The Pricing of Sovereign Risk Under Costly Information

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Motivation

- Attention paid to sovereign nations is not constant
  - Emerging market fund managers use ‘flags’
  - Attention increases during crises
Motivation

Sovereign Spreads versus Google Search Volume Index:

[Graph showing the relationship between Sovereign Spreads and Google Search Volume Index over time.]
Motivation

Figure: Quarterly ASVI for the Search Term “Ukraine IMF”
Motivation

Research question:
What is the role of forecasters/investors’ attention in the pricing of sovereign debt?

Why important:

- Fit well for less informative EM sovereign bond markets
- Provide a richer lender-side theory → Generate non-trivial results for spread dynamics, default risk inference, and policy implications
- Generate endogenous time-varying volatility
Role of private information for sovereign debt pricing

- Cole and Kehoe, 1998; Sandleris, 2008; Catao, Fostel, and Kapur, 2009; Phan, 2015; Pouzo and Presno, 2015; Blot, Ducoudre, and Timbeau, 2016
- Use investors’ attention allocation problem

Endogenous investor attention

- Sims, 2003; Reis, 2006; Barber and Odean, 2007; Andrei and Hasler, 2015; Mackowiak and Wiederholt, 2009, 2014, 2015
- Financial assets & intl finance: Andrei and Hasler, 2014; Bacchetta and van Wincoop, 2010; van Nieuwerburgh and Veldkamp, 2009, 2010
- Interact with sovereign’s states and its debt pricing
- Estimate info cost by targeting Google search volume index on relevant search phrases (Da, Engelberg, and Gao, 2011)
Our Contributions Relative to Literature (optional)

- **Time-varying volatility**
  - Bloom, 2009; Fernandez-Villaverde, Guerron-Quintana, Rubio-Ramirez, and Uribe, 2011; Justiniano and Primiceri, 2011; Curran, 2015; Seoane, 2015; Johri et al., 2015
  - Endogenize and amplify time-variation in sovereign spread volatility

- **Default-risk inference**
  - Bi and Traum, 2012; Lizarazo, 2013; Stangebye, 2015; Bocola, 2016; Bocola and Dovis, 2016; Cimadomo, Claeys, and Poplawski-Ribeiro, 2016
  - Provide a new layer of uncertainty premium that is state contingent
    - sovereign spread = Default risk + Observed states’ future uncertainty premium + Unobserved info uncertainty premium
    - Bias in econometric estimates of default risk from yield data
Model Environment

- Like many sovereign default models:
  1. Small open economy, stochastic endowment
  2. Govt. maximizes household utility, and issues 1-period non-state-contingent defaultable bonds to risk-averse foreigners
  3. Default $\implies$ No debt; endowment loss; financial autarky with return probability $\theta$

- New in this model:
  1. Observed growth shock $s$ (Aguiar and Gopinath, 2006) + Unobserved default output cost shock $m$ (one-time, i.i.d., known marginal distribution)
  2. Both info can affect borrower’s default decisions
  3. Forecasters’ costs in terms of attention to obtain relevant info about $m$
  4. Forecasters’ endogenous optimal attention choice $\implies$ choose a signal $x$ to help investors infer $m$: $\rho_{mx}$
  5. Investors, given $x$ and $\rho_{mx}$, form their bond demand function
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Model: Timing at $t$

Sovereign chooses $B_{t+1}$ to max expected value over $M_{t+1}$.

$M_{t+1}$ and signal $x_t$ realize.

Bond policy does not depend on $M_{t+1}$.

Investors offer a bond demand schedule $B_{Dt+1}(x_t, q_t, s_t, B_t)$.

$s_t$ Realizes.

Forecasters choose optimal attention and signal accuracy $\rho_{xm,t}$

Sovereign decides to repay $B_t$ or default.

Market clears with bond price $q_t$ such that $B_{Dt+1} = B_{t+1}$
Model: Sovereign’s Problem (optional)

- Before $m'$ (or $m_{t+1}$) realizes:

  $$V(s, B, m) = \max \{ V_R(s, B), V_D(s, m) \}$$

  $$V_R(s, B) = \max_{B'} E_{m'} \left\{ U \left[ y(s) - B + q(B'|s, m')B' \right] + \beta E_{s'} V(s', B', m') \right\}$$

  $$V_D(s, m) = U[\tilde{y}(s)] + \beta E_{s', m'}[\theta V(s', 0, 1) + (1 - \theta) V_D(s', 1)]$$

  where $q(B'|s, m')$ is provided by investors’ problem, and $\tilde{y}$ is penalized output for consumption.

- Growth process:

  $$y_t = e^{g_t} y_{t-1} \quad \text{where} \quad s(y_t, g_t)$$

  $$g_t = (1 - \rho) \mu_g + \rho g_{t-1} + \sigma \epsilon_t \quad \text{where} \quad \epsilon \sim N(0, 1)$$

- Default cost:

  $$\tilde{y}_t = y_t e^{-\psi + m_t}$$
Model: Sovereign’s Problem (optional)

After $m'$ realizes:

- Default probability:
  \[
  \mathcal{D}(m, B) = \{ s \in S : V_R(s, B) < V_D(s, m) \},
  \]
  \[
  \delta(m', s, B') = \int_{s' \in \mathcal{D}(m', B')} f(s, s') ds'
  \]

- Default decision tomorrow:
  \[
  d(m', s', B') = \begin{cases} 
  1 & \text{if } V_R(s', B') < V_D(s', m') \\
  0 & \text{if } V_R(s', B') \geq V_D(s', m')
  \end{cases}
  \]
Model: Forecasters’ Problem

Optimal attention/signal accuracy before \( m' \) realizes:

\[
\min_{\rho_{mx}} \quad E_x E_{s',m'} I_{s,x} [d' - E_{s',m'} I_s(d')]^2 + \kappa I(\rho_{mx})
\]

\[
s.t. \quad I(\rho_{mx}) = \frac{1}{2} \log_2 \left( \frac{1}{1 - \rho_{mx}^2} \right)
\]
Model: Investors’ Problem & Market Clearing

- **Optimal Investment** \( |x(m') \), after \( m' \) realizes:

\[
\max_{B'_D} E_{s', m'}[s, x][U(c')]
\]

\[
s.t. \quad c' = [\bar{w} - qB'_D](1 + r) + [1 - d(m', s', B')]B'_D
\]

where \( U(c) = \frac{c^{1-\gamma}}{1-\gamma} \)

- **Market Clearing**, after \( m' \) realizes:

Bond market clears with the price \( q(s, m', B') \) such that \( B'_D = B' \)
**Proposition**

When $\sigma_m = 0$, the model becomes that of Aguiar et al (2016) with permanent shocks and short-term debt.

- Nest standard sovereign default model, produce consistent results:
  1. High growth $\rightarrow$ High borrowing/low spreads
  2. Countercyclical net exports
  3. Default: Series of good shocks followed by surprise bad shock
New Mechanism

Optimal Attention

Default risk too low

Default anyways

Debt-to-GDP
New Mechanism

- Endogenous cyclical variations in spread volatility:

  At crisis times, bond prices contain inferred info about $m'$ realization

  $\rightarrow$ Spread volatility $\uparrow$ in crises
Table: Parameterization

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter by Simulation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sovereign discount factor</td>
<td>$\beta = 0.811$</td>
<td>Annual default frequency of 1.5%</td>
</tr>
<tr>
<td>Known Default cost</td>
<td>$\phi = 0.0226$</td>
<td>Ave Debt-to-output ratio 12.6%</td>
</tr>
<tr>
<td>Investor wealth</td>
<td>$\bar{w} = 2.5$</td>
<td>Ave spread 6.5%</td>
</tr>
<tr>
<td>Unobs shock std dev</td>
<td>$\sigma_m = 0.0153$</td>
<td>Ave spread std dev of 5.5%</td>
</tr>
<tr>
<td>Unit info cost</td>
<td>$\kappa = 0.000522$</td>
<td>Frac of Crisis Attn Periods 7.1%</td>
</tr>
</tbody>
</table>

- Using Ukraine data from 2004-2014 at a quarterly frequency
Results:
Policy Functions & Dynamics
Information Acquisition Policy Functions: across $g$

$$
\rho(B_{t+1}; Y_t, g_t)
$$

$g_t = \mu_g + 1.5\sigma_g$

$g_t = \mu_g - 1.5\sigma_g$
Dynamics before Defaults: $\rho_{mx}$
Results:

Time-varying Volatility
Time-varying Volatility Measurement
Crisis Volatility Ratio (CVR)

- Define top 2.5% of the spread-change distribution as "jump" periods
- Compute the volatility 5 periods (i.e., quarters) before a jump event and 5 periods after (excluding the jump period itself)

\[
CVR = \frac{1}{|\hat{T}|} \sum_{t \in \hat{T}} \frac{\hat{\sigma}_{t:t+5}}{\hat{\sigma}_{t-6:t-1}}
\]
Time-varying Volatility

Time-varying volatility (CVR):

**Table:** Simulated statistics: the model and the data

<table>
<thead>
<tr>
<th>Data (Ukraine)</th>
<th>Benchmark Model</th>
<th>$\kappa = \infty$</th>
<th>$\sigma_m = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.67</td>
<td>2.86</td>
<td>1.33</td>
<td>1.27</td>
</tr>
</tbody>
</table>
Time-Varying Volatility (optional)
Those Sensitive to $\kappa$ Changes (optional)
Results:
Optimal Transparency
Transparency: Trade-offs

How do investor information costs affect sovereign?

1. Cheaper information $\implies$ Lower risk premium (esp. during crises)

2. Cheaper information $\implies$ More volatile prices (esp. during crises)

Model suggests optimum in middle, i.e., some opacity optimal
Transparency: Trade-offs

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Transparency: Welfare Comparative Statics

Certainty Equivalent Consumption: $g_t = \bar{g}$ and $B_t = 0$

![Graph showing the relationship between Information Cost and Certainty Equivalent Consumption](image-url)
Conclusion

Key contributions:

▶ Explore the role of costly information for sovereign debt pricing, via forecasters/investors’ attention allocation problem

▶ Endogenize and amplify time-variation in sovereign spread volatility

Main results:

▶ Time-varying spread volatility

▶ Transparency: Some opacity optimal

▶ Time-varying spread composition: without considering endogenous info acquisition, default risk estimates can be underestimated during crises
Motivation

**Figure:** Comparison of SVI and Extreme Returns
Motivation

Figure: Comparison of Benchmark Search Term to Alternate Search Terms
Motivation

Figure: Benchmark Search Language versus Most Common Alternatives

Figure: Blue: English (Benchmark), Yellow: Russian, Red: Chinese
Results

Figure: Equilibrium Bond Demand Functions

\[ q_t(B_{t+1}; Y_t, g_t, 1) \]

\[ B_{t+1}/Y_t \]

\[ g_t = \mu_g + 1.5 \sigma_g \]

\[ g_t = \mu_g - 1.5 \sigma_g \]
Results

Figure: Equilibrium Bond Demand Functions
Results

**Figure:** Equilibrium Bond Policy Functions

\[ g_t = \mu_g + 1.5\sigma_g \]
\[ g_t = \mu_g - 1.5\sigma_g \]
Results

**Figure:** Benchmark Behavior Around Default
Results

**Figure:** Benchmark Behavior Around Default
Risk Premium Difference: Baseline

- Spread = (1) Default risk + (2) Observed states’ uncertainty premium
  + (3) Unobserved info uncertainty premium

No-Information Spread Crisis at $t = 0$ and $x_t = 0$