Sovereign Debt, Default Risk, and the Liquidity of Government Bonds

Gaston Chaumont
University of Rochester

Fiscal Policy and Sovereign Debt
IMF-CARF-TCER-Waseda University Conference
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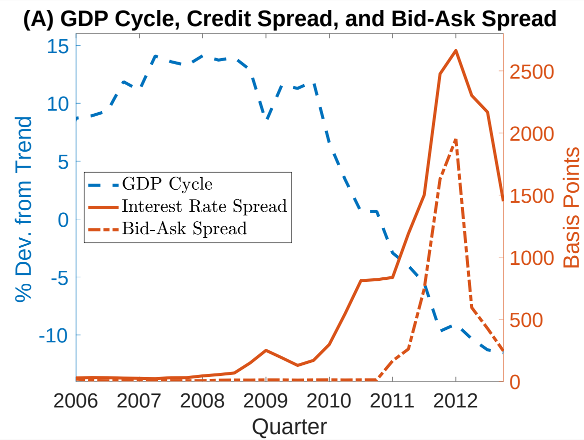
Motivation: Greek GDP Cycle, Credit Spread, and Liquidity



- Credit spreads and bid-ask spreads were very large in the crisis
- Bid-ask spreads arise because bonds are traded in OTC markets
- Liquidity is **endogenous** to macro conditions

▸ Dealers ▸ MarketsStructure ▸ Correlations ▸ Volumes ▸ AuctionRates ▸ Debt

This Paper

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- Transaction cost perspective: resources and time to trade
- Measured mainly through bid-ask spreads

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- How the state of the economy affects sovereign bonds liquidity?
- How does liquidity affect bond prices and gov't incentives to default?

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Approach:

- Incorporate trading frictions into a sovereign default model
- Illiquidity due to search frictions in the secondary market
- Liquidity and gross flows traded are endogenous and affects default risk through bond prices

Outline

1. Overview of the default model with endogenous illiquidity
2. Some model Implications
3. Conclusions

Model

Model

Time and markets

- $t = 1, 2, ...$
- Centralized market: Walrasian, market clearing price for bonds is q
- Decentralized market: subject to search frictions

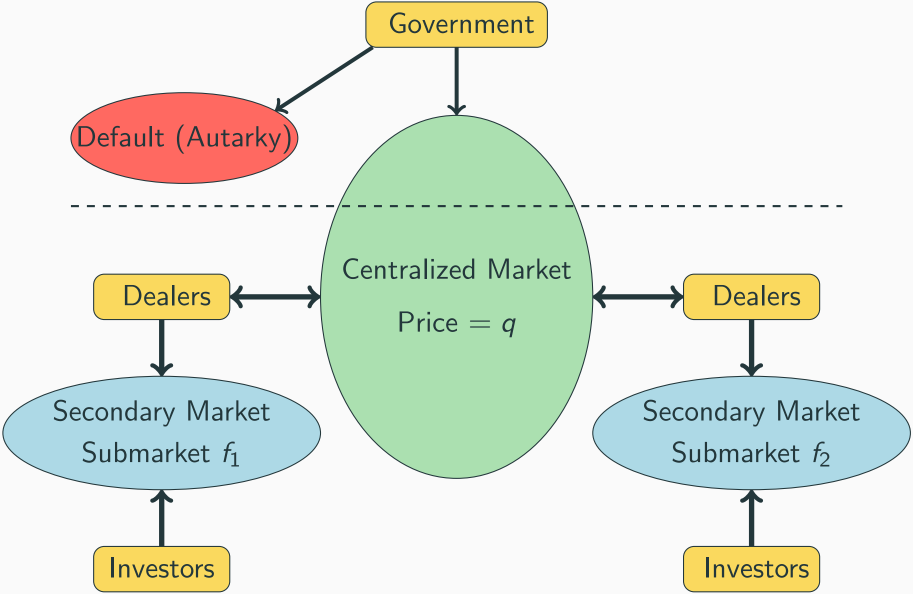
Three types of agents:

- Government: Issues long-term bonds only in centralized market
- Dealers: Access centralized market and decentralized market
- Investors: Access only decentralized market
  - High type: Derive utility $u_h > 0$ from bond holdings ("buyers")
  - Low type: Derive utility $u_\ell < 0$ from bond holdings ("sellers")
  - Bond holdings are $a \in \{0, 1\}$
  - Investors distribution: $\{H_0, H_1, L_1\}$, $\bar{I} = H_0 + H_1 + L_1$

Timing of Actions

Graphical Description of the Model

◂ Environment ◂ Dealers ◂ MktClearing



Government's Problem ▸ more

Government's option value of default is

$$V(y,B) = \max_{\delta\in\{0,1\}} (1-\delta)V^R(y,B) + \delta V^D(y),$$

$$V^D(y) = U(h(y)) + \beta\mathbb{E}_{y'|y}V^D(y')$$

$$V^R(y,B) = \max_{B'} \left\{U(c) + \beta\mathbb{E}_{'|y}V(y',B')\right\}$$

with

$$c = y + q(y,B,B')\left[B' - (1-\lambda)B\right] - \lambda B$$

- B caputres potential demand and supply in secondary market:
  - Potential sellers are $L_1 = \zeta B$ and potential buyers are $H_0 = \bar{I} - B$
  - Liquidity enters into Gov't problem through $V^R(\cdot)$
  - In particular, through $q(y,B,B')$, the price in centralized market

Centralized Market Clearing

- Supply of bonds is upward slopping and given by

$$\underbrace{B' - (1-\lambda)\,B}_{\text{Government's supply}} + \underbrace{\alpha\left(f_\ell^1(s;\overset{+}{q})\right)(1-\lambda) \times [\text{Mass of sellers}(L_1)]}_{\text{Dealers' supply}}$$

- Demand for bonds is downward slopping and given by

$$\underbrace{\alpha\left(f_h^0(s;\overset{-}{q})\right) \times [\text{Mass of buyers}(H_0)]}_{\text{Dealers' demand}}$$

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- Trading probabilities derived from expected gains from trade:

$$\textit{Buyers} \quad : \quad \max_f \alpha(f)\left[-\underbrace{(f+q(s))}_{\text{ask price}} + u_h + \frac{\mathbb{E}_{y'|y}\left[1-\delta(y',B')\right]\left[I^1(s') - I^0(s')\right]}{1+r}\right]$$

$$\textit{Sellers} \quad : \quad \max_f \alpha(f)\left[\underbrace{(q(s)-f)}_{\text{bid price}} - u_\ell - \frac{\mathbb{E}_{y'|y}\left[1-\delta(y',B')\right] I^1(s')}{1+r}\right]$$

Quantitative Analysis

Model Calibration: New Parameters

Parameter	Value	Target/Source
u_h	0.001	$\mathbb{E}u = 0.$
u_ℓ	-0.160	$mean\left(S^{B-A}\right)$
ζ	0.315	Quarterly turnover rate 0.78
γ	0.00025	Minimum $S^{B-A} \approx 5$ bpts
$\bar{I}$	5.000	Large. Never binding

Quantitative importance of secondary market frictions

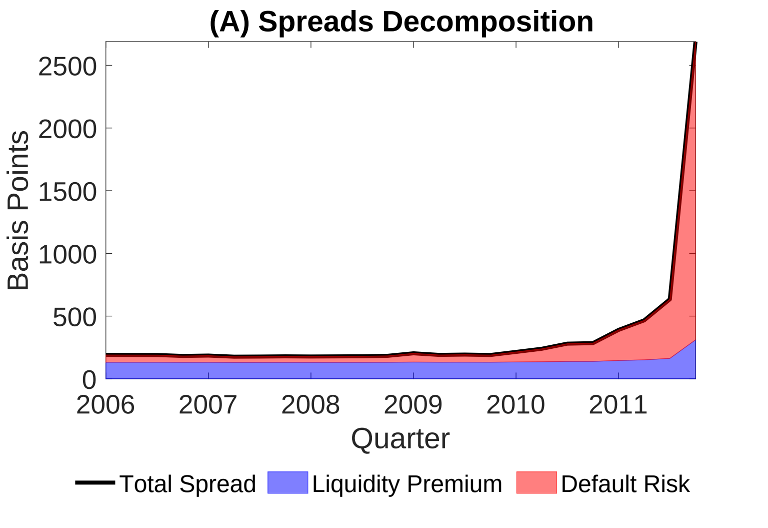
Key Parameters	Baseline	Frictionless	Longer holding	Hold to maturity
Low type probability: ζ	0.315	—	0.1575	0.000
Dealer's entry cost: $\gamma \times 100$	0.025	0.000	0.025	0.025
Moments	Baseline	Frictionless	Longer holding	Hold to maturity
Mean bond spread (%)	3.42	2.67	3.03	2.00
Std. dev. bond spread (%)	2.18	2.67	2.81	1.83
Debt to output (%)	124	139	134	137
Mean bid-ask spread (bps.)	76	—	74	71
Bonds turnover rate (%)	78	—	42	6

1. Trading frictions significantly tighten the borrowing constraint of the government
2. If investors hold bonds for longer horizon spreads are lower and government borrows more

Additional model implications

Implication 1: Trading frictions are important for spreads

1. Trading frictions and secondary market flows matter for bond prices



Implication 2: Risk and liquidity interact in equilibrium

2 Changes in default risk affect size of flows and change the liquidity component in bond prices

$$\text{Buyers} \quad : \quad \max_f \alpha(f) \left[-\underbrace{(f + q(s))}_{\text{ask price}} + \frac{\mathbb{E}_{y'|y}[1 - \delta(y', B')] \left[I_h^1(s') - I_h^0(s') \right]}{1 + r} \right]$$

$$\text{Sellers} \quad : \quad \max_f \alpha(f) \left[\underbrace{(q(s) - f)}_{\text{bid price}} - \frac{\mathbb{E}_{y'|y}[1 - \delta(y', B')] I_\ell^1(s')}{1 + r} \right]$$

Implication 3: The distribution of bond holders matters

3 Changes in the distribution of bond holders affect bond prices

- Supply of bonds is upward slopping and given by

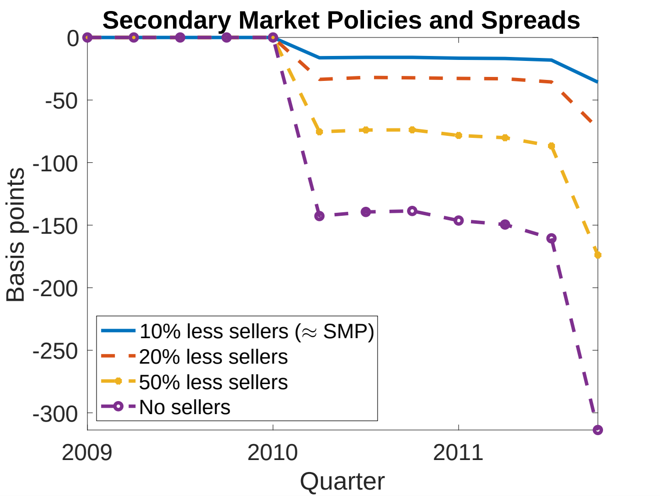
$$\underbrace{B' - (1-\lambda)B}_{\text{Government's supply}} + \underbrace{\alpha\left(f_\ell^1(s; \overset{+}{q})\right)(1-\lambda) \times [\text{Mass of sellers}(L_1)]}_{\text{Dealers' supply}}$$

- Demand for bonds is downward slopping and given by

$$\underbrace{\alpha\left(f_h^0(s; \overset{-}{q})\right) \times [\text{Mass of buyers}(H_0)]}_{\text{Dealers' demand}}$$

Implication 4: Policy can affect liquidity and bond prices

4 Secondary market purchases of bonds can increase bond prices by increasing average holding horizon and reducing sell volumes



Conclusions

Conclusions

I proposed a model of sovereign default with endogenous liquidity in the secondary market

Implications:

1. Bond prices depend on trading frictions and secondary market flows
2. Changes in default risk affect size of flows and change the liquidity component in bond prices
3. Changes in the distribution of bond holders affect bond demand and supply flows, liquidity and prices
4. QE policy can affect liquidity and bond prices by changing the average holding horizon of bonds and reducing sell volumes

Argentina

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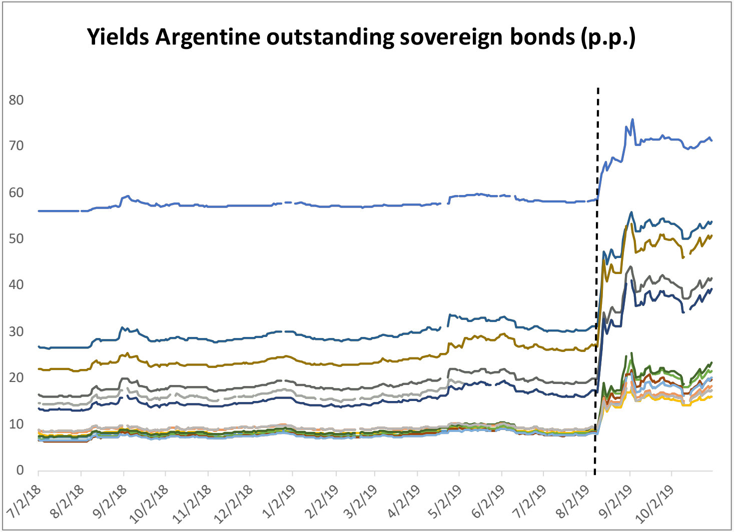
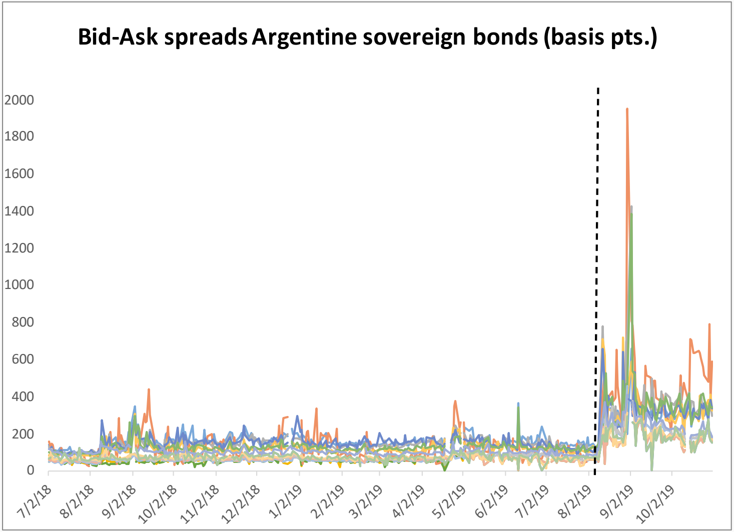
Default “shock” and yields in Argentina



- Updated belief of elections upcoming election outcomes lead to large increase in bond yields

Default “shock” and Bid-Ask Spreads in Argentina



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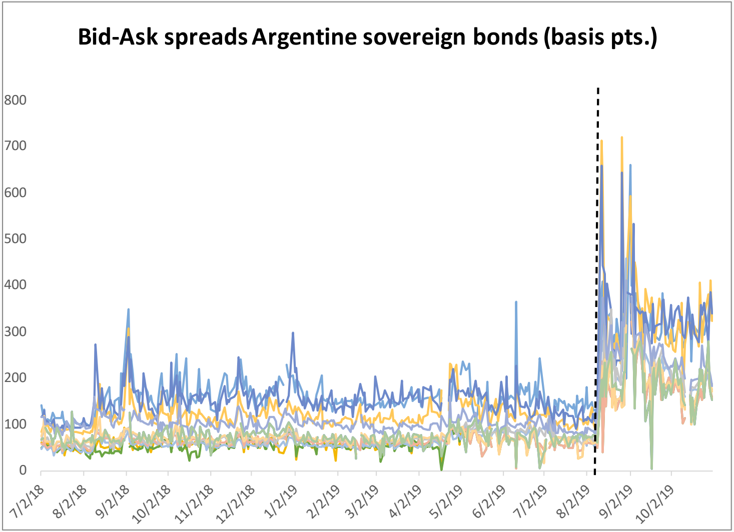

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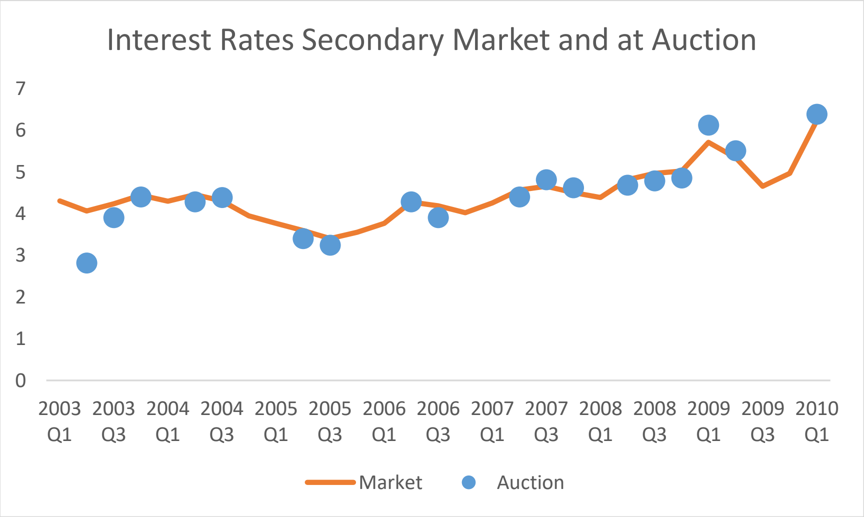
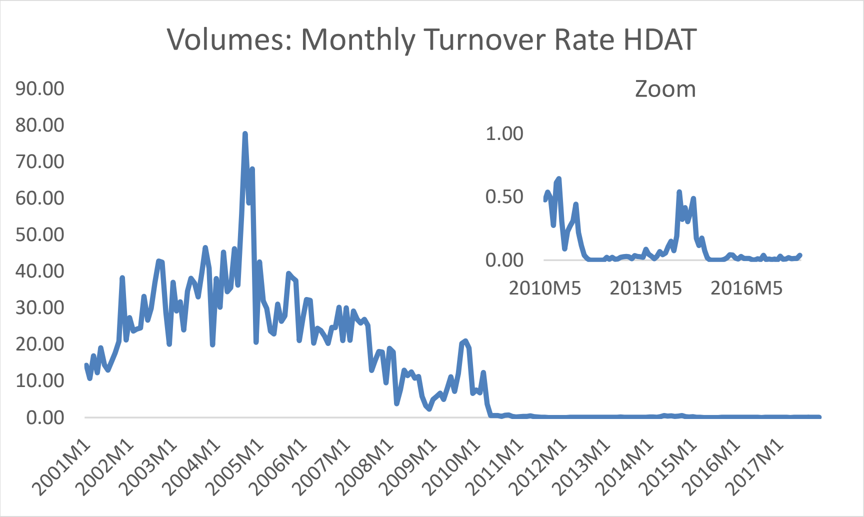
Greece: Interest Rates in the Market and at Issuance

Back



Greece: Secondary Market Volumes

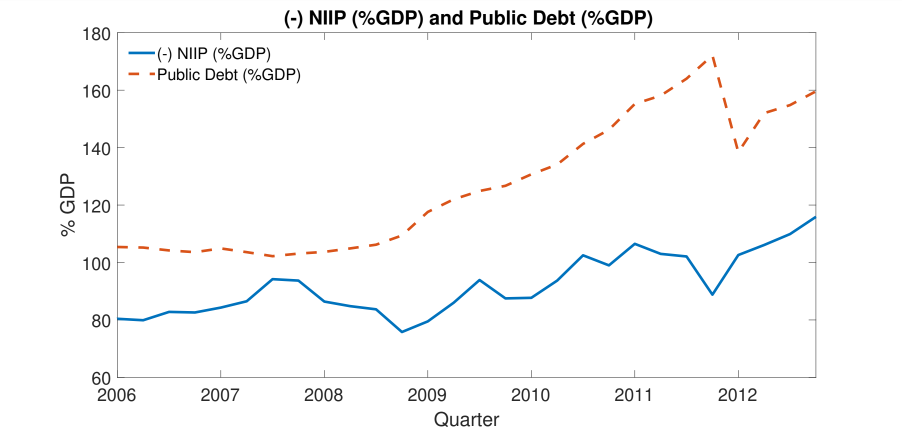
Back



$$\text{Turnover} = \frac{\text{Transactions}}{\text{Outstanding Bonds}} \times 100.$$

Greece: Debt and International Investment Position

Back



Sovereign Bonds are Traded in Decentralized Markets
Back

- Only a few banks can directly purchase bonds from gov't Dealers

- All other investors trade bonds in the secondary market:
  - Participants: banks, institutional investors, private investors, etc.
  - Volumes in secondary market **12 times** larger than primary market

- Secondary markets are OTC where transactions are
  - Decentralized
  - Bilateral
  - Costly
  - Time consuming

- A standard liquidity measure is the bid-ask spreads

$$S^{B-A} \equiv \frac{q^A - q^B}{\left(q^A + q^B\right)/2} \times 10,000$$

Greece: List of Primary Dealers

Back

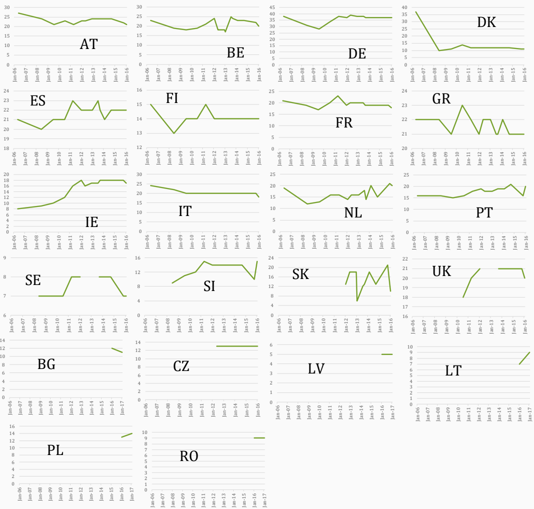
A. List of Primary Dealers[1]

FIRM	Greece (GR)	Firm's location
Alpha Bank	X	Athens
Banca IMI	X	Milan
Bank of America Merrill Lynch	X	London
Barclays	X	London
BNP Paribas	X	London
Citigroup	X	London
Commerzbank	X	Frankfurt
Crédit Suisse	X	London
Deutsche Bank	X	Frankfurt
EFG Eurobank-Ergasias	X	Athens
Goldman Sachs	X	London
HSBC	X	Athens
J.P. Morgan	X	London
Morgan Stanley	X	London
National Bank of Greece	X	Athens
NatWest Markets	X	London
Nomura	X	London
Piraeus Bank	X	Athens
Société Générale	X	Paris
UBS	X	London
Unicredit	X	Munich
TOTAL	21	

Source: AFME and Greek Central Bank

Europe: Number of Primary Dealers 2006-2017

Back

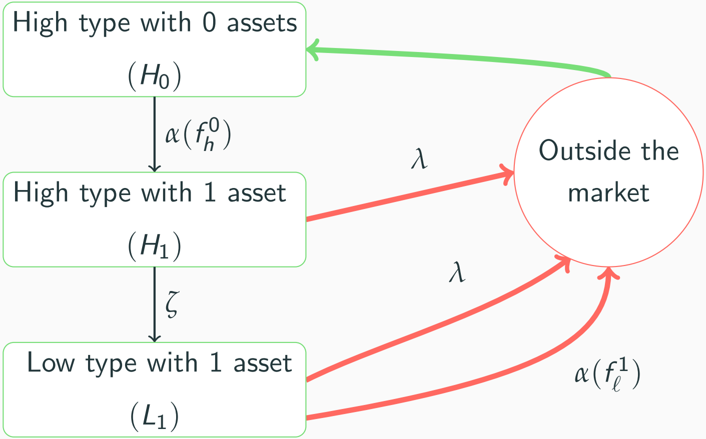


Source: Association for Financial Markets in Europe

Appendix to the Model

Investors Types and Transitions

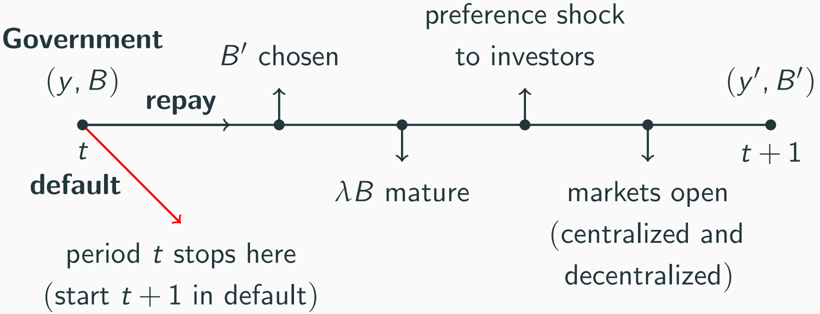
Investors: $\bar{I} = H_0 + H_1 + L_1$



- $\alpha(\cdot)$ is trade prob., λ mature prob., ζ prob. type switches

Timing of Actions

◂ Environment



Government Back

- Maximizes representative household utility: $\sum_t \beta^t U(c_t)$

- Income $y \in Y \equiv \{y_1, y_2, ..., y_N\}$ with Markov transitions $\pi_{i,j}$

- Issues debt in the centralized market
  - Each bond matures randomly with probability $\lambda \in [0, 1]$

