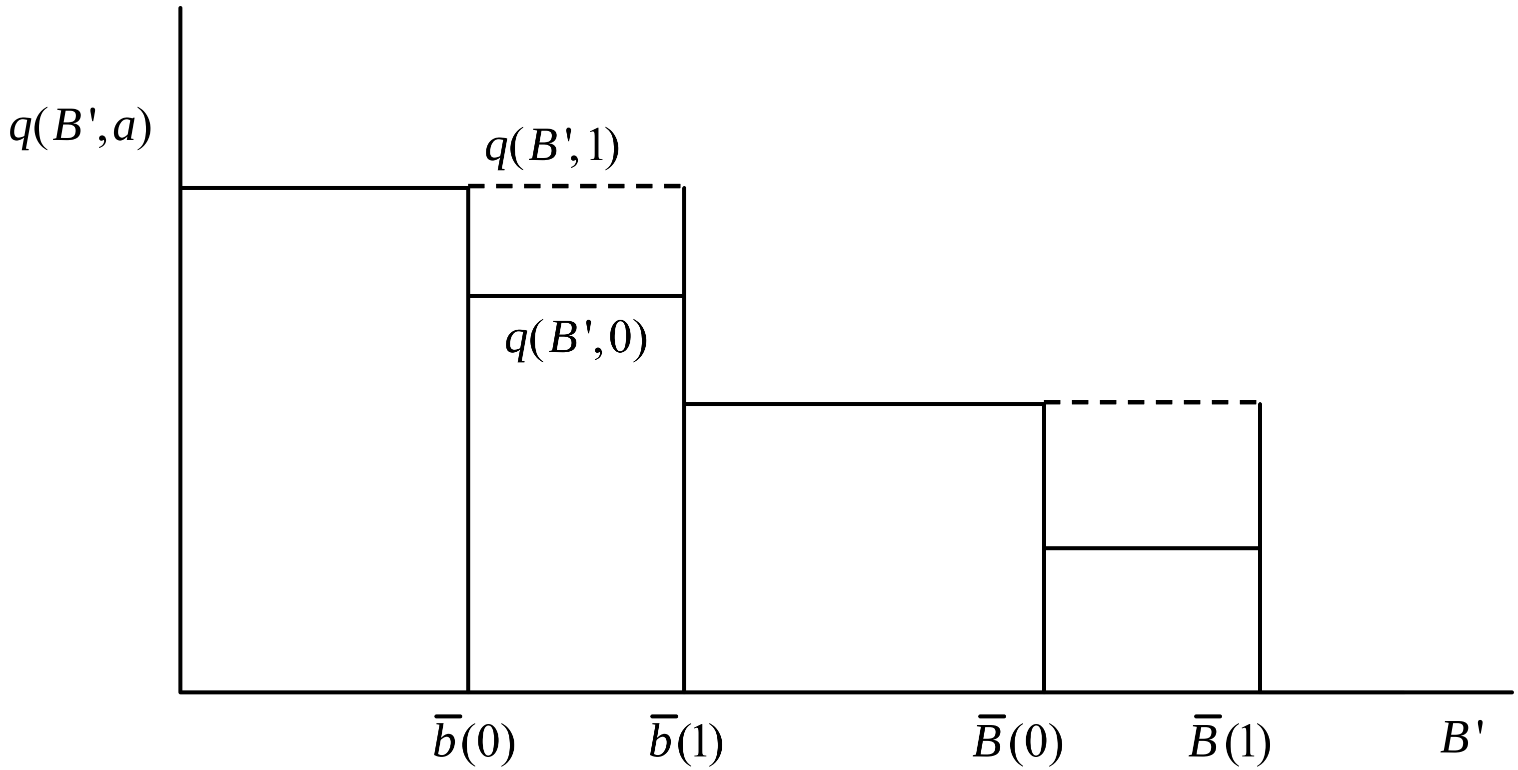
Bond prices as a function of debt and conditions in the private sector



In case where

$$\overline{b}(0;p,\pi) < \overline{B}(0;p,\pi) < \overline{b}(1;p,\pi) < \overline{B}(1;p,\pi),$$

$$q(B',(B,0,1,\zeta);p,\pi) = \begin{cases} \beta & \text{if } B' \leq \overline{b}(0;p,\pi) \\ \beta\big(p + (1-p)(1-\pi)\big) & \text{if } \overline{b}(0;p,\pi) < B' \leq \overline{B}(0;p,\pi) \\ \beta p & \text{if } \overline{B}(0;p,\pi) < B' \leq \overline{b}(1;p,\pi) \\ \beta p(1-\pi) & \text{if } \overline{b}(1;p,\pi) < B' \leq \overline{B}(1;p,\pi) \\ 0 & \text{if } \overline{B}(1;p,\pi) < B' \end{cases}$$

Technical complexities:

$V(s;p,\pi)$ has kinks — and the optimal policy function $B'(s;p,\pi)$ is discontinuous — because of the discontinuity of $q(B',s;p,\pi)$.

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Even so, we can analytically characterize equilibria in the case where $p=0$ and in the case where $\pi=0$.

In the general case where $p>0$ and $\pi>0$, we resort to numerical experiments.

Self-fulfilling liquidity crises

Cole-Kehoe (1996, 2000) without private sector capital.

Also limiting case where $a = 0$ and $p = 0$: Replace $\bar{y}$ with $A\bar{y}$.

Self-fulfilling crises are possible, but no incentive for gambling for redemption

Start by assuming that $\pi = 0$. When $s = (B, a, z_{-1}, \zeta) = (B, 1, 1, \zeta)$,

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

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

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

$\overline{b}(1; p,0)$:

The utility of repaying even if bankers do not lend is

$$V_n(B,1,0; p,0) = u((1-\theta)\overline{y}, \theta\overline{y} - B) + \frac{\beta u((1-\theta)\overline{y}, \theta\overline{y})}{1-\beta}.$$

The utility of defaulting if bankers do not lend is

$$V_d(B,1,0; p,0) = \frac{u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta}.$$

$\overline{b}(1; p,0)$ is determined by

$$V_n(\overline{b}(1; p,0),1,0; p,0) = V_d(\overline{b}(1; p,0),1,0; p,0)$$

$$u((1-\theta)\overline{y}, \theta\overline{y} - \overline{b}(1; p,0)) + \frac{\beta u((1-\theta)\overline{y}, \theta\overline{y})}{1-\beta} = \frac{u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta}$$

We can similarly determine $\bar{B}(1; p, 0)$.

