Chapter 24: Sovereign debt and default risk

Graduate Macroeconomics Slides

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Outline

Chapter Context

Focus: Understanding business cycles in countries classified as *emerging-market economies (EMEs)*, which:

- Are typically in the middle of the world income distribution.
- Have begun transitioning toward advanced/developed status.
- Have weaker commitment (default risk) in international capital markets.
- Often have distinctive features compared to advanced economies (volatility of consumption, sovereign spreads, etc.).

Key Distinction: Sovereign borrowing with risk of default plays a major role in EMEs, leading to different cycle dynamics.

Why Emerging Markets?

- EMEs typically rely on borrowing from international capital markets with:
  - Relatively weaker property rights and financial market institutions.
  - Higher and more volatile risk premia (sovereign spreads).
- **Consequences:**
  - More pronounced volatility in consumption and net exports.
  - Greater likelihood of sovereign default events.
- **Aim of this Chapter:**
  - Summarize empirical features of EMEs.
  - Present a theoretical model (*strategic default model*) capturing default risk and borrowing.
  - Explore how this model explains observed business-cycle patterns in EMEs.

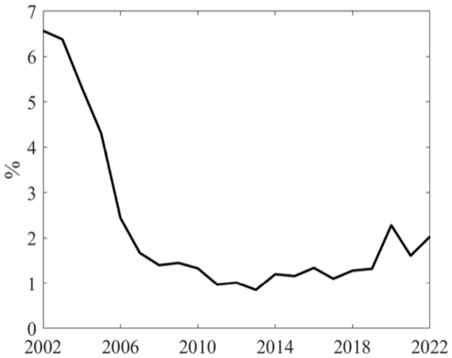

Figure 24.1: Fraction of public debt in default for emerging economies.

Notes: The series is expressed as a percentage of the combined GDP of emerging economies.
Source: 2023 Bank of Canada Sovereign Default Database.

Outline of the Chapter

1. **Empirical Patterns in EMEs vs. Advanced Economies**
   - Volatility patterns for consumption, investment, net exports.
   - Sovereign spreads and default frequencies.
2. **Stylized Two-Period Default Model**
   - Basic building blocks and strategic default considerations.
3. **Infinite-Horizon Default Model**
   - Calibration and simulation results.
   - Empirical performance and policy implications.
4. **Appendix: Computation & Calibration Details**

Consumption Volatility vs. Income

Key Empirical Fact:

- Aguiar and Gopinath (2007) and Neumeyer and Perri (2005) show that in small open *advanced* economies, consumption is *less volatile* than income, but in *emerging* economies, consumption is *more volatile* than income.
- Contradicts the standard consumption-smoothing intuition.

Mechanism:

- EMEs often run trade deficits during booms (borrowing abroad) and surpluses during recessions (paying back).
- Procyclical borrowing contributes to amplified consumption fluctuations.

Evidence: Business Cycle Moments

Table 24.1: Business Cycle Moments

	$\sigma(Y)$	$\sigma(C)/\sigma(Y)$	$\sigma(I)/\sigma(Y)$	$\sigma(NX/Y)$	$\rho(C,Y)$	$\rho(I,Y)$	$\rho(NX/Y,Y)$
Argentina	3.9	1.2	3.3	2.6	0.9	1.0	-0.8
Brazil	1.7	1.2	3.2	1.0	0.8	0.9	-0.7
Ecuador	2.2	2.1	7.0	3.9	0.6	0.6	-0.4
Israel	1.5	1.0	2.3	1.1	0.7	0.6	0.2
Korea	2.0	1.6	2.5	1.7	0.9	0.9	-0.8
Malaysia	4.7	1.0	-.-	3.9	0.5	-.-	-0.1
Mexico	2.3	1.0	3.2	1.3	0.9	0.9	-0.6
Peru	3.9	0.8	2.1	2.0	0.6	0.4	0.1
Philippines	1.1	0.7	5.5	1.7	0.2	0.6	0.2
Slovak Republic	2.2	0.8	3.6	2.1	0.5	0.6	-0.0
South Africa	1.0	1.6	3.8	1.0	0.8	0.6	-0.1
Thailand	2.2	0.8	2.5	3.2	0.6	0.5	0.1
Turkey	3.4	1.0	3.2	2.1	0.9	0.9	-0.6
Mean Emerging	2.5	1.1	3.5	2.1	0.7	0.7	-0.3
Australia	0.6	1.4	6.4	0.9	0.6	0.6	-0.3
Austria	1.2	0.6	1.9	0.7	0.5	0.7	0.4
Belgium	0.9	0.6	3.3	0.6	0.6	0.7	0.1
Canada	1.1	0.7	3.3	0.7	0.6	0.7	-0.0
Denmark	1.3	1.0	3.5	0.8	0.6	0.7	-0.1
Finland	1.9	0.6	1.9	1.1	0.7	0.9	0.3
Netherlands	1.2	0.8	7.0	1.9	0.8	0.4	-0.0
New Zealand	1.0	1.2	5.0	1.1	0.6	0.6	-0.2
Norway	1.1	1.0	5.2	1.0	0.6	0.5	-0.2
Portugal	1.3	1.2	3.6	1.1	0.9	0.9	-0.4
Spain	1.2	1.2	2.9	0.8	0.9	0.8	-0.6
Sweden	1.5	0.7	2.4	0.6	0.7	0.8	0.0
Switzerland	1.1	0.4	2.1	1.9	0.5	0.7	0.4
Mean Advanced	1.2	0.9	3.7	1.0	0.7	0.7	-0.0