- Can default on their debt obligations
  - There is an output loss $h(y) \leq y$
  - Goverment is excluded from debt markets
  - Regains market access with prob. $\phi \in (0, 1)$, and $B = 0$

- Takes as given a pricing schedule $q(\cdot)$ and policies of investors and dealers

Dealers

- Risk-neutral and there is competitive entry at cost $\gamma > 0$
- No Inventories: permanent access to centralized market ▸ Diagram
- Dealers are static and profits are $\Pi(f) = -\gamma + \rho(f)f$
- By free entry:

$$\rho(f) = \frac{\gamma}{f}$$

- Matching function implies $\alpha(f)$ increasing and concave

Dealer's Problem and Market Tightness ◂ Back

Dealers choose which submarket f to visit to maximize profits given by

$$\max_f \Pi(f) = \max_f \{-\gamma + \rho(\theta(f))[f + q(s) - q(s)]\}$$

Then, free entry implies that

$$\Pi(f) \leq 0 \text{ and } \theta(f) \geq 0,$$

with complementary slackness.

Market tightness in each submarket is given by

$$\theta(f) = \begin{cases} \rho^{-1}\left(\frac{\gamma}{f}\right) & \text{if } \Pi(f) = 0, \\ 0 & \text{otherwise.} \end{cases}$$

How are Bonds Priced? An Example

Assume investors hold bonds until maturity and a Telephone-Line matching function

$$\mathcal{M}(d, n) = \frac{d \times n}{d + n}$$

Then, market clearing price is

$$q(s) = \underbrace{\frac{1}{1+r}\mathbb{E}_{y'|y}\{[I_h^1(s') - I_h^0(s')]}_{\text{Value of holding bond}}\underbrace{[1 - \delta(y', B')]}_{\text{Default Risk}}\} - \underbrace{\gamma\left[\frac{1}{1 - \frac{\Delta B}{H_0}}\right]^2}_{\text{Liquidity Component}}$$

Liquidity Components:

- Intermediation frictions γ: more efficient matching reduce liquidity penalty
- Relative supply $\Delta B / H_0 = [B' - (1 - \lambda) B] / [\bar{I} - (1 - \lambda) B]$: the larger relative supply the higher liquidity penalty
- Bond maturity λ: longer maturity implies less liquidity penalty $(\bar{I} > B')$

Pricing and the Bid-Ask Spread

Back

Implied interest rate, $r_g(s)$:

$$q(s) = \frac{\lambda + (1-\lambda) z}{\lambda + r_g(s)}$$

Interest Rate Spread, $S^R(s)$:

$$\begin{aligned} S^R(s) &\equiv (1 + r_g(s))^4 - (1+r)^4 \\ &= \left[1 + \frac{\lambda + (1-\lambda) z}{q(s)} - \lambda\right]^4 - (1+r)^4 . \end{aligned}$$

Bid-Ask Spread

$$S^{B-A}(s) \equiv \frac{q^A(s) - q^B(s)}{q(s)}$$

$$\begin{aligned} q^B(s) &\equiv q(s) - f^B(s) \\ q^A(s) &\equiv q(s) + f^A(s) \end{aligned}$$

Functional Forms

Back

Government utility function

$$U(c) = \frac{c^{1-\sigma}}{1-\sigma}$$

Output under default

$$h(y) = y - \max\left\{0, d_0 y + d_1 y^2\right\}$$

Matching function

$$\mathcal{M}(d, n) = \frac{d \times n}{d + n}$$

Model Calibration: Standard Parameters

Back

Parameter	Value	Target/Source
σ	2.000	Literature
ρ_y	0.953	AR(1) for GDP Cycle
η_y	0.020	AR(1) for GDP Cycle
ϕ	0.050	5 years average exclusion
β	0.976	Match Default Probability of 0.68%
d_0	-0.522	average $r(s) - r$
d_1	0.650	standard deviation of $r(s) - r$
λ	0.039	6.5 year average time to maturity
z	0.011	So price in PM is at par-value
r	0.010	˜4% annual

Non-Targeted Moments

Non-Targeted Moments

Moment	Model	Data
σ_c/σ_y	1.07	0.98
$\rho_{S^R,tb/y}$	0.58	0.71
$\rho_{S^R,c}$	-0.77	-0.45
$\rho_{S^R,y}$	-0.75	-0.56
$\rho_{y,tb/y}$	-0.43	-0.59

◂ Back