Now let $\pi > 0$. Observe that

$$\bar{b}(1; p, \pi) = \bar{b}(1; p, 0).$$

Suppose that $B_0 > \bar{b}(1; p, \pi)$ and the government decides to reduce B to $\bar{b}(1; p, \pi)$ in T periods, $T = 1, 2, ..., \infty$. First order conditions imply

$$g_t = g^T(B_0; \pi).$$

The government's budget constraints are

$$g^T(B_0;\pi) + B_0 = \theta\bar{y} + \beta(1-\pi)B_1$$

$$g^T(B_0;\pi) + B_1 = \theta\bar{y} + \beta(1-\pi)B_2$$

$$\vdots$$

$$g^T(B_0;\pi) + B_{T-2} = \theta\bar{y} + \beta(1-\pi)B_{T-1}$$

$$g^T(B_0;\pi) + B_{T-1} = \theta\bar{y} + \beta\bar{b}(1;p,\pi).$$

Multiply each equation by $(\beta(1-\pi))^t$ and adding, we obtain

$$\sum_{t=0}^{T-1}(\beta(1-\pi))^t g^T(B_0;\pi) + B_0 = \sum_{t=0}^{T-1}(\beta(1-\pi))^t\theta\bar{y} + (\beta(1-\pi))^{T-1}\beta\bar{b}(1;p,\pi)$$

$$g^T(B_0;\pi) = \theta\overline{y} - \frac{1-\beta(1-\pi)}{1-(\beta(1-\pi))^T}\Big(B_0 - (\beta(1-\pi))^{T-1}\beta\overline{b}(1;p,\pi)\Big).$$

Notice that

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

Compute $V^T(B_0;\pi)$:

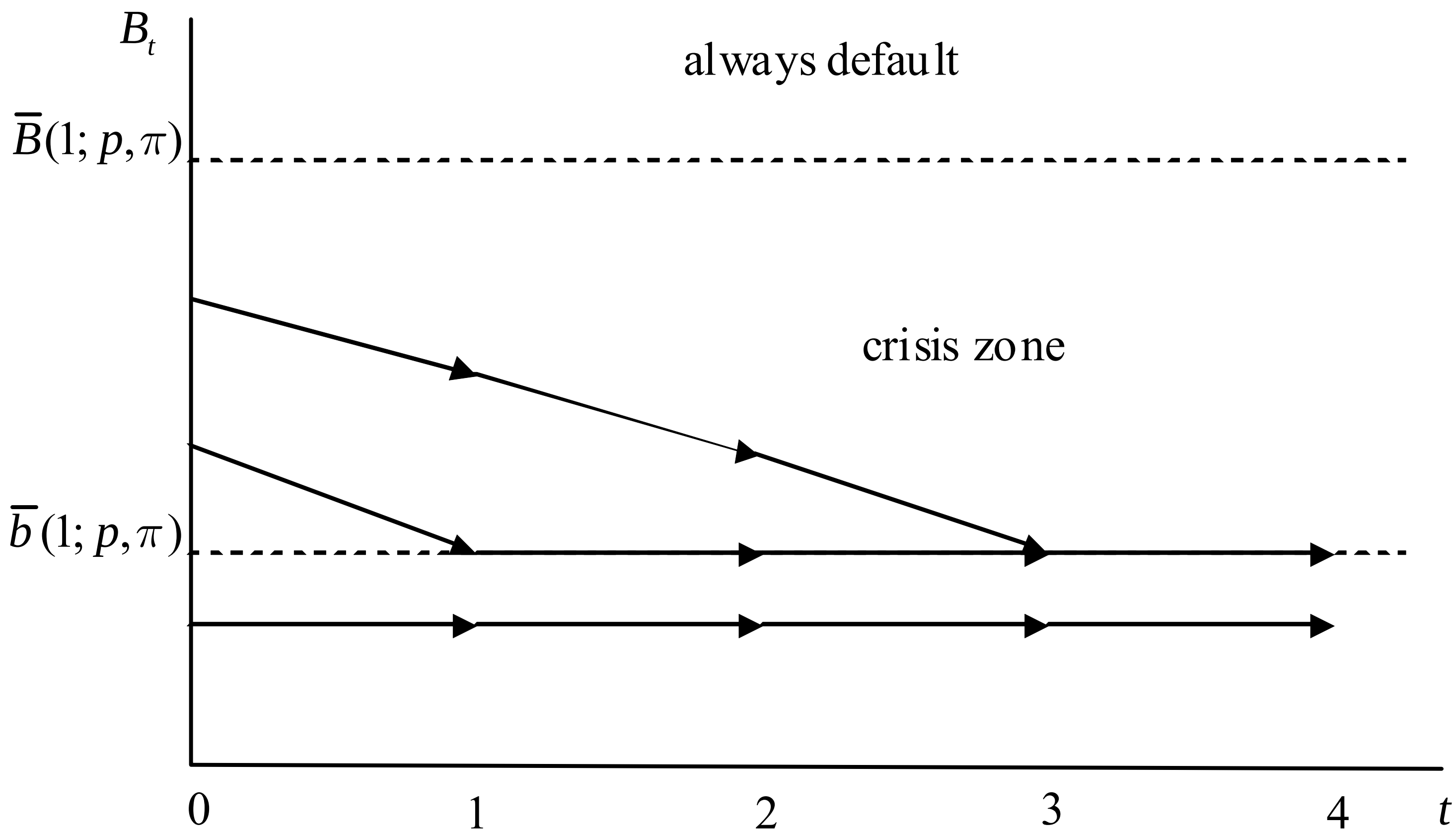
$$\begin{aligned}
V^T(B_0;\pi) &= \frac{1-(\beta(1-\pi))^T}{1+\beta(1-\pi)}u((1-\theta)\overline{y}, g^T(B_0;\pi)) \\
&+ \frac{1-(\beta(1-\pi))^{T-1}}{1+\beta(1-\pi)}\frac{\beta\pi u((1-\theta)Z\overline{y}, \theta Z\overline{y})}{1-\beta} \\
&+ (\beta(1-\pi))^{T-2}\frac{\beta u((1-\theta)\overline{y}, \theta\overline{y})}{1-\beta}
\end{aligned}$$

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

$$\max\left[V^{1}(\overline{B}(1;p,\pi)),V^{2}(\overline{B}(1;p,\pi)),\ldots,V^{\infty}(\overline{B}(1;p,\pi);\pi)\right]$$
$$=u((1-\theta)Z\overline{y},\theta Z\overline{y}+\beta(1-\pi)\overline{B}(1;p,\pi)))+\frac{\beta u((1-\theta)Z\overline{y},\theta Z\overline{y})}{1-\beta}\cdot$$

