The Consequences of Financial Center Conditions for Emerging Market Sovereigns

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[1] The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.

Financial Center Conditions

- Consequences of *tight financial conditions* in the US for EM sovereigns?
  - Recessionary, increased yield spreads
  - Focus on the sovereign borrowing and default risk *channel*

- Less known about *predictable* changes in future conditions
  - E.g. the start of a US monetary tightening cycle

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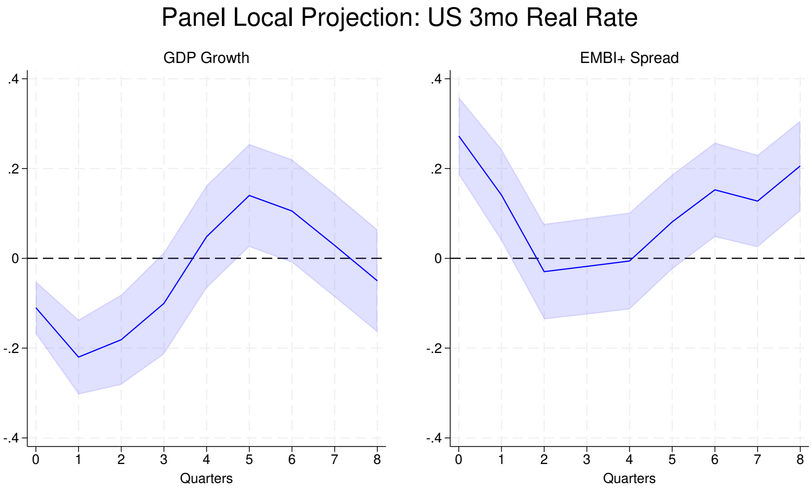
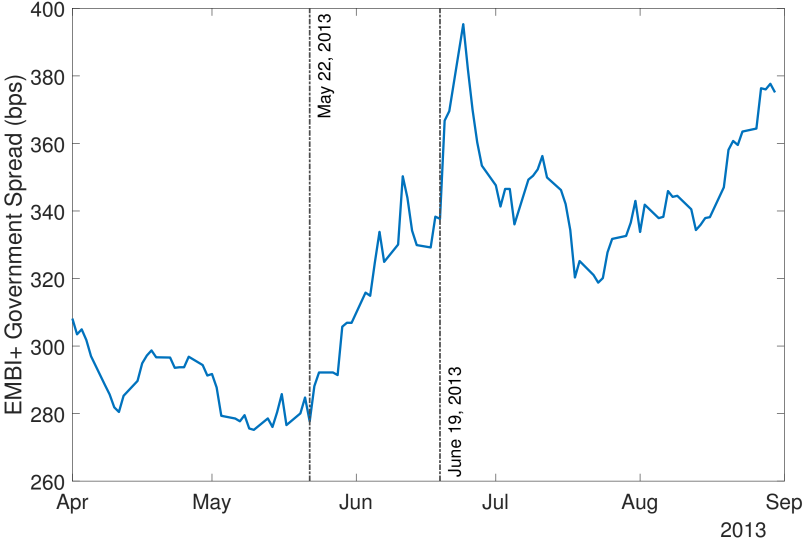
- What we do…
  1. Isolate incentives for borrowing and default in a tractable model
     - Ambiguity in the response of spreads
  2. Statistical model of US yield curve and inflation with predictable dynamics
  3. Sovereign default model to confront the evidence
     - Domestic financial frictions

