ESTIMATING SOVEREIGN DEFAULT RISK

Huixin Bi (BoC) & Nora Traum (NC State)

March 2, 2012

WHERE WE ARE TODAY

TABLE 1: 10-yr Nominal Interest Rate Spread (against Germany)

	2010	2011
Italy	1.65	5.19
Greece	8.99	16.05

Where We Are Today

- Theory
  - Ability to service debt is country specific
  - Rational expectations $\rightarrow$ default probabilities forward looking
  - e.g. Bi (2011), Juessen, et al (2011)

Where We Are Today

- Theory
  - Ability to service debt is country specific
  - Rational expectations $\rightarrow$ default probabilities forward looking
  - e.g. Bi (2011), Juessen, et al (2011)
- Empirical
  - Panel regressions, e.g. Alesina, et al (1992)
  - Backward looking debt limits, e.g. Ostry, et al (2010)

THIS PAPER

- Estimate RBC model of sovereign default
- Use Bayesian methods; Italian and Greek post-EMU data
- Main Results
    - For given debt level, Greece had lower default probability
    - Italy more willing to service debt than Greece

MODEL

- RBC, closed economy model
- Fiscal instruments: spending, taxes, transfers, debt
- Endogenous probability of sovereign (partial) default

MODEL: HOUSEHOLDS

Preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log\left(c_t - h\bar{c}_{t-1}\right) + \phi \log(1 - n_t) \right\}$$

Budget constraint:

$$(1 - \tau_t) A_t n_t + z_t - c_t = \frac{b_t}{R_t} - (1 - \Delta_t) b_{t-1}$$

$$A_t - A = \rho_A (A_{t-1} - A) + \epsilon_t^A. \qquad \epsilon_t^A \sim \mathcal{N}(0, \sigma_A^2)$$

Model: Government

- Government budget constraint:

$$\tau_t A_t n_t + \frac{b_t}{R_t} = g_t + z_t + \underbrace{(1-\Delta_t)b_{t-1}}_{b^d_{t-1}}$$

- Fiscal Rules:

$$\begin{aligned}
g_t - g &= \rho_g(g_{t-1} - g) - \gamma_g\left(b^d_{t-1} - b\right) + \epsilon^g_t, \quad \epsilon^g_t \sim \mathcal{N}(0, \sigma^2_g) \\
\tau_t - \tau &= \rho_\tau(\tau_{t-1} - \tau) + \gamma_\tau\left(b^d_{t-1} - b\right) + \epsilon^\tau_t, \quad \epsilon^\tau_t \sim \mathcal{N}(0, \sigma^2_\tau) \\
z_t - z &= \rho_z(z_{t-1} - z) + \epsilon^z_t, \quad \epsilon^z_t \sim \mathcal{N}(0, \sigma^2_z)
\end{aligned}$$

Model: Government

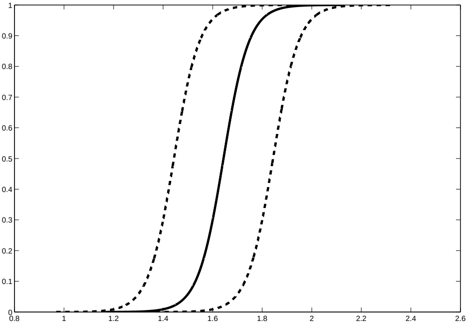
- Effective, stochastic fiscal limit b_t^* implying default scheme:

$$\Delta_t = \begin{cases} 0 & \text{if } b_{t-1} < b_t^* \\ \delta & \text{if } b_{t-1} \geq b_t^* \end{cases}$$

- b_t^* related to
  - Dynamic tax Laffer curve
  - Political willingness to finance debt
- b_t^* drawn from Logistic distribution

MODEL: FISCAL LIMIT

- Estimate point: P($\tilde{b}^* \geq b$) = 0.3
- Assume $\hat{b}^* - \tilde{b}^* = 0.4$, where P($\hat{b}^* \geq b$) = 0.999
- Prior: $\tilde{b}^* \sim U(1.4, 1.8)$



Equilibrium

Competitive equilibrium:

- HH maximize utility subject to budget
- Gov. policy satisfies its budget
- Markets clear, implying

$$c_t + g_t = A_t n_t$$

Estimation

- Italy (1999:2-2010:3) and Greece (2001:2-2010:3)
- Observables: y, g, T, b, R
- Assume measurement error
- Priors: standard in literature

Solving Model

- Use monotone mapping method
  - Coleman (1991), Davig (2004)
  - Discretize state space
  - Iterate on policy functions

Estimating Model

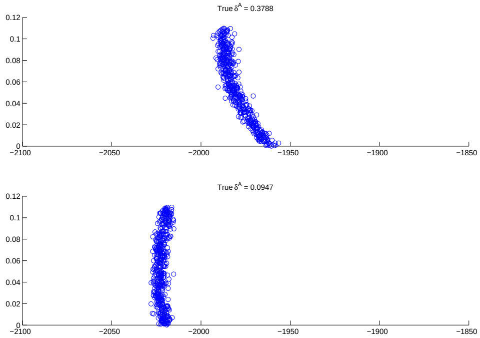
- Sequential Monte Carlo approximation of likelihood [Doh (2011)]
  - Initialize state x_0 with N particles
  - Drawn N particles $u^{t|t-1,i}$
  - Construct $x^{t|t-1,i}$ and assign weight

$$w_t^i = \frac{1}{(2\pi)^{5/2}|\Sigma|^{1/2}} \exp\left[-\frac{1}{2}\left(y_t - Ax^{t|t-1,i}\right)' \Sigma \left(y_t - Ax^{t|t-1,i}\right)\right]$$

  - Normalize weights & resample w/ replacement
  - Log-likelihood approximation: $\sum_{t=1}^{T} \ln\left(\frac{1}{N}\sum_{i=1}^{N} w_t^i\right)$
- Posterior distribution from Metropolis-Hastings algorithm

Estimating Model

- Identifiability of parameters



- Calibrate $\delta = \{0.0978, 0.05, 0.0245\}$

Calibrated Parameters

	Italy	Greece
β	0.99	0.99
$\bar{n}$	0.75	0.75
$\bar{g}/\bar{y}$	0.1966	0.1795
$\bar{b}/\bar{y}$	1.19*4	1.14*4
τ	0.4148	0.3387

- Estimated parameters: $\tilde{b}^*$, h, γ^g, γ^τ, ρ^a, ρ^z, ρ^g, ρ^τ, σ_a, σ_g, σ_τ, σ_z

Estimates for Italy

	Prior	$\delta^A =$ **0.3788**
$\tilde{b}^*$	1.60 [1.42, 1.78]	1.52 [1.46, 1.60]
$\gamma^{g,L}$	0.40 [0.12, 0.82]	0.30 [0.16, 0.56]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.53 [0.45, 0.66]

- $\tilde{b}^*$ **informed from data**

Estimates for Italy

	Prior	$\delta^A = \mathbf{0.3788}$	$\delta^A = \mathbf{0.2}$
$\tilde{b}^*$	1.60	1.52	1.47
	[1.42, 1.78]	[1.46, 1.60]	[1.44, 1.51]
$\gamma^{g,L}$	0.40	0.30	0.59
	[0.12, 0.82]	[0.16, 0.56]	[0.17, 0.82]
$\gamma^{\tau,L}$	1.1	0.53	0.56
	[0.64, 1.67]	[0.45, 0.66]	[0.45, 0.68]

ESTIMATES FOR ITALY

	Prior	$\delta^A = \mathbf{0.3788}$	$\delta^A = \mathbf{0.2}$
$\tilde{b}^*$	1.60 [1.42, 1.78]	**1.52** **[1.46, 1.60]**	**1.47** **[1.44, 1.51]**
$\gamma^{g,L}$	0.40 [0.12, 0.82]	0.30 [0.16, 0.56]	0.59 [0.17, 0.82]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.53 [0.45, 0.66]	0.56 [0.45, 0.68]

