Why Prices Don't Respond Sooner to a Prospective Sovereign Debt Crisis

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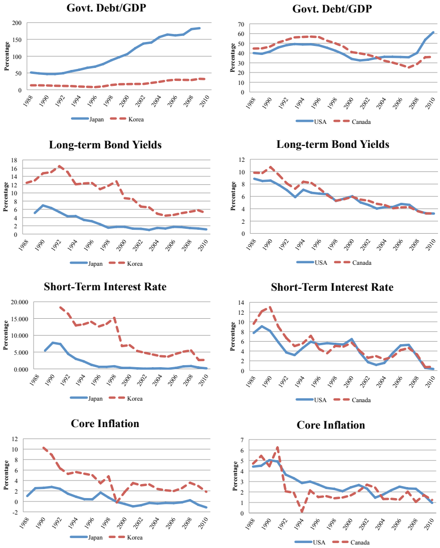
Preliminary. Comments Welcome. These are our own personal views.

Fiscal problems



Resolutions

- It seems fairly obvious that the current level of deficit spending in Japan and U.S. cannot be sustained for ever.
- Possible resolutions:
  1. Increase taxes (or reduce spending);
  2. fail to increase taxes (sovereign debt crisis):
     - inflation?
     - payment suspension?
- Is the second scenario a realistic possibility?
  - If so, how can we explain the current state of Japan or the U.S. with
    - stable or declining prices;
    - high government-bond prices;
    - high yen rate, etc?

Our message

- The fact that inflation and bond yields are low today does not mean that the risk of a debt crisis is low.
- The current situations in Japan and the U.S. are perfectly consistent with the view that there is a non-negligible probability of a sovereign debt crisis.

How we make our point

- Consider two types of default (separately):
  1. Implicit default via inflation (fiscal theory of the price level);
  2. Explicit default on long-term government debt.
- Compare two specifications:
  1. Frictionless asset markets (complete markets);
  2. Financial frictions.
- Agents have heterogenous beliefs about the probability of default.
- Financial frictions are modeled as in Geanakoplos (2003,2010):
  - no contingent claims are traded;
  - agents can borrow to purchase govt debt;
  - govt debt cannot be short sold.

Properties of the model

- Complete markets:
  - Prices respond instantly to news about the possibility of a debt crisis.
  - Inflation smoothing.
- Financial frictions:
  - No response of price to news about the possibility of a debt crisis.
  - Price responses are concentrated in states immediately prior to default state.
- Key in our model with financial frictions:
  - Some individuals want to use leverage to purchase govt debt;
  - Others do not want to purchase govt debt by themselves, but are willing to lend to those who buy it.
- In reality, a large proportion of sovereign debt is held by leveraged financial institutions.

Related literature

- Our model builds on the following two strands of literature:
  1. Fiscal theory of the price level (FTPL):
     - Leeper (1991); Sims (1994); Woodford (1994); Cochrane (2001); Bassetto (2002); etc.
  2. Collateral, beliefs, and leverage:
     - Geanakoplos (1997, 2003, 2010); Fostel and Geanakoplos (2008); Geanakoplos and Zame (2009), Simsek (2010),etc.

Fiscal theory of the price level

- "Naive" assumptions made in the standard FTPL:
  - The government commits to a fixed sequence of real tax revenues, $\{T_t\}$.
  - Such a commitment is made both in and out of the equilibrium path.
  - The price level "adjusts" so that the govt budget constraint holds.
- Criticism against the FTPL by Bassetto (2002):
  - It is impossible to consider "out of the equilibrium path" in the Walrasian framework assumed in the FTPL.
  - Bassetto (2002) considers a market game and finds that a version of the FTPL holds.
- For simplicity, here we follow the naive version of the FTPL, but it is straightforward to build a market game similar to Bassetto's for our model.