Note: We use data from the same countries considered in Aguiar and Gopinath (2007b). The time series are quarterly and seasonally adjusted, and span the period Q1 1994 - Q4 2019 for whenever data are available. All variables are logged and filtered using the Hodrick-Prescott filter, with a smoothing parameter of 1600. The standard deviations are reported in percentage terms. We use Y to denote GDP, C to denote private consumption, I to denote gross capital formation, and NX to denote net exports.

Figure: (Aguiar and Gopinath, 2007)

Observations:

- $\sigma(C)/\sigma(Y)$ often > 1 in EMEs; < 1 or near 1 in advanced.
- Net exports ratio (NX/Y) more countercyclical in EMEs.

Countercyclical Trade Balance

Why is TB so Countercyclical in EMEs?

- EMEs borrow extensively in good times (booms) and repay in bad times (recessions).
- Standard *risk-sharing* logic would imply *lower* consumption volatility, but we see the opposite.
- Raises the question: *What drives this seemingly "perverse" borrowing behavior?*

Hypothesis from Literature:

- Neumeyer and Perri (2005), García-Cicco et al. (2010), and Alvarez-Parra et al. (2013) suggest that the **cost of borrowing** (interest rate spreads) crucially shapes EMEs' procyclical borrowing.
- In expansions, external market rates (spreads) are lower, inducing more borrowing.

Sovereign Defaults in EMEs

Definition:

- Following rating agencies, a **default event** includes every episode of missed payment or “pre-emptive” restructuring on terms less favorable than the original.

Empirical Insight:

- Asonuma and Trebesch (2016) record 201 sovereign defaults to private creditors between 1970 and 2010.
- Average present-value *haircut* of around 37% in sovereign restructurings (see Cruces and Trebesch (2013)).

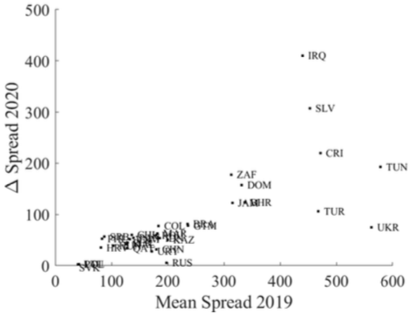

Figure 24.2: EMBI Spread increase after COVID-19.

Notes: The (average daily) spread and spread change (2020 average minus 2019 average) are expressed in basis points. We removed countries with a spread higher than 1000 basis points in 2019 (Argentina, Lebanon, and Venezuela). Source: Bloomberg.

Spread Behavior

Table 24.2: Sovereign spread yield

	E(Spread)	σ(Spread)	ρ(Spread, Y)
Argentina	732	377	-0.5
Brazil	514	380	-0.2
Ecuador	1021	647	-0.6
Korea	162	116	-0.7
Malaysia	174	115	-0.3
Mexico	318	221	-0.4
Peru	307	199	-0.1
Philippines	283	172	-0.3
Slovak Republic	57	36	-0.6
South Africa	242	111	-0.3
Thailand	155	112	-0.5
Turkey	385	199	-0.5
Average Emerging	362	224	-0.4

Note: The sovereign spread is expressed in basis points. The spread series is quarterly and spans the period Q1 1994 - Q4 2019 whenever data is available. We removed periods in which the sovereign is in default. The series for aggregate GDP (Y) was logged and filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600.

Stylized Facts:

- **High**, **volatile**, and **countercyclical** sovereign spreads.
- When GDP is below trend, spreads rise.