- $\downarrow \delta \Longrightarrow \downarrow \tilde{b}^*$

ESTIMATES FOR ITALY

	Prior	$\delta^A =$ **0.2**	$\delta^A =$ **0.0978**
$\tilde{b}^*$	1.60 [1.42, 1.78]	1.47 [1.44, 1.51]	1.60 [1.44, 1.78]
$\gamma^{g,L}$	0.40 [0.12, 0.82]	0.59 [0.17, 0.82]	0.54 [0.25, 0.80]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.56 [0.45, 0.68]	0.56 [0.28, 0.70]

Estimates for Italy

	Prior	$\delta^A =$ **0.2**	$\delta^A =$ **0.0978**
$\tilde{b}^*$	**1.60**	1.47	**1.60**
	[1.42, 1.78]	[1.44, 1.51]	**[1.44, 1.78]**
$\gamma^{g,L}$	0.40	0.59	0.54
	[0.12, 0.82]	[0.17, 0.82]	[0.25, 0.80]
$\gamma^{\tau,L}$	1.1	0.56	0.56
	[0.64, 1.67]	[0.45, 0.68]	[0.28, 0.70]

- **Low δ calibration $\Longrightarrow$ $\tilde{b}^*$ not well-identified**

ESTIMATES FOR GREECE

	Prior	$\delta^A =$ **0.0978**
$\tilde{b}^*$	1.60 [1.42, 1.78]	1.45 [1.40, 1.57]
$\gamma^{g,L}$	1.1 [0.64, 1.67]	1.51 [1.08, 1.78]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	1.14 [0.94, 1.48]

- $\tilde{b}^*$ **informed from data**

ESTIMATES FOR GREECE

	Prior	$\delta^A =$ **0.2**	$\delta^A =$ **0.0978**
$\tilde{b}^*$	1.60 [1.42, 1.78]	1.69 [1.57, 1.79]	1.45 [1.40, 1.57]
$\gamma^{g,L}$	1.1 [0.64, 1.67]	1.53 [1.22, 1.85]	1.51 [1.08, 1.78]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.76 [0.46, 1.00]	1.14 [0.94, 1.48]

Estimates for Greece

	Prior	$\delta^A =$ **0.2**	$\delta^A =$ **0.0978**
$\tilde{b}^*$	1.60 [1.42, 1.78]	**1.69** **[1.57, 1.79]**	**1.45** **[1.40, 1.57]**
$\gamma^{g,L}$	1.1 [0.64, 1.67]	1.53 [1.22, 1.85]	1.51 [1.08, 1.78]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.76 [0.46, 1.00]	1.14 [0.94, 1.48]

- $\downarrow \delta^A \Longrightarrow \downarrow \tilde{b}^*$

Estimates for Greece

	Prior	$\delta^A =$ **0.3788**	$\delta^A =$ **0.2**
$\tilde{b}^*$	1.60 [1.42, 1.78]	1.67 [1.58, 1.78]	1.69 [1.57, 1.79]
$\gamma^{g,L}$	1.1 [0.64, 1.67]	1.73 [0.87, 2.97]	1.53 [1.22, 1.85]
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.82 [0.54, 1.09]	0.76 [0.46, 1.00]

Estimates for Greece

	Prior	$\delta^A = \mathbf{0.3788}$	$\delta^A = \mathbf{0.2}$
$\tilde{b}^*$	1.60	**1.67**	**1.69**
	[1.42, 1.78]	**[1.58, 1.78]**	**[1.57, 1.79]**
$\gamma^{g,L}$	1.1	1.73	1.53
	[0.64, 1.67]	[0.87, 2.97]	[1.22, 1.85]
$\gamma^{\tau,L}$	1.1	0.82	0.76
	[0.64, 1.67]	[0.54, 1.09]	[0.46, 1.00]

- $\tilde{b}^*$ **same for high/mid** δ^A

Estimates for Greece

	Prior	$\delta^A = \mathbf{0.3788}$	$\delta^A = \mathbf{0.2}$
$\tilde{b}^*$	1.60 [1.42, 1.78]	1.67 [1.58, 1.78]	1.69 [1.57, 1.79]
$\gamma^{g,L}$	1.1 [0.64, 1.67]	**1.73** **[0.87, 2.97]**	**1.53** **[1.22, 1.85]**
$\gamma^{\tau,L}$	1.1 [0.64, 1.67]	0.82 [0.54, 1.09]	0.76 [0.46, 1.00]

- $\tilde{b}^*$ **same for high/mid** δ^A**,** γ**'s adjust**

Estimated Fiscal Limit

- How close is estimated fiscal limit to maximum serviceable debt implied by model?