Theory of leverage by Geanakoplos

- Conditions of loans:
  - interest rate;
  - collateral;
  - collateral rate.
- How can the interest rate and the collateral rate be determined in markets simultaneously?
  - That is, how can one demand-equals-supply equation for a loan determine two variables — the interest rate and the collateral rate?
- Geanakoplos has developed a competitive-equilibrium framework determining the interest rate and the collateral rate for loans simultaneously.
  - The key is to consider loans with different collateral rates as different assets.
- In our model only one type of loans are traded in equilibrium, whose collateral rate is given by the 'no-default constraint.'

Some evidence

- Rheinhart and Rogoff (2010) find that the probability of sovereign debt crises goes up following:
    - banking crises;
    - sharp increases in government and external debt.
- Nieto Parra (2008):
    - Investment banks demand higher underwriting fees 1 to 3 years before debt crisis.
    - bond spreads do not respond to the news and remain stable up to the crisis.
- Lau (2003): Argentine CDS only increase about 2 months prior to IMF package and 15 months prior to default.
- Greek sovereign debt spread first increased to 2 percent in December 2008 about 16 months before their request for funds from EU/IMF.

Plan of the talk

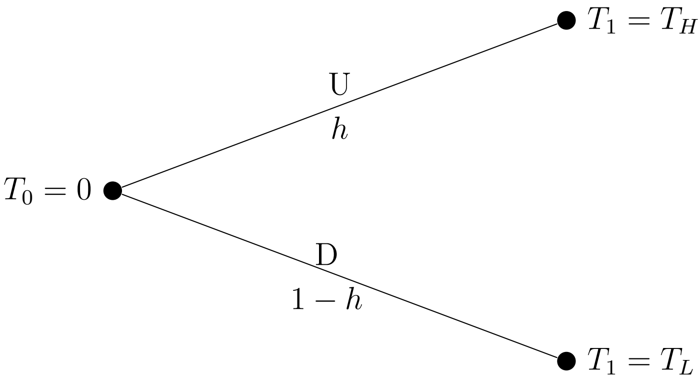
Model

- Two periods: $t = 0, 1$.
- Two states at date 1: $s_1 \in \{U, D\}$.
  - Notation: $s^0 \in S^0 = \{0\}$ and $s^1 = s_1 \in S^1 = \{U, D\}$.
- More generally, s_t denotes the shock realized in period t and s^t denotes the history of shocks.
- States are distinguished by the amount of taxes:

$$T_1 = \begin{cases} T_H, & \text{if } s_1 = U, \\ T_L, & \text{if } s_1 = D \quad \text{(debt crisis)}. \end{cases}$$

  where $T_L \ll T_H$.
- A continuum of agents $h \in [0, 1]$.
  - At date 0, agent h believes that $s_1 = U$ with probability h.
  - Agents are identical except for their beliefs.

Event tree



Individuals

- Preferences:

$$c_0 + \sum_{s^1 \in S^1} \gamma^h(s^1) c(s^1)$$

where $\gamma^h(s^1)$ = subjective probabilities given by

$$\gamma^h(s^1) = \begin{cases} h, & \text{for } s_1 = U, \\ 1 - h, & \text{for } s_1 = D. \end{cases}$$

- Endowments:
  - y_0 at date 0, and y_1 at date 1 (for all $s^1 \in S^1$).
- Storage technology:
  - Gross real rate of return = R (riskfree).

Government

- Flow budget constraint:

$$\bar{B} = P_0 T_0 + q_0 B_0,$$
$$B_0 = P(s^1) T(s^1), \qquad \text{for } s^1 \in S^1.$$

where $\bar{B}$ = initial amount of govt debt (nominal); B_0 = amount of govt bonds issued at date 0; $P(s^t)$ = price level at date-event s^t; q_0 = nominal price of govt bonds at date 0.

- Monetary policy: the nominal interest rate, $\frac{1}{q_0}$.
- Fiscal policy: real amount of taxes collected in each period:

$$T_0 = 0,$$
$$T(s^1) = \begin{cases} T_H, & \text{if } s_1 = U, \\ T_L, & \text{if } s_1 = D. \end{cases}$$

Three market structures

1. "complete markets"
    - asset markets without frictions.
        - complete set of contingent claims with a "natural debt limit."
2. "no borrowing"
    - two assets:
        - govt bonds, and storage.
    - frictions:
        - no borrowing;
        - no short sales of govt bonds.
3. "leverage"
    - three assets:
        - govt bonds, storage, and loans.
    - frictions:
        - agents can borrow to purchase govt debt;
        - borrowing is limited by the "no-default constraint."
        - no short sales of govt debt.

Complete Markets

- frictionless asset markets:
  - complete set of contingent claims (Arrow securities) are traded under the mildest possible debt limit (natural debt limit).
- Arrow security $(s^1|s^0)$:
  - traded at s^0 and pays off one unit of account in period 1 iff s^1 occurs.
  - $b^h(s^1|s^0)$ = quantity of Arrow security $(s^1|s^0)$ purchased by individual h.
  - $q(s^1|s^0)$ = price of Arrow security $(s^1|s^0)$.
- Govt bonds pay one unit of account at every state in period 1.
  - No arbitrage condition:

$$q_0 = \sum_{s^1 \in S^1} q(s^1|s^0).$$

Individual h

- Utility maximization problem of agent h:

$$\max \quad c_0 + \sum_{s^1 \in S^1} \gamma^h(s^1) c(s^1)$$

subject to

$$c_0 + k_0 + \sum_{s^1 \in S^1} q(s^1|s^0) \frac{b(s^1|s^0)}{P_0} + q_0 \frac{b_0}{P_0} \leq \frac{\bar{B}}{P_0} + y_0,$$

$$c(s^1) \leq y_1 - T(s^1) + \frac{b(s^1|s^0)}{P(s^1)} + \frac{b_0}{P(s^1)} + Rk_0, \quad s^1 \in S^1,$$

$$c_0, k_0, b_0, c(s^1) \geq 0.$$

Equilibrium with complete markets

- $c_0^h = 0$ for all $h \in [0, 1]$.
- "Marginal agent": $h_0 = \frac{1}{2}$.
  - Pessimistic agents, $h \leq h_0$,

$$c^h(s^1) = \begin{cases} 0, & \text{for } s^1 = U, \\ \frac{1}{h_0}(Ry_0 + y_1), & \text{for } s^1 = D. \end{cases}$$

  - Optimistic agents, $h > h_0$,

$$c^h(s^1) = \begin{cases} \frac{1}{1-h_0}(Ry_0 + y_1), & \text{for } s^1 = U, \\ 0, & \text{for } s^1 = D. \end{cases}$$

- Equilibrium prices:

$$\frac{\bar{B}}{P_0} = \frac{1}{R}\left\{h_0 T_H + (1 - h_0) T_L\right\},$$

$$\frac{B_0}{P(s^1)} = T(s^1), \qquad \text{for } s^1 \in S^1.$$

Equilibrium Trading Strategies

- Optimistic and pessimistic agents hold 'symmetric' portfolios:
  - Optimistic agents purchase Arrow security U, and sell Arrow security D.
  - Pessimistic agents do the opposite.
- The equilibrium price level will equally reflect the views of optimists and pessimists.

Market structure

- Two assets:
  - govt bonds and storage.
- Frictions:
  - no short sales of govt bonds;
  - no borrowing.
- Budget set for each individual:

$$
\begin{aligned}
& c_0 + k_0 + q_0 \frac{b_0}{P_0} \leq \frac{\bar{B}}{P_0} + y_0, \\
& c(s^1) \leq Rk_0 + \frac{b_0}{P(s^1)} - T(s^1) + y_1, \qquad \text{for } s^1 \in S^1, \\
& c_0, k_0, b_0, c(s^1) \geq 0.
\end{aligned}
$$

Utility maximization

- h_0 = marginal buyer of govt bonds.
- Pessimistic agents only invest in storage: For $h \leq h_0$,

$$c_0^h = b_0^h = 0,$$
$$k_0^h = \frac{\bar{B}}{P_0} + y_0,$$
$$c^h(s^1) = Rk_0^h + y_1 - T(s^1)$$

- Optimistic agents only invest in govt bonds: For $h > h_0$,

$$c_0^h = k_0^h = 0,$$
$$b_0^h = \frac{P_0}{q_0}\left(\frac{\bar{B}}{P_0} + y_0\right),$$
$$c^h(s^1) = \frac{1}{P(s^1)} b_0^h + y_1 - T(s^1)$$

Equilibrium without borrowing

- $h_0 =$ marginal buyer of govt bonds:

$$\frac{q_0}{P_0} = \frac{1}{R}\left\{\frac{1}{P(U)}h_0 + \frac{1}{P(D)}(1-h_0)\right\},$$

- Market clearing condition for govt bonds:

$$\frac{q_0}{P_0}B_0 = (1-h_0)\left(\frac{\bar{B}}{P_0} + y_0\right),$$

- Equilibrium prices at date 1:

$$P(s^1) = \frac{B_0}{T(s^1)}, \qquad \text{for } s^1 \in S^1,$$

- Evolution of the govt debt:

$$\bar{B} = q_0 B_0.$$

Market structure

- Three kinds of assets:
    - govt bonds, storage and loans.
- Frictions:
    - govt bonds cannot be short sold;
    - agents can borrow to purchase govt bonds using those bonds as collateral;
    - loans are limited by collateral requirements.
- Use Geanakoplos's (2003, 2010) theory of collateral contracts.
    - Loans with different collateral rates are traded.
- In this model, only one type of loans are traded in equilibrium.
    - It is the loan contract with the lowest collateral rate sufficient to avoid default.
    - Thus, we need to consider only one type of loans, which is characterized by the risk-free interest rate R, and the 'no-default constraint.'

Budget constraint with loans

- The budget set for each agent can be defined by

$$c_0 + k_0 + q_0 \frac{b_0}{P_0} \leq \frac{\bar{B}}{P_0} + y_0 + \phi_0,$$

$$c(s^1) \leq y_1 - T(s^1) + \frac{b_0}{P(s^1)} + Rk_0 - R\phi_0, \qquad \text{for } s^1 \in S^1,$$

$$R\phi_0 \leq \frac{b_0}{P(D)}, \quad \text{(no-default condition)},$$

$$c_0, k_0, b_0, c(s^1) \geq 0.$$

- Loan contract with one unit of govt bond b_0 as collateral:
  - $\frac{1}{RP(D)}$ = (real) amount of borrowing;
  - $\frac{q_0}{P_0}$ = (real) value of the bond (collateral) at date 0;
  - collateral rate = value of the bond/ amount of borrowing = $q_0 \frac{P(D)}{P_0} R$.

Utility maximization

- Equilibrium leverage:
  - Optimistic agents borrow as much as they can and use the proceeds to purchase government debt.
  - Pessimistic agents lend to optimistic agents.
- Asymmetry between optimists and pessimists:
  - Optimistic agents can bet on their beliefs.
    - Indeed, borrowing to purchase govt debt is effectively equivalent to purchasing Arrow security U.
  - Pessimistic agent cannot bet on their beliefs.
    - Short selling of government debt is ruled out so that there is no trading strategy mimicking Arrow security D.
- The price level will reflect the optimists' view more than the pessimists'.
  - This generates deflationary pressure.