Spread Determinants & Regression Evidence

Panel Regression Example:

$$\ln(\text{Spread}_{it}) = \alpha + \beta_1 (\text{Debt/GDP})_{it} + \beta_2 (\text{GDP Growth})_{it} + \beta_3 (\text{Reserves/GDP})_{it} + \beta_4 (\text{VIX})_{t} + \dots$$

- Typically, spreads:
  - Increase with total government debt.
  - Decrease with GDP growth and with higher foreign reserves.
  - Rise with global risk aversion (e.g. VIX).

Interpretation:

- Higher indebtedness $\Longrightarrow$ greater default risk $\Longrightarrow$ higher spread.
- Stronger fundamentals (growth, reserves) $\Longrightarrow$ lower default risk $\Longrightarrow$ narrower spread.

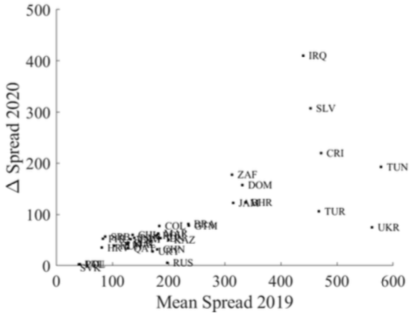

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Table 24.3: Panel regressions

	Coeff.	SE
Public debt to GDP	0.020	(0.004)
Real GDP growth	-0.042	(0.006)
Reserves to GDP	-0.033	(0.017)
Net gov borrowing to GDP	0.020	(0.014)
VIX	0.034	(0.003)
Observations	523	
R-squared	0.77	
Number of countries	33	

Note: We use annual data from a sample of 33 emerging market countries spanning from 1994 to 2018. Robust standard errors are in parentheses.

Debt Intolerance and Currency Composition

- Many EMEs issue debt in **foreign currency**—the "original sin" (Eichengreen and Hausmann, 1999).
- Makes debt servicing more *expensive* in recessions since local currency tends to depreciate.
- **Debt Intolerance:** Heterogeneous thresholds for debt levels at which spreads soar (Reinhart et al., 2003).

Implications:

- Countries that manage to issue more *local-currency debt* have somewhat more stable debt dynamics.
- Persistent *structural differences* in legal/institutional frameworks lead to cross-country heterogeneity.

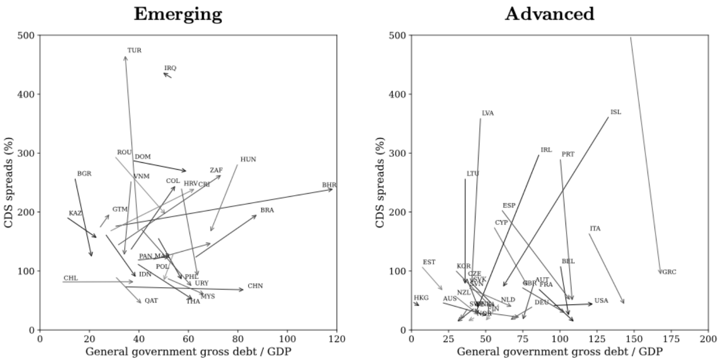

Figure 24.3: Credit default swaps (CDS) spread and public debt ratios for emerging and advanced economies.

Notes: The origin point of each arrow illustrates the debt-spread combination in 2010, and its end point the debt-spread combination in 2023. We use the CDS spread because it enables us to expand the sample of countries to advanced economies. Sources: Bloomberg and IMF-WEO database.

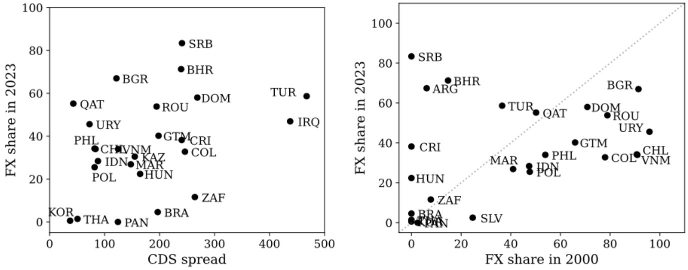

Figure 24.4: Spreads and foreign currency sovereign debt.

Notes: The left panel shows a positive association between the CDS spread (in basis points) and the share of foreign currency sovereign debt in emerging economies. The right panel illustrates how the share of foreign currency sovereign debt in emerging economies changed from 2000 to 2023. Source: WEO database and Bloomberg.

Costs of Sovereign Risk

- Arellano et al. (2024) estimate significant **spillovers** onto corporate borrowing costs.
- **Growth and Investment Effects:** Elevated spreads stunt investment, hamper output.
- **COVID-19 Lesson:** Higher initial sovereign risk $\implies$ larger spread hikes during the pandemic, constraining fiscal response.

Conclusion So Far:

- EMEs face high and variable spreads, frequently default, and exhibit large consumption swings.
- We need a model that endogenizes default and matches these cyclical observations.

Policy Remedies & Fiscal Rules

- Many EMEs adopt **fiscal rules** (debt ceilings, balanced budget laws) to address "debt intolerance."
- Hatchondo et al. (2022a) and Aguiar and Amador (2020) explore debt limits in sovereign default models to quantify potential welfare gains.
- The challenge: **one-size-fits-all** (e.g., same debt-to-GDP limit in the EU) might be too restrictive or too lenient for different countries.

Possible Solutions:

- Replacing rigid debt rules with **fiscal standards** guided by risk assessments (cf. IMF, 2022).
- Linking borrowing constraints to **sovereign spreads** or other real-time market signals (Hatchondo et al., 2022b).

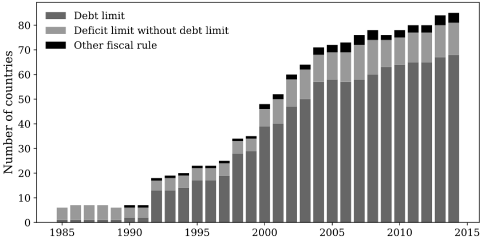

Figure 24.5: Number of countries with fiscal rules.

Source: IMF Fiscal Rules dataset.

Motivation for a Simple Model

- Eaton and Gersovitz (1981): Pioneering framework for strategic sovereign default in a small open economy.
- **Two-Period Setup** clarifies how **default risk** constrains equilibrium borrowing.
- Key: *Endogenous* bond prices factor in default probabilities.

Model Outline:

- Periods: $t = 1, 2$.
- Stochastic endowment Y_2; deterministic $Y_1 = 0$.
- Government can borrow B_2 in period 1, repaid in period 2, or default in period 2.

Household Welfare and Government Choice

Preferences:

$$\max \quad u(C_1) + \beta\, E\left[u(C_2)\right]$$

where $\beta \in (0, 1)$.

Budget Constraints:

$$C_1 = B_2\, q_1(B_2),$$

$$C_2 = \begin{cases} Y_2 - B_2, & \text{if repay} \\ Y_2 - \phi Y_2, & \text{if default} \end{cases}$$

No Commitment to Repay: Government decides whether to default in period 2 after observing Y_2.

Equilibrium Bond Pricing

- Risk-neutral, competitive lenders. Zero interest rate for simplicity $\implies$

$$q_1(B_2) = 1 - F\left(\frac{B_2}{\phi}\right),$$

- Lenders internalize that default occurs if $B_2 > \phi Y_2$.
- **Endogenous Borrowing Constraint**: As B_2 rises, $q_1(B_2)$ falls.

Key Result: Government picks B_2 to balance the present benefit of more C_1 against higher default probability, which lowers $q_1(B_2)$ for all units of debt.

Interpretation

- In this two-period setting, we see a **trade-off**:
  - Borrow more now $\implies$ lower price (higher yield) $\implies$ bigger default temptation.
  - Borrow less $\implies$ safer profile, higher bond price.
- Demonstrates how the inability to commit to future repayment **tightens** the feasible borrowing set.
- Real-world analog: EMEs face relatively larger default premiums, limiting how much they can smooth consumption.

From Two-Period to Dynamic Framework

Motivation:

- Actual EMEs face repeated borrowing decisions, persistent income shocks, and can default in *any* period.
- Arellano (2008), Aguiar and Gopinath (2006), and others: Build infinite-horizon, small-open economy models with strategic default.

Key Changes from Two-Period Case:

- **Stochastic** Y_t with AR(1) process.
- **Long-term** bonds (perpetuities) with decay rate δ.
- **Markov Perfect Equilibrium**: Government's decisions in each period depend on current debt B_t and income Y_t.

Model Environment: Main Equations

Preferences:

$$\max \ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \, u(C_t).$$

Income:

$$\log(Y_t) = (1-\rho)\mu + \rho \log(Y_{t-1}) + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma^2).$$

Debt Dynamics (Perpetuity):

$$B_{t+1} = (1-\delta)\, B_t + I_t, \quad \text{where } I_t \text{ is new issuance.}$$

Budget Constraint:

$$C_t + \delta B_t = Y_t + q_t \, I_t.$$

Default and Exclusion

- Government may default on all outstanding debt B_t.
- **Consequence of Default:** Excluded from capital markets for random length of time, plus output cost $\phi(Y_t)$ each period in exclusion.
- Once back in the market, debt restarts at $B = 0$.

Bond Price Formula (zero-profit):

$$q_t(B_{t+1}, Y_t) = \frac{1}{1+r}\mathbb{E}\Big[\left(1 - D_{t+1}\right)\left(\delta + (1-\delta)q_{t+1}\right)\Big],$$

where D_{t+1} is the default indicator next period.

Equilibrium Definition

Markov Perfect Equilibrium is a set of:

- Value functions V, V^R, V^D,
- Borrowing rule $B_{t+1} = \widehat{B}(B_t, Y_t)$,
- Default rule $D_t = \widehat{D}(B_t, Y_t)$,
- Bond price function $q_t = q\left(\widehat{B}, \widehat{D}\right)$,

such that:

1. Given q, the default and borrowing rules solve the government's Bellman equations.
2. q satisfies investors' zero-expected profit condition.
3. Government's decisions are *optimal* given no commitment, taking (B_t, Y_t) as the relevant states.

Quantitative Implementation

Calibration Strategy:

- Target Mexico data:
  - Average public debt-to-GDP $\approx 43\%$
  - Average sovereign spread $\approx 3.2\%$
  - Income process: ρ, σ_ε from GDP data
  - β, r, and δ set to match discounting, risk-free rate, bond duration
  - Default cost $\phi(Y)$: scaled with parameters (λ_0, λ_1)
- Solve the model numerically and simulate for large T.
- Compare simulated **moments** to empirical business cycle facts.

Selected Results: Match with Data

Table 24.4: Business Cycle Statistics: Model and Data

Targeted moments		
	Model	Data
Mean Debt-to-GDP	43	43
Mean *Spread*	3.2	3.2
Non-Targeted moments		
$\sigma(C)/\sigma(Y)$	1.3	1.0
$\sigma(TB/Y)$	0.8	1.3
$\sigma\,(Spread)$	1.6	2.2
$\rho(TB/Y, Y)$	-0.7	-0.6
$\rho\,(C, Y)$	0.98	0.91
$\rho\,(Spread, Y)$	-0.8	-0.4
$\rho(Spread, TB/Y)$	0.9	0.6

Note: The standard deviation of x is denoted by $\sigma\,(x)$. The coefficient of correlation between x and z is denoted by $\rho\,(x, z)$. Moments are computed using detrended series. Trends are computed using the Hodrick-Prescott filter with a smoothing parameter of 1,600. Moments for the simulations correspond to the mean value of each moment in 500 simulation samples. We take the last 120 periods (30 years) for each sample without a default episode. Simulation samples start at least five years after a default. Default episodes are excluded to improve comparability with the data. Consumption and income are expressed in logs.

Observations:

- The model replicates **high consumption volatility**, **countercyclical trade balance**, and plausible spread levels.
- *Excess consumption volatility* emerges endogenously due to **default risk** constraints.

Mechanics: Bond Price Schedules

- For a given (B, Y), bond price q decreases in B (higher default risk).
- Bond price q increases in Y (lower default risk in good states).
- This **time-varying borrowing set** leads to more severe consumption slumps in recessions.

Key Implication:

- Procyclical borrowing + harsh terms in bad times $\Rightarrow$ strongly countercyclical net exports, matching EMEs' data.

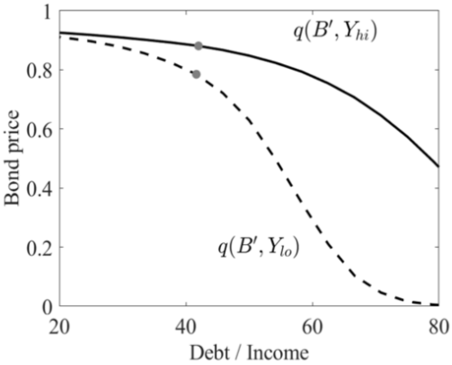

Figure 24.6: Bond price schedule for a low income ($Y_{lo} = E(Y) - \sigma(Y)$) and a high income level ($Y_{hi} = E(Y) + \sigma(Y)$).