Laffer Curve & Fiscal Limit

- τ_t^{max}: tax rate at Laffer curve peak
- T_t^{max}: tax revenue at Laffer curve peak
- Maximum debt level in model:

$$\mathcal{B}^{max} = E\sum_{t=0}^{\infty}\beta^{t+1}\frac{u_c^{max}(A_{t+1},g_{t+1})}{u_c^{max}(A_0,g_0)}\left(T^{max}(A_t,g_t)-g_t-z_t\right)$$

Fiscal Limit in Practice

- Political obstacles to achieve tax peak
- Reduced-form political economy representation
- Introduce "'political factor" β^{pol}:

$$\mathcal{B}^* = E\sum_{t=0}^{\infty}\beta^{t+1}\beta^{pol}\frac{u_c^{max}(A_{t+1},g_{t+1})}{u_c^{max}(A_0,g_0)}\left(T^{max}(A_t,g_t)-g_t-z_t\right)$$

- Ratio of $\tilde{b}^{max}$ to $\tilde{b}^*$ is political factor estimate

Fiscal Limit in Italy

	$\delta^A = 0.3788$		$\delta^A = 0.0947$	
	median	$[5, 95]$	median	$[5, 95]$
$\tilde{b}^{max}$	2.45	[2.38, 2.49]	2.47	[2.24, 2.51]
$\tilde{b}^{*}$	1.52	[1.46, 1.6]	1.6	[1.44, 1.78]
β^{pol}	0.62	[0.59, 0.67]	0.65	[0.58, 0.73]

Fiscal Limit in Greece

	$\delta^A = 0.3788$		$\delta^A = 0.0947$	
	median	$[5, 95]$	median	$[5, 95]$
$\tilde{b}^{max}$	3.32	[3.15, 3.36]	3.26	[3.07,3.35]
$\tilde{b}^{*}$	1.67	[1.58, 1.78]	1.45	[1.40,1.57]
β^{pol}	0.5	[0.48, 0.54]	0.45	[0.42, 0.48]

Fiscal Limit in Italy/Greece

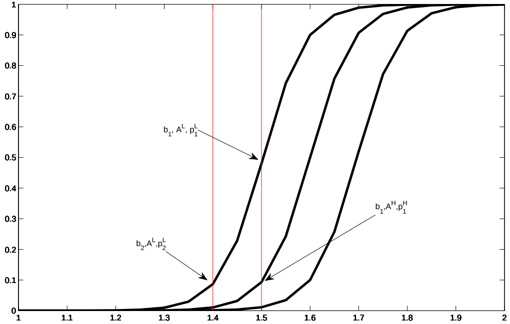
	$\delta^A = 0.3788$		$\delta^A = 0.0947$	
	median	$[5, 95]$	median	$[5, 95]$
β^{pol}: Italy	0.62		0.65	
β^{pol}: Greece	0.5		0.45	

Extension: State Dependent Fiscal Limit

- Issue: Model has difficulty w/ recent recession

EXTENSION: STATE DEPENDENT FISCAL LIMIT

- Issue: Model has difficulty w/ recent recession
- Stochastic fiscal limit drawn from conditional distribution, $b_t^* \sim \mathcal{B}^*(A_{t-1})$
- $P(b_{t-1} \geq b^*) = \frac{\eta_3 \exp(\eta_1 + \eta_2 b_{t-1} + \eta_5 A_{t-1})}{\eta_4 + \exp(\eta_1 + \eta_2 b_{t-1} + \eta_5 A_{t-1})}$



Conclusion

- Show how to estimate DSGE model of sovereign default
- For given debt level, Greece had lower default probability
- Italy more willing to service debt than Greece

Conclusion

- Show how to estimate DSGE model of sovereign default
- For given debt level, Greece had lower default probability
- Italy more willing to service debt than Greece
- Ongoing research:
  - Estimate model with broader set of Eurozone countries
  - Incorporate state dependence in fiscal limit