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

Optimal debt policy with self-fulfilling crises

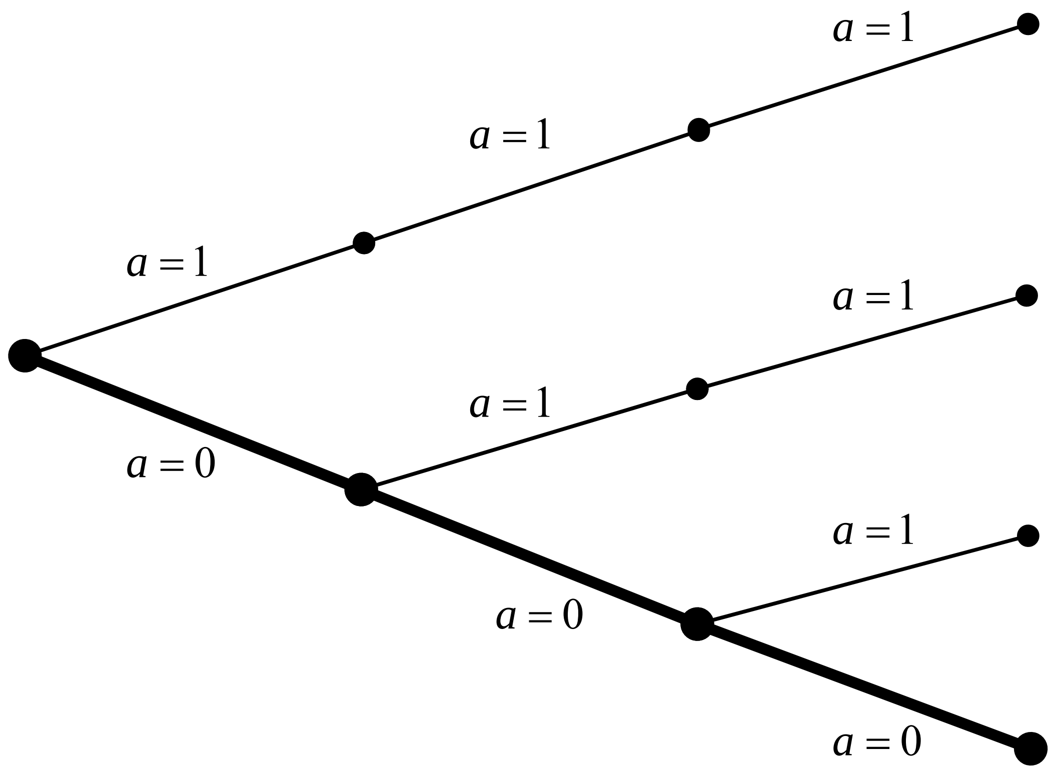


Gambling for redemption without self-fulfilling crises

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

no self-fulfilling crises are possible, but the private sector is in a recession and faces the possibility p, $1 > p > 0$, of recovering in every period.

Uncertainty tree with recession path highlighted

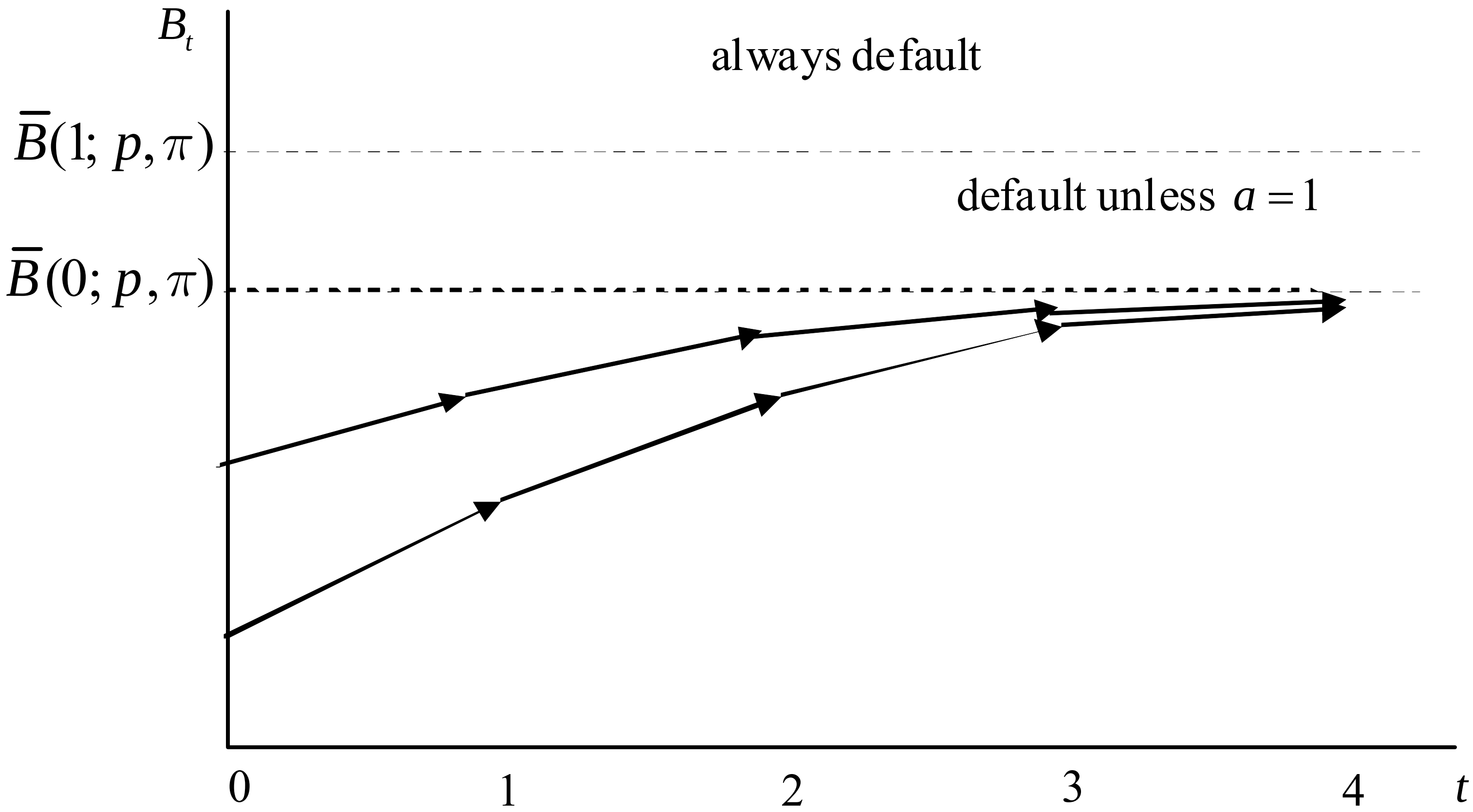


There are two cases:

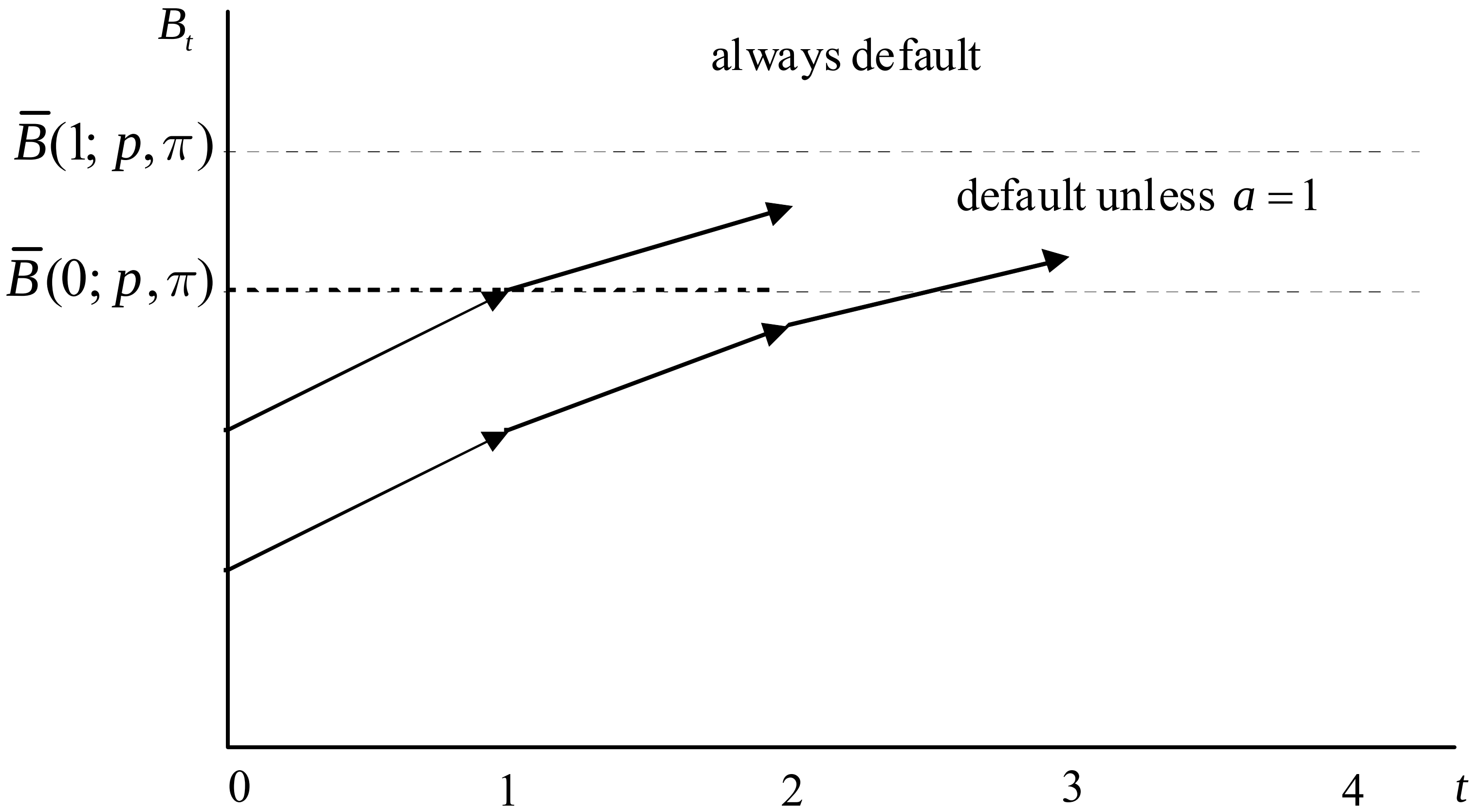
1. The government chooses to never violate the constraint $B \leq \overline{B}(0; p, 0)$, and the optimal debt converges to $\overline{B}(0; p, 0)$ if $a = 0$ sufficiently long.

2. The government chooses to default in T periods if $a = 0$ sufficiently long.

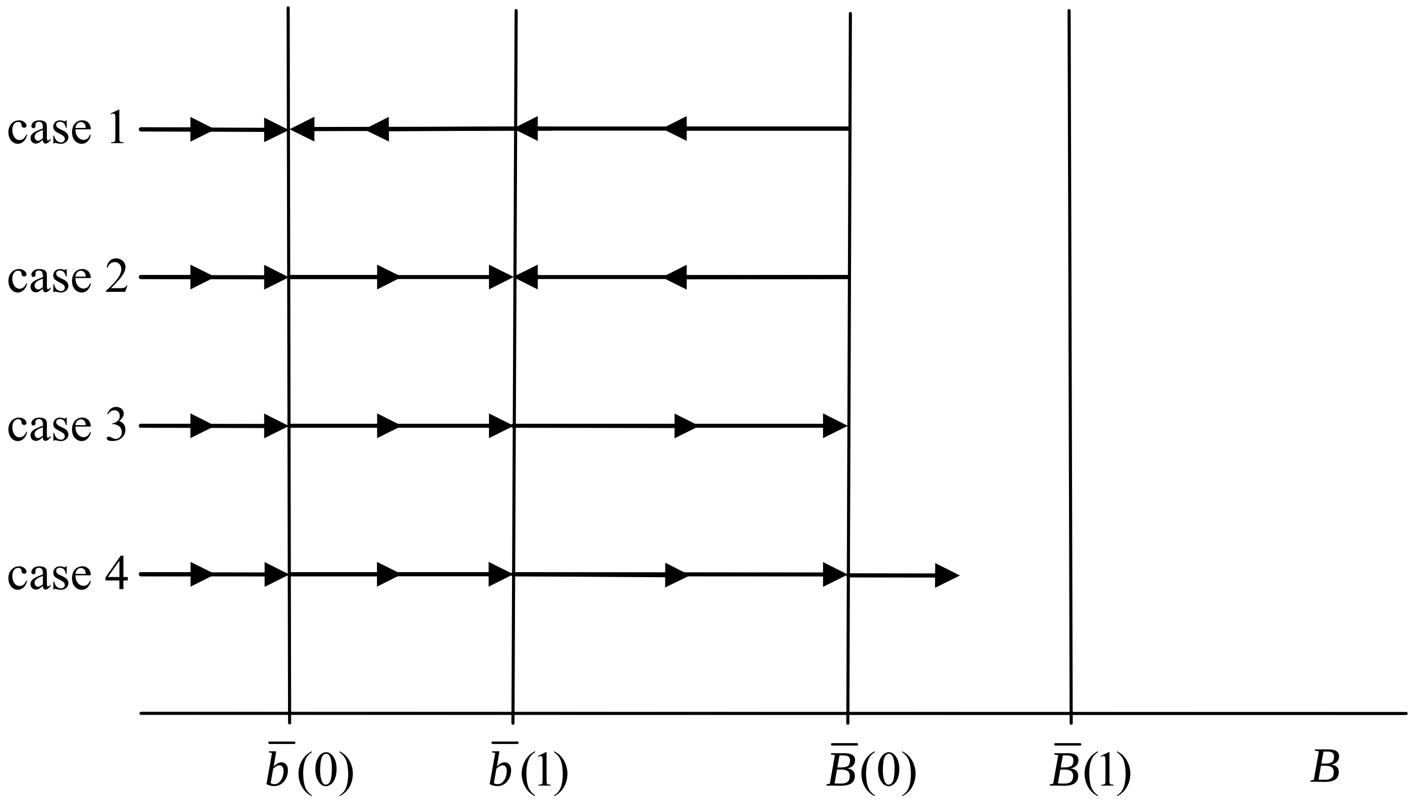
Equilibrium with no default



Equilibrium with eventual default



Some possible phase diagrams in general model



Time varying risk premia

We assume that there are two different probabilities of a self-fulfilling crisis π_1 and π_2, $\pi_2 > \pi_1$, and allow the transitions from one to the other to 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.

Suppose we are in case 1. Then, if realization of the sunspot variable signals that a crisis will take place that period, the provision of a loan from a third party an interest rate higher than

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

can prevent a crisis but leave the government in case 1.

Suppose that we are in case 1 or case 2. Then, the provision of a loan from a third party an interest rate lower than

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can push the government into case 3 or 4.

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U.S. President Bill Clinton's 1995 loan package for Mexico

Suppose that we are in case 1 or case 2. Then, the provision of a loan from a third party at an interest rate lower than

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

can push the government into case 3 or 4.

European Union's 2010 rescue package for Greece

General result

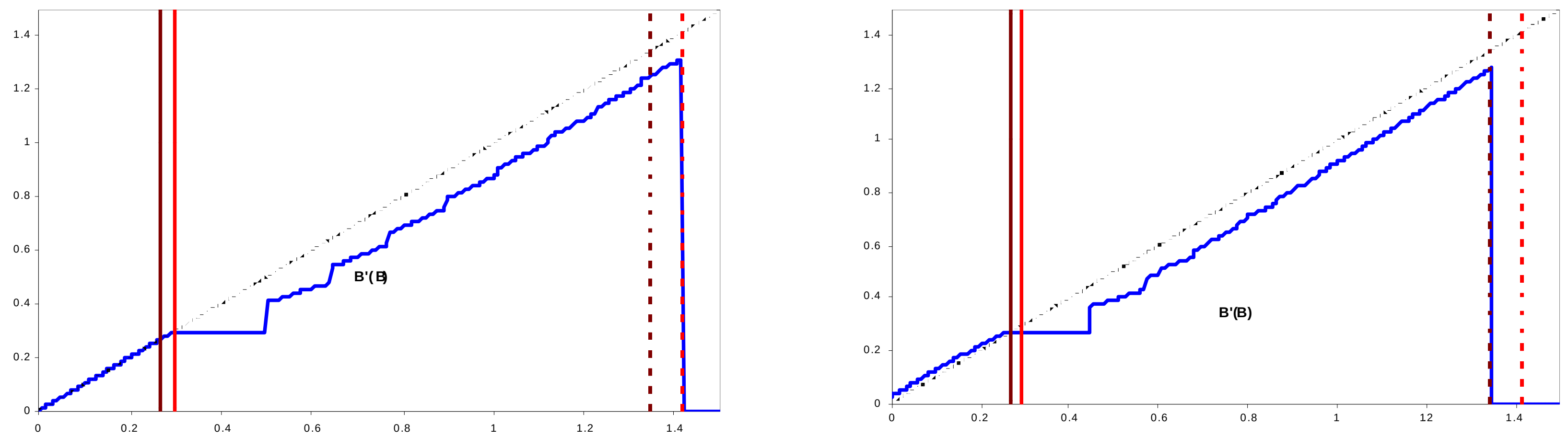
Any policy of a third party that lowers the cost of default or lowers the interest rate on government debt increases the government's incentive to gamble for redemption.

Calibrated model

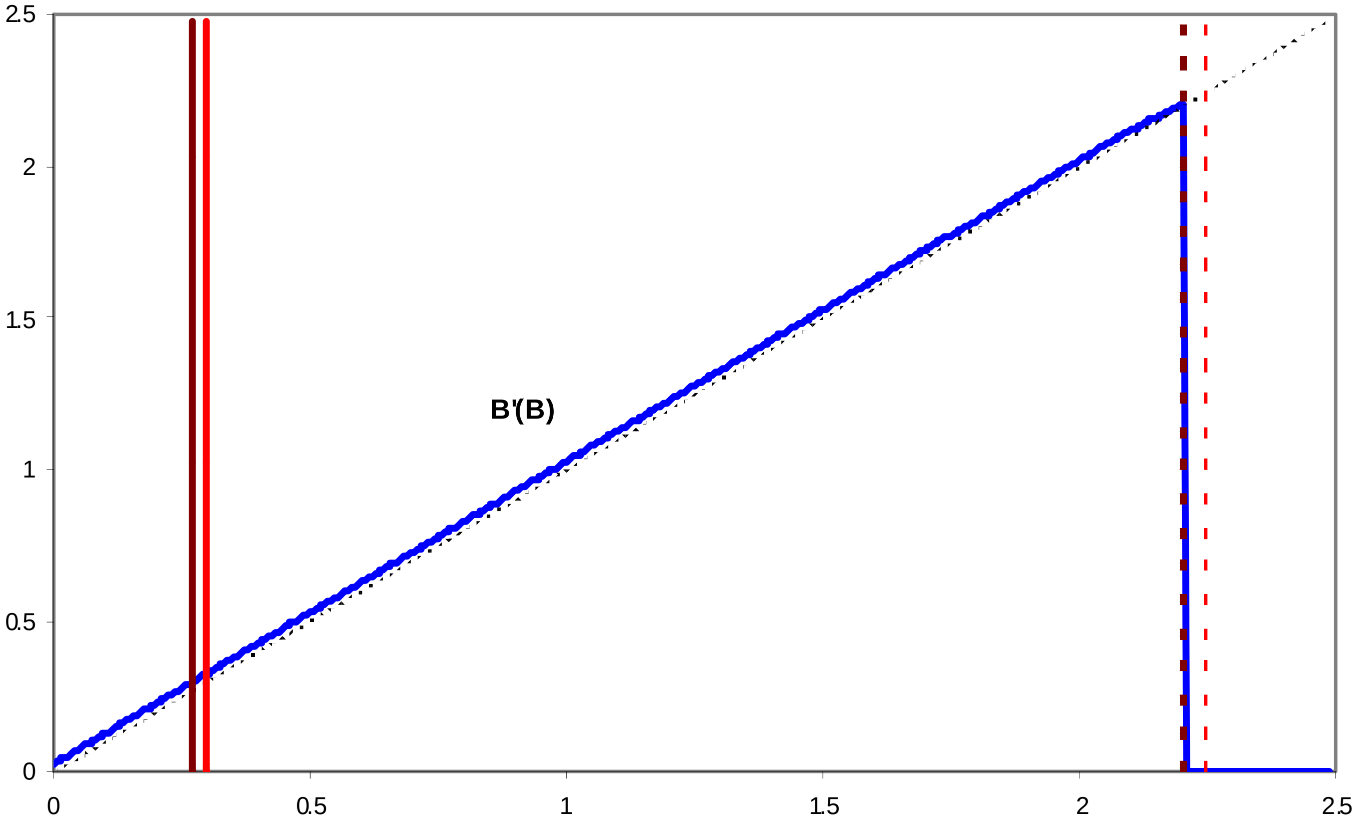
$$u(c,g) = (1-\gamma)\log c + \gamma \log g$$

Parameter	Value	Target
A	0.90	Average government revenue loss
Z	0.95	Cole and Kehoe (1996)
p	0.20	Average recovery in 5 years
β	0.98	Real interest rate of safe bonds 2%
π	0.03	Real interest rate in crisis zone 5%
γ	0.25	Consumers value c 3 times more than g
θ	0.30	Government revenues as a share of output

Policy functions in good (left panel) and bad (right) times



Policy function in bad times for small π



Maturity of debt

Maturity structure makes a difference, not just average maturity!

Suppose that every period, the government sells the 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

$$\frac{300(30 + 29 + ... + 1)\,/\,30 + 300}{600} = \frac{150(30) + 300}{600} = \frac{15(3) + 3}{6} = 8.$$

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

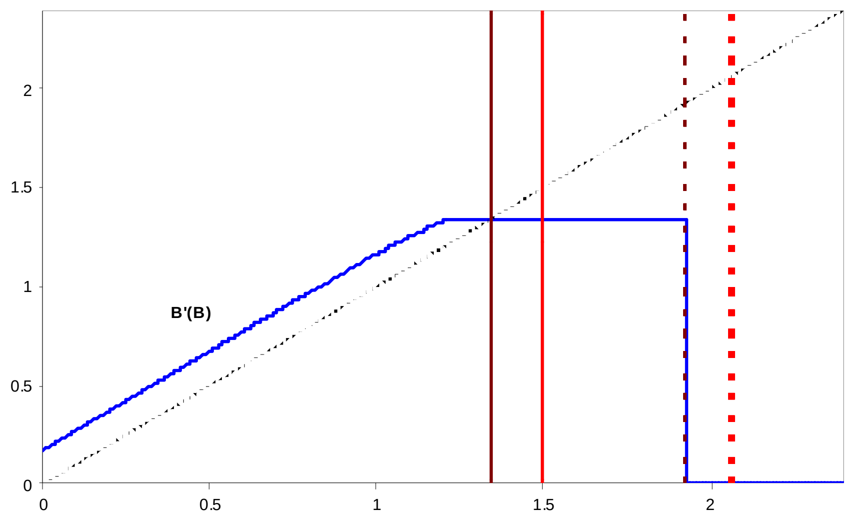
$$\frac{40}{600} = 0.0667.$$

Maturity of debt

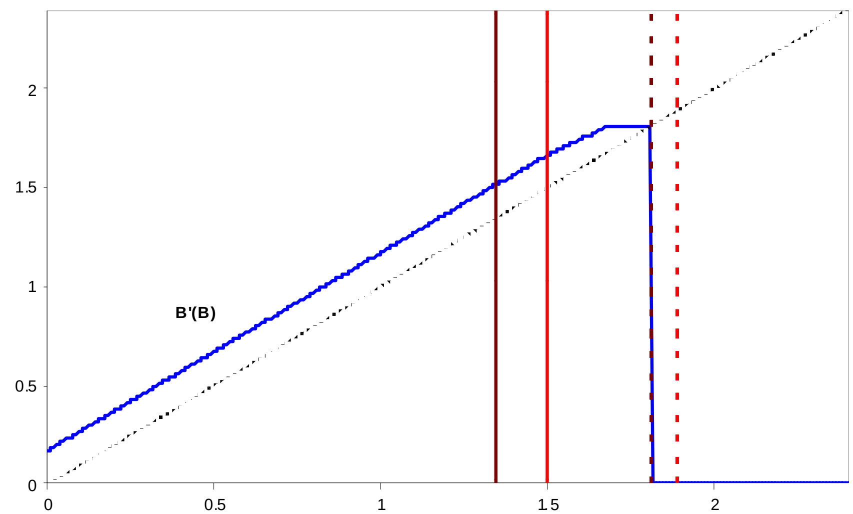
	Weighted average years until maturity	Percent debt with one year or less maturity at issuance
Germany	6.8	7.2
Greece	7.1	11.9
Ireland	6.4	0.0
Italy	7.1	19.2
Portugal	6.0	12.6
Spain	6.8	16.1

Policy functions in bad times with 6-year periods

Normal



Low π

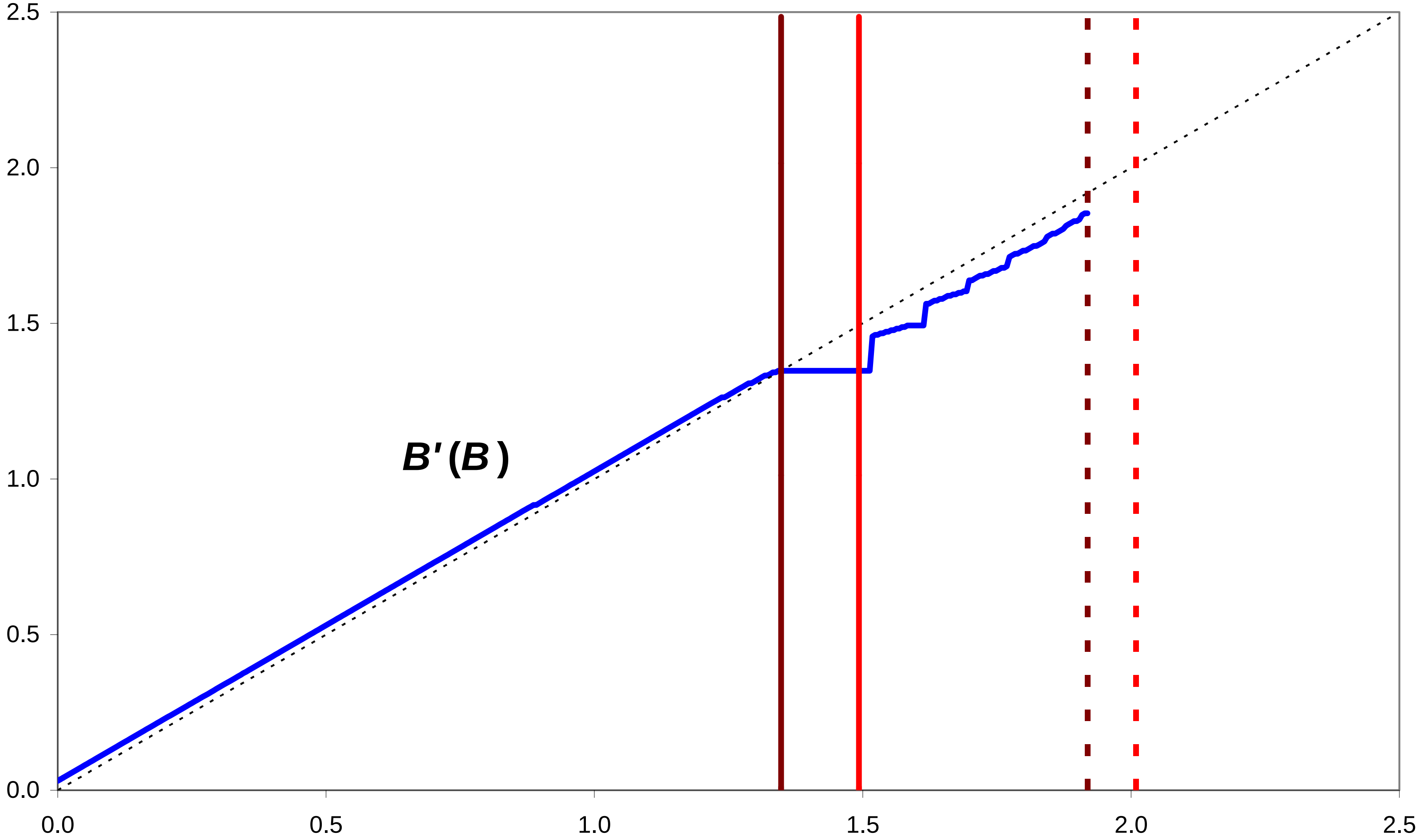


Model with long maturity bonds

Assume that

- At $t = 0$, debt is equally divided among bonds of maturity $1, 2, \ldots, N$;
- New sales are similarly divided among bonds of these maturities;
- If one period bonds are sold at price q, then n period bonds are sold at price q^n.

Average maturity 6 years



Extensions:

Keynesian features

Panglossian borrowers *á la* Krugman (1998)

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Government expenditures are close substitutes for private consumption expenditures:

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

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

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

or

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

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

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

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.

Longer term implications and questions:

European Union has to become either stronger or weaker.

Sargent and Wallace's *Unpleasant Monetarist Arithmetic* implies successful coordination of monetary policy requires successful coordination of fiscal policy. (Maastricht Accords have not worked!)

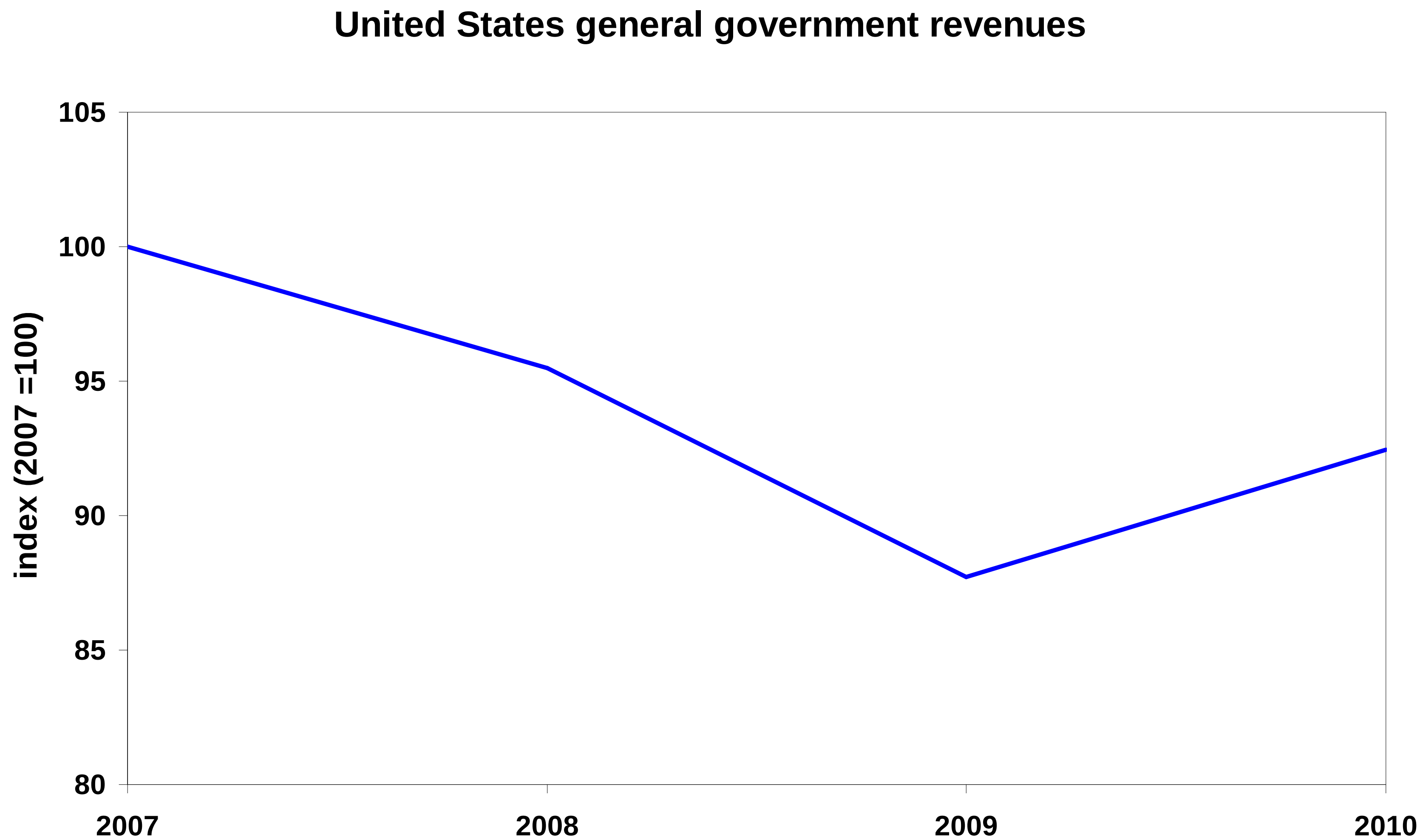
Why is Greece not like California?

What will happen to the welfare state in Europe?

A possible extension:

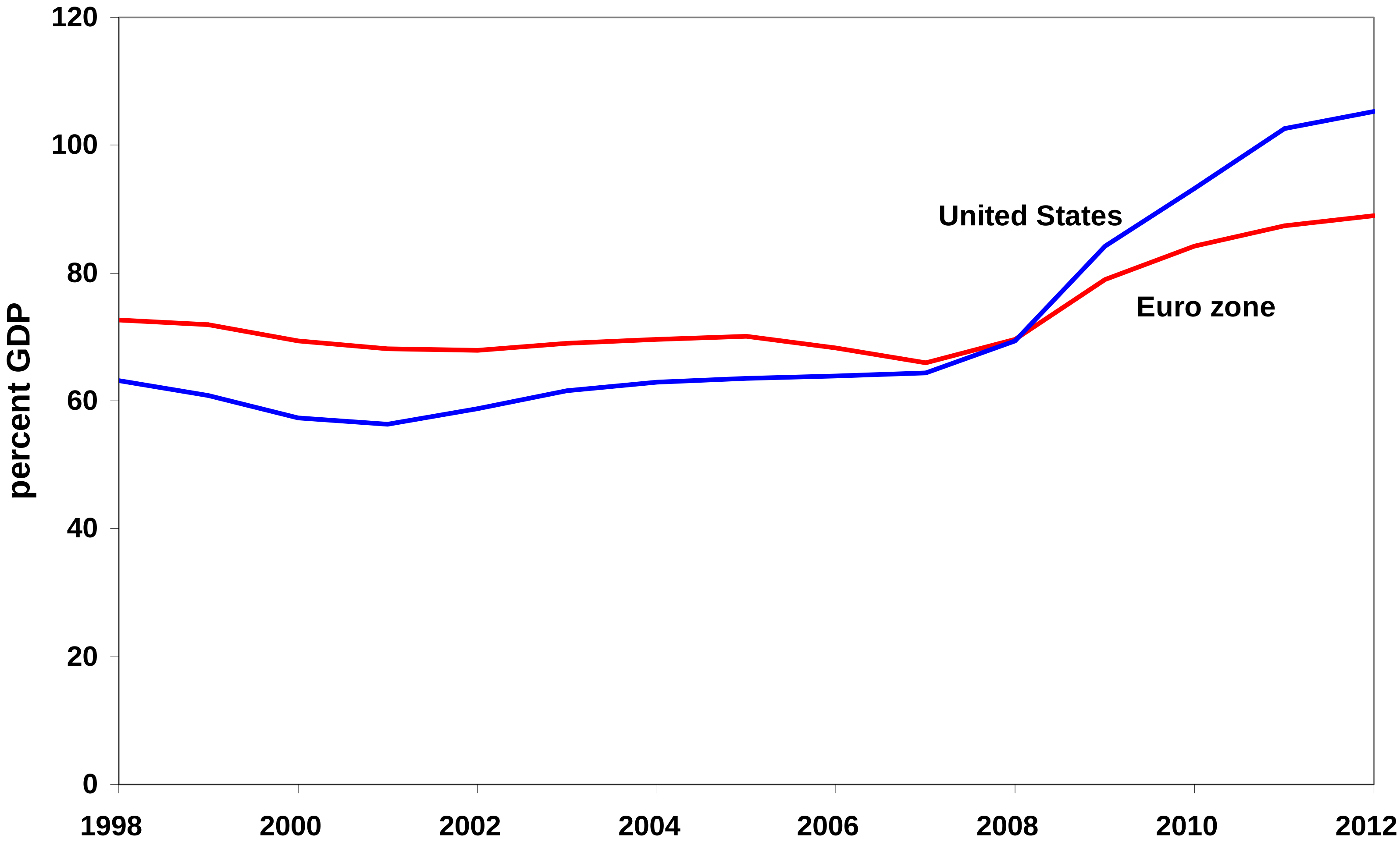
Angela Merkel and Nicolas Sarkorzy (and the European Monetary Union) may be themselves gambling for redemption.

What about the United States?

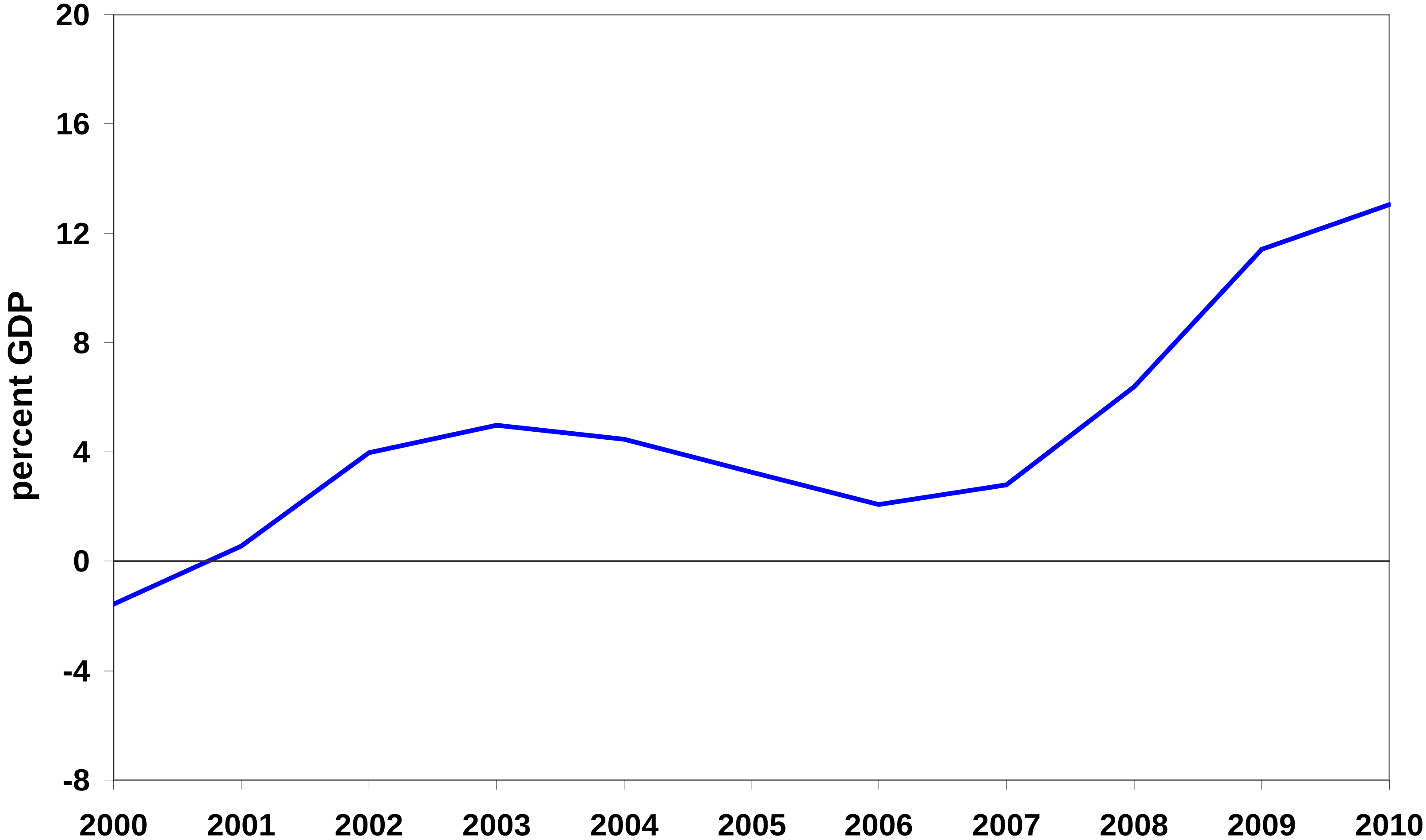


United States general government revenues
index (2007 =100)
105
100
95
90
85
80
2007
2008
2009
2010

General goverment debt with projections



United States net government borrowing



One way for the United States to “avoid” the possibility of default is to inflate/devalue.

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The average maturity of U.S. government debt is 4.9 years. Suppose that the United States has inflation that is 10 percent higher than expected for 5 years (13 percent per year instead of 3 percent per year). Then the payment on any debt that has already been issued and becomes due in 5 years or more will be 38 percent lower than purchasers of bonds were forecasting when they purchased the bonds:

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Of course, there are costs to this sort of inflationary policy.