Notes: The horizontal axis displays the ratio of debt to average annual income $B'/4E(Y)$ the government could choose. Solid dots correspond to the optimal choices when the government enters the period with the mean debt level in the simulations.

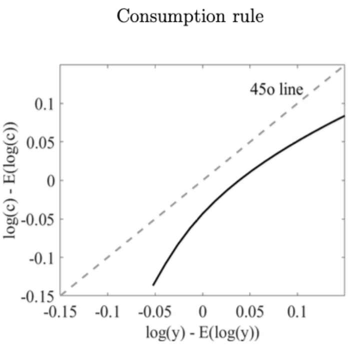

Figure 24.7: Consumption policy under repayment when the sovereign enters the period with the mean debt level in the simulations.

Normative Considerations

- Model suggests a **benevolent** government still *chooses* risky debt levels. Why?
  - **Time Inconsistency** in default decisions and borrowing policies:
    1. Government cannot commit not to default in the future.
    2. Government also cannot commit to future borrowing plans (long-term debt environment).
- If it could commit, it would borrow more prudently or not default as often, yielding lower spreads and higher welfare.

Policy Relevance:

- Hatchondo et al. (2022a): Well-designed fiscal rules can partially mimic commitment.
- The gains can be large, though **heterogeneity** across countries complicates uniform policy design.

Key Takeaways

1. **EMEs' Business Cycles:**
   - High consumption volatility relative to income.
   - Countercyclical trade balance; high, volatile sovereign spreads.
2. **Quantitative Default Model:**
   - Explains EMEs' stylized facts through endogenous default risk and procyclical borrowing.
   - Incorporates key constraints on international credit faced by EMEs.
3. **Policy & Extensions:**
   - Fiscal rules, debt maturity structure, and partial commitment devices can improve outcomes.
   - Variation in "debt intolerance" remains crucial for cross-country differences.

Further Research Directions

- **State-Contingent Debt** or **Indexed Bonds**: Potential to reduce default risk, but less common in practice.
- **Political Economy** of default and government turnover.
- **Interaction with Domestic Financial Systems**: Spillovers from sovereign risk to banks/firms.
- **Global Factors**: Tighter or looser global credit conditions (VIX, risk-off episodes).

Appendix Outline

- **Computation Methods:**
  - Fixed point approach and numerical issues.
  - Alternative smoothing techniques (temporary shocks, extreme value, etc.).
- **Calibration Details:**
  - Mexico data specifics.
  - Parameter matching for (λ_0, λ_1), β, r, δ, ρ, σ_ε.

Numerical Computation: Sketch

Value Function Iteration:

- Discretize state space (B, Y) or use polynomial interpolation.
- For each (B, Y):
$$V(B, Y) = \max\{V^D(Y),\ V^R(B, Y)\}.$$
- $$V^R(B, Y) = \max_{B'}\Big\{u\big(Y - \delta B + q(B', Y)[B' - (1 - \delta)B]\big) + \beta\mathbb{E}[V(B', Y')]\Big\}.$$
- $$V^D(Y) = u(Y - \phi(Y)) + \beta\mathbb{E}\big[\psi V(0, Y') + (1 - \psi)V^D(Y')\big].$$

Dealing with Nonconcavities and Discontinuities

- **Grid Refinement:** Need fine grids for B and Y.
- **Interpolation/Extrapolation:** E.g., linear or spline.
- **Stochastic shocks:** Smoothing out “knife-edge” default boundaries.
- **Extreme-Value Shocks:** (Dvorkin et al., 2021) approach to ensure uniqueness.

Calibration Details

- **Income process**: Estimate AR(1) parameters $(\rho, \sigma_\varepsilon)$ from $\log(Y_t)$.
- **Preferences:** $\sigma = 2$ (CRRA), $\beta = 0.975$, $r = 0.01$ per quarter.
- **Bond Decay Rate** δ: matched to average duration of 5 years (20 quarters).
- **Default Cost Function:**

$$\phi(Y) = \max\Big\{ Y\big[\lambda_0 + \lambda_1(Y - E[Y])\big], 0\Big\}.$$

- Adjust (λ_0, λ_1) to hit mean debt/GDP and mean spread targets.

Sensitivity to (λ_0, λ_1)

- **Higher λ_0:** Increases cost of default at all income levels, raising bond prices and allowing more borrowing (lower spreads).
- **Higher λ_1:** Raises cost more in high-income states but can lower cost in low-income states $\Rightarrow$ can increase spread volatility.
- **Unique Combination**: Matches *both* average debt ratio *and* spread.

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Thank you!

Questions or comments?

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