Impact of US Short-term Real Rates on EMs

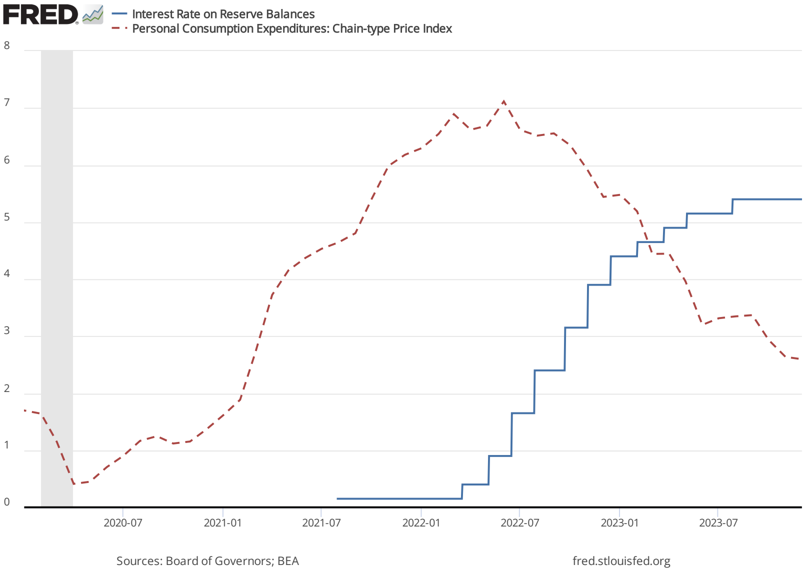


Unbalanced panel 1996Q1–2019Q4: Argentina, Brazil, Bulgaria, Chile, Colombia, Ecuador, Hungary, Indonesia, Mexico, Turkey. ▸ UY 2006

2013 “Taper Tantrum” Episode



2022– Tightening Cycle



Roadmap

1. Intuition on borrowing and spreads in the simplest default model
2. A statistical model of the US yield curve
3. A quantitative sovereign default model with domestic financial frictions

Simple Analytics of Risk-free Rate Movements in a Tractable Default Model

A Tractable Default Model

$$V\left(b|r,r'\right) = \max_{b'}\left\{\overline{y} - b + q(b'|r,r')b' + \beta\mathbf{E}_{\nu}\max\left\{V\left(b'|r',r'\right), V^{d} - \nu\right\}\right\}$$

$$q(b'|r,r') = \frac{1}{1+r}\Pr\left[\nu \leq V^{d} - V(b'|r',r')\right]$$

- Linear utility
- One period debt
- Constant endowment $\overline{y}$
- Default value shock ν, with pdf ϕ and cdf Φ
- Risk-free rate r this period, r' in all future periods

Default Behavior

$$v^*(b'|r') \equiv V^d - V\left(b'|r',r'\right) \qquad \text{(Default Threshold)}$$

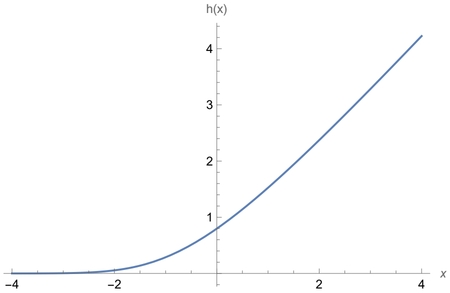
$$V\left(b|r,r'\right) = \bar{y} - b + \max_{b'}\left\{q(b'|r,r')b' + \beta\left[\int_{-\infty}^{v^*(\cdot)}\left(V^d - v\right)d\Phi + \int_{v^*(\cdot)}^{\infty} V(b'|r',r')d\Phi\right]\right\}$$

$$q(b'|r,r') = \frac{1 - \Phi\left[v^*(b'|r')\right]}{1+r}$$

Borrowing Behavior

$$h\left(v^{*}\left(b'|r'\right)\right)b' = \underbrace{1-\beta\left(1+r\right)}_{>0} \qquad \text{(Optimal Borrowing)}$$

$$h(v) \equiv \frac{\phi(v)}{[1-\Phi(v)]} \qquad \text{(Hazard Ratio)}$$



A One Time Increase in r

Start at $r = r' = \bar{r}$ and consider a one time increase in today's r:

$$h\left(v^*(b'|r')\right) b' = \underbrace{1 - \beta(1 + r)}_{\downarrow} \qquad \text{(Optimal Borrowing)}$$