Equilibrium with leverage

- Utility maximization:

$$c_0^h = 0, \quad h \in [0,1],$$

$$b_0^h = \begin{cases} \left(\frac{q_0}{P_0} - \frac{1}{RP(D)}\right)^{-1}\left(\frac{\bar{B}}{P_0} + y_0\right), & h > h_0, \\ 0, & h \le h_0 \end{cases}$$

$$k_0^h - \phi_0^h = \begin{cases} -\frac{1}{R}\frac{b_0^h}{P(D)}, & h > h_0, \\ \frac{\bar{B}}{P_0} + y_0, & h \le h_0 \end{cases}$$

$$c^h(s^1) = y_1 - T(s^1) + \frac{b_0^h}{P(s^1)} + R(k_0^h - \phi_0^h), \quad h \in [0,1]$$

Equilibrium with leverage

- h_0 = marginal buyer of govt bonds:

$$h_0 \frac{\frac{1}{P(U)} - \frac{1}{P(D)}}{\frac{q_0}{P_0} - \frac{1}{RP(D)}} = R,$$

- Market clearing condition for govt bonds:

$$\left(\frac{q_0}{P_0} - \frac{1}{RP(D)}\right) B_0 = (1 - h_0)\left(\frac{\bar{B}}{P_0} + y_0\right),$$

- Equilibrium prices at date 1:

$$P(s^1) = \frac{B_0}{T(s^1)}, \qquad \text{for } s^1 \in S^1,$$

- Evolution of the govt debt:

$$\bar{B} = q_0 B_0.$$

Two Period model: numerical example

Inflation rates (%) at $t = 0$ and $s^1 = D$, and marginal buyers

	π_{-1}	π_0	$\pi(D)$	h_0
(1) complete markets	-1.96	30.72	47.06	0.5
(2) no borrowing	-1.96	25.57	53.09	0.56
(3) leverage	-1.96	9.46	75.62	0.79

- At $t = -1$, everyone believes $\Pr(s_1 = U) = 1$.
- At $t = 0$, news arrives so that agents start to hold different views.
- Parameters: $\bar{B} = 1,\ y_0 = 1,\ q_0 = 1,\ R = 1.02,\ T_H = 1,\ T_L = 0.5$.
- Because $q_0 = 1$ and $R > 1$, there is deflation in period -1 ($\pi_{-1} < 0$).

Environment

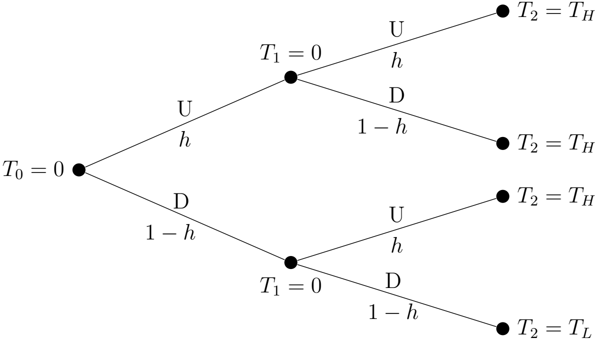
- Shocks: $s_t \in \{U, D\}$, $t = 1, \ldots, T$.
- Endowments:

$$y(s^t) = \begin{cases} y_0, & \text{for } t = 0, \\ 0, & \text{for all } s^t \text{ with } t = 1, \ldots, T-1, \\ y_T, & \text{for all } s^T. \end{cases}$$

- Taxes:

$$T(s^t) = \begin{cases} 0, & \text{for all } s^t \text{ with } t = 0, \ldots, T-1, \\ T_L, & \text{for } s^T = D^T, \\ T_H, & \text{for all } s^T \neq D^T. \end{cases}$$

Example: Event tree in three period model



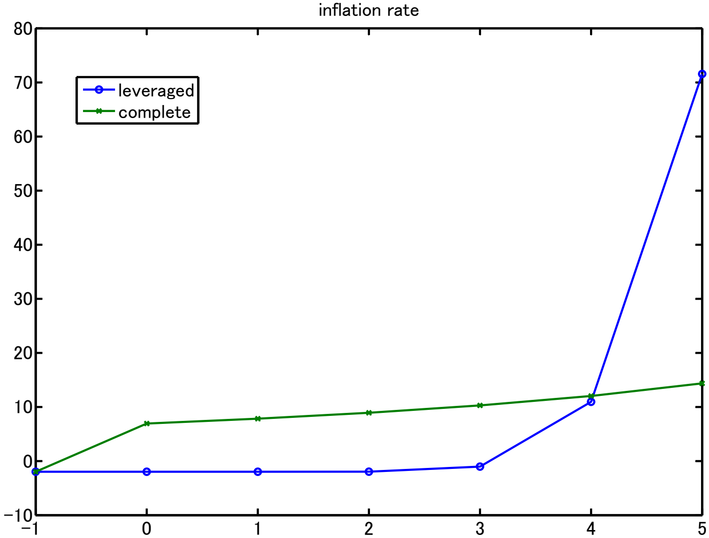
Numerical example: Three period model

Inflation rates and marginal buyers

	π_{-1}	π_0	$\pi(D)$	$\pi(D^2)$	h_0	$h(D)$
(1) complete markets	-1.96	17.65	22.55	30.72	0.50	0.33
(2) with leverage	-1.96	-1.09	10.86	71.89	0.94	0.75

- At $t = -1$, everyone believes $\Pr(s_t = U) = 1$.
- At $t = 0$, news arrives so that agents start to hold different views.
- $\bar{B} = 1,\ y_0 = 1,\ q_0 = q(D) = q(U) = 1,\ R = 1.02,\ T_H = 1,\ T_L = 0.5.$

Inflation rates at $s^t = D^t$ when $T = 5$



Properties of the equilibrium

- Complete Markets
  - Inflation rate jumps on the news in period 0
  - Smoothing. Inflation is smooth along the path to a debt crisis.
  - Along path to crisis, marginal buyer is falling at the rate $1/(t+2)$
- Financial frictions
  - No response of inflation rate to news.
  - Concentration: Inflation rate is low except in states near and during the debt crisis.
  - Marginal buyer is much higher (above 0.74 in all periods)

Setup with long-term bonds and explicit default

- Shock U, D is realized in each period.
- Price levels, $\{P(s^t)\}$, are exogenously given.
- Govt debt:
  - $\bar{B}$ = amount of government debt in period 0.
  - No new debt issued in any other period.
  - All debt is long-term and matures in period T.
- Sovereign debt crisis:
  - Govt defaults in period T only if $S^T = D^T$.
    - When the govt defaults, it repays only a fraction $\alpha \in (0,1)$ of $\bar{B}$.
  - Govt only collects taxes in final period.

$$T(s^T) = \begin{cases} \frac{\bar{B}}{P(s^T)}, & \text{if } s^T \neq D^T, \\ \alpha \frac{\bar{B}}{P(s^T)}, & \text{if } s^T = D^T. \text{ (debt crisis)} \end{cases}$$

Numerical example

- Look at the evolution of the log yield of the govt debt in s^t:

$$\rho(s^t) \equiv \frac{1}{T-t} \ln\left[\frac{1}{q(s^t)}\right],$$

where $q(s^t) =$ price of govt debt in s^t, which matures in period T.

- parameter values:
  - Constant price levels: $P(s^t) = P$ for all s^t and t.
  - Real interest rate: $R = 1.02$.
  - Default rate: $\alpha = 0.2$.
- Prior to period 0, everyone believes that there is not govt default, i.e., $\alpha(s^T) = 1$ with probability one.
  - Under this assumption, the log yield of govt debt in period -1 is

$$\rho_{-1} = \ln(1.02) = 1.98\%.$$

Yields on long-term bond at $s^t = D^t$ when $T = 5$

Log yields in the five-period model (%)

	ρ_{-1}	ρ_0	$\rho(D)$	$\rho(D^2)$	$\rho(D^3)$
(1) complete markets	1.98	6.34	14.84	34.68	104.15
(2) financial frictions	1.98	1.98	2.05	5.04	38.70

- Complete markets
  - bond yield responds to news
  - yield rises along the path towards default
- Financial frictions
  - bond yield does not respond to news
  - Bond yield response is delayed.
  - Magnitude of the increase in bond yield is smaller along path to default.

Who holds Japanese govt debt?

Holdings of Japanese Government Debt
End of fiscal year 2008

	Amount (trillion yen)	Fraction (%, net of govt)
Total	936.63	
Government	114.04	
Individuals and non-financial companies	75.88	9.2
Domestic Financial Institutions	687.45	83.6
Private	354.27	43.1
Public	268.06	32.6
Central Bank	65.12	7.9
Foreign sector	59.26	7.2

- financial sector: accepts deposits and holds government debt
- individual holdings of government debt are small.

Who holds US debt?

Holdings of U.S. Government Debt
End of Calendar year 2010

	Amount (trillion $)	Fraction (%, net of govt)
Total	14.03	
Government	6.17	
Individuals and non-financial companies	1.41	12.4
Domestic Financial Institutions	5.38	47.2
Private	1.82	16.0
Public	2.44	21.4
Central Bank	1.11	9.8
Foreign sector	4.44	38.9

- Financial sector also holds a lot of government debt.
- Foreign sector is also important.
- Our result is robust to the introduction of a foreign sector.

Discussion:Restrictions on short selling govt debt.

- A cheap way to finance a mortgage: short government debt.
  1. Borrow government debt today.
  2. Sell it. Use proceeds to purchase a home.
  3. Repay at the interest rate on government debt.
- Mortgage rates are higher than the yield on government debt.

Spreads on Mortgage Rates over
Government Debt in U.S. and Japan
Data collected on October 24, 2011*

	U.S. (Percentage)	Japan (Percentage)
1- Year ARM	2.84	0.86
5/1-year ARM	1.92	1.22
15-Year Fixed	0.5125	n.a.
20-Year Fixed	n.a.	0.47
30-Year Fixed	1.06	0.46

*Government debt yields and
U.S. Mortgage rates are from Bloomberg.
Japan Mortgage rates are from Shinsei Bank.

Government restrictions

- Basel I and II induce banks to take long leveraged positions in government debt.
- Governments take actions to restrict short selling in states where the risk of default is high.
- Our model suggests that banning short sales of government debt is effective in reducing price pressure!

Summary

- We have presented a model in which deflation/low yields can persist even when people recognize that a debt fiscal crisis is not a negligible possibility.
- Crucial features of our model:
  - asset markets are imperfect:
    - borrowing is limited by the no-default constraint;
  - individuals hold heterogeneous portfolios:
    - some agents want to purchase govt debt;
    - others do not want to purchase it by themselves, but are willing to lend to those who buy it.
- Compared to the case with frictionless asset markets, our model implies:
  - the inflation rate is much lower before the crisis, but it gets much higher once the crisis occurs.
  - In the model with long-term govt debt, the yield on govt debt behaves similarly.

Robustness

- Here we have assumed that individuals have different beliefs on how likely the debt crisis occurs.
    - Any other assumption that leads to the same type of heterogeneity in portfolios would work too.
        - Example: different degrees of risk aversion.
- We have also assumed that loans are risk-free.
    - If we interpret "loans" in our model as "demand deposits" in banks, this may sound odd, because they are also subject to the risk of inflation.
    - In reality, govt bonds offer higher interest rates than demand deposits.
    - Any other assumption that generates this type of rate-of-return differentials would work too.
        - Example: difference in maturity.

Some directions for future research

- other forms of heterogeneity (e.g., degrees of risk aversion).
- allowing some agents to short-sell government debt (arbitrageurs) as in e.g. Vayanos and Gromb (2010), Chen et al. (2001), but impose limits on arbitrage.
- Endogenous default
- normative analysis.
- more traditional DSGE framework.
- open economy.