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- LHS $\downarrow$, must have RHS $\downarrow$, and therefore $b' \downarrow$
- r' unchanged, so $v^*(b'|r') \downarrow$
- *Lower* default probability and spread

Future Interest Rates

Start at $r = r' = \bar{r}$ and consider an increase in all future rates r':

$$h\left(v^*(b'|r')\right) b' = \underbrace{1 - \beta\left(1 + r\right)}_{\text{no change}} \qquad \text{(Optimal Borrowing)}$$

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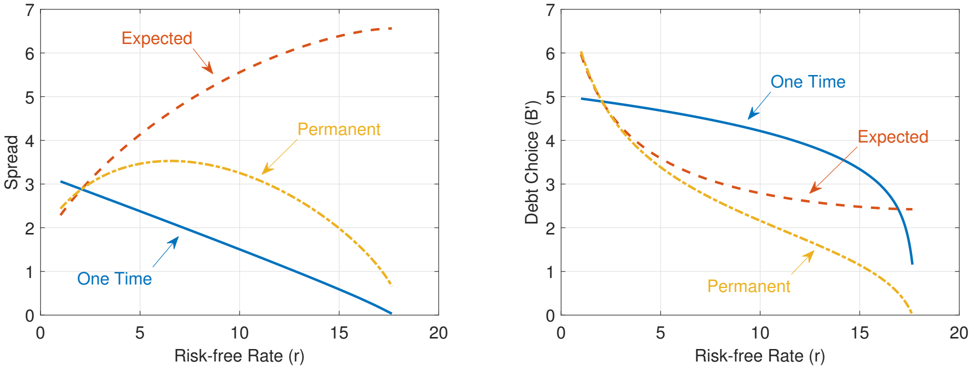
$$\frac{\partial}{\partial r'} V(b'|r', r') \overset{?}{<} 0 \qquad \text{(Value of Market Access)}$$

$$r' \uparrow \quad \Rightarrow \quad V(b'|r', r') \downarrow \quad \Rightarrow \quad v^*(b'|r') \uparrow \quad \Rightarrow \quad b' \downarrow$$

Spread and Borrowing Response to Risk-free Rate Shocks



- One Time: $r > \bar{r}, r' = \bar{r} = 2\%$
- Expected: $r = \bar{r}, r' > \bar{r}$
- Permanent: $r = r' > \bar{r}$

A Pricing Kernel with Predictable Dynamics

A One-Factor SDF

$$q_t^{\$,n} = \mathbf{E}_t \left\{ \frac{m_{t+1}}{\Pi_{t+1}} q_{t+1}^{\$,n-1} \right\}, \qquad q_t^{\$,0} = 1 \qquad \text{(ZC Bond Prices)}$$

A One-Factor SDF

$$q_t^{\$,n} = \mathbf{E}_t \left\{ \frac{m_{t+1}}{\Pi_{t+1}} q_{t+1}^{\$,n-1} \right\}, \qquad q_t^{\$,0} = 1 \tag{ZC Bond Prices}$$

$$-\log m_{t+1} = x_t + \frac{\lambda_m^2}{2} + \lambda_m \varepsilon_{t+1} \tag{Real SDF}$$

$$x_{t+1} = (1-\rho)v_t + \rho_x x_t + \sigma_x \varepsilon_{t+1} \tag{Factor}$$

$$v_{t+1} = \begin{cases} v_t, & \text{w.p. } p \\ \text{iid } N(\mu_v, \sigma_v^2), & \text{otherwise} \end{cases} \tag{Trend}$$

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$$x_{t+1} = (1-\rho)\nu_t + \rho_x x_t + \sigma_x \varepsilon_{t+1} \qquad \text{(Factor)}$$

$$\nu_{t+1} = \begin{cases} \nu_t, & \text{w.p. } p \\ \text{iid } N(\mu_\nu, \sigma_\nu^2), & \text{otherwise} \end{cases} \qquad \text{(Trend)}$$

$$-\log \Pi_{t+1} = \mu_\pi + \iota_\nu \nu_t + \iota_x x_t + A_4(L)\eta_{t+1} \qquad \text{(Inflation)}$$

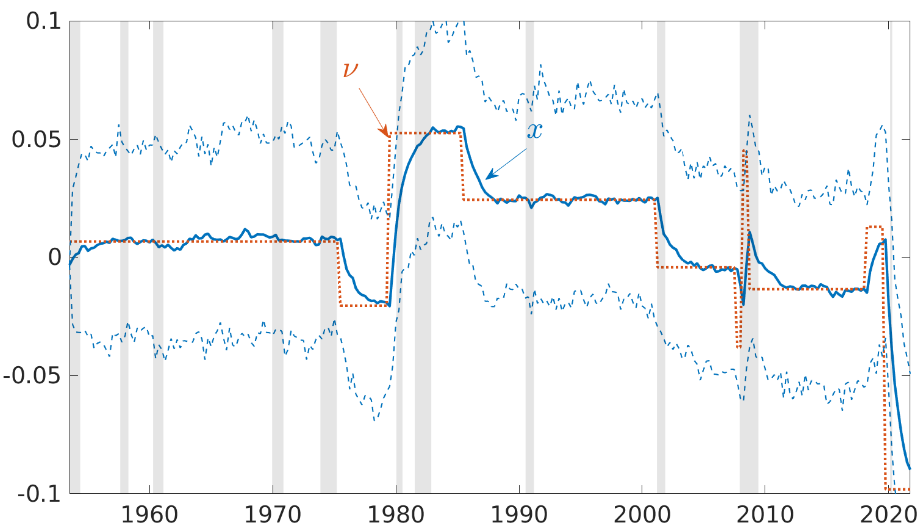
SDF Parameter Estimates

	Estimate	95% CI
First Stage		
ρ_x	0.7395	[0.6123, 0.8183]
σ_x	0.0036	[0.0000, 0.0048]
σ_η	0.0045	[0.0000, 0.0524]
J	9	
p	0.9672	
μ_ν	$-8.2e^{-4}$	
σ_ν	0.0109	
Second Stage		
ι_x	-0.7425	
A_1	-0.4676	
A_2	-0.1445	
A_3	0.0369	
A_4	-0.0578	
λ_m	-0.2359	

Two stage procedure…

1. Use 3mo yield and inflation to estimate and filter x_t and ν_t (including breaks/jumps)
2. Use higher maturities to estimate Π_{t+1} equation and market price of risk λ_m

x_t and ν_t Estimates



A Quantitative Sovereign Default Model

Model Outline

- Domestic private sector
  - Households
  - Financial Intermediaries
  - Producers

- The sovereign
  - Operates in international financial markets
  - Long-term defaultable bond
  - Transfers (or taxes) lump sum proceeds to household

- International lenders
  - Price and hold the sovereign's bond
  - One factor SDF with x_t and ν_t

- Equilibrium default (Markov Perfect Equilibrium)

The Household and the Domestic Interest Rate

$$\max_{\{\ell_t, b^h_{t+1}\}} \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, \ell_t\right) \quad \text{s.t.} \quad c_t = w_t \ell_t + \Pi_t + \Pi^f_t + T_t - b^h_t + \frac{1}{1+i_t} b^h_{t+1}$$

$$u_\ell(c_t, \ell_t) + u_c(c_t, \ell_t) w_t = 0 \tag{FOC ℓ_t}$$

$$u_c(c_t, \ell_t) = \beta(1+i_t)\mathbf{E}_t u_c(c_{t+1}, \ell_{t+1}) \tag{FOC b^h_{t+1}}$$

$$b^h_t = b^h_{t+1} = 0 \tag{Zero Net Supply}$$

Producers and the Working Capital Constraint

$$\Pi_t = \max_{\ell_t} \left\{ A_t \ell_t^{\alpha} - \left[\left(1 - \theta\right) w_t \ell_t + \theta \left(1 + i_t\right) w_t \ell_t \right] \right\}$$

$$\ell_t = \left(\frac{\alpha}{1 + \theta i_t} \cdot \frac{A_t}{w_t} \right)^{1/(1-\alpha)} \tag{FOC ℓ_t}$$

$$\log A_{t+1} = \rho_A \log A_t + \sigma_A \varepsilon_{t+1} \tag{Productivity}$$

Domestic Financial Intermediaries

$$\Pi_t^f = -a_t + (1 + i_t)\, a_t = i_t a_t$$

$$a_t = \theta w_t \ell_t \qquad \text{(Market Clearing)}$$

$$i_t = \frac{u_c(c_t, \ell_t)}{\beta \mathbf{E}_t u_c(c_{t+1}, \ell_{t+1})} - 1 \qquad \text{(Domestic Rate)}$$

The Sovereign

$$T_t = q_t \left[B_{t+1} - (1-\delta) B_t\right] - \kappa B_t - \overline{G}$$

Transfer to household

- proceeds from sale of new issuance $B_{t+1} - (1-\delta)B_t$ at market price q_t,
- minus debt service payment κB_t,
- minus government spending

In default, $T_t = -\overline{G}$

Adding Up

Consolidate sovereign, household, and domestic firms...

$$w_t \ell_t + \Pi_t + \Pi_t^f = A_t \ell_t^\alpha = c_t + \overline{G} + tb_t \tag{GDP}$$

$$tb_t = \kappa B_t - q_t[B_{t+1} - (1-\delta)B_t] \tag{BoP}$$

Equilibrium

$$\ell_t(A_t, B_t, B_{t+1}) \Leftrightarrow i_t(A_t, B_t, B_{t+1})$$

International Lenders

$$q_t = \mathbf{E}_t \left\{ m_{t+1} \left(1 - d_{t+1}\right) \left[\kappa + (1-\delta) q_{t+1}\right] \right\} \qquad \text{(Bond Price Schedule)}$$

$$q_t^{\mathrm{rf}} = \mathbf{E}_t \left\{ m_{t+1} \qquad\qquad \left[\kappa + (1-\delta) q_{t+1}^{\mathrm{rf}}\right] \right\} \qquad \text{(Risk-free Bond Price)}$$

- m_t driven by x_t factor and trend ν_t (real SDF)
- Same duration for sovereigns' and risk-free bonds
- Yield-to-maturity spread

$$sp_t = \left(\frac{1}{q_t} - \frac{1}{q_t^{\mathrm{rf}}} \right) \kappa$$

Domestic versus Sovereign Yields

Why is the domestic rate i_t not the yield on the sovereign's bond?

$$u_c(c_t, \ell_t) = \beta(1 + i_t)\mathbf{E}_t u_c(c_{t+1}, \ell_{t+1}) \qquad \text{(Household FOC)}$$

$$u_c(c_t, \ell_t) = \beta \frac{\kappa}{q_t + \frac{\partial q_t}{\partial B_{t+1}} B_{t+1}} \mathbf{E}_t (1 - d_{t+1}) u_c(c_{t+1}, \ell_{t+1}) + \ldots \qquad \text{(Sovereign FOC)}$$

- Sovereign as monopolist in own bonds: internalize slope of demand
- Marginal cost of borrowing only in repayment (default option)
- Difference in maturity: one period vs long-term with δ
- Use B' to alter domestic allocation

Outcomes in Default

- Productivity penalty

$$A_t \to h(A_t) \leq A_t$$

- Market exclusion of random length (stops w.p. χ)

- Return to market without outstanding debt (full repudiation)

Recursive Formulation

- State variables: $s = \langle A, x, v \rangle$ and B

- Private domestic outcomes for arbitrary $\langle s, B, B' \rangle$
  - $c(s, B, B'), \ell(s, B, B'), i(s, B, B'), \ldots$

- Sovereign policies $d(s, B)$ and $B'(s, B)$
  Taking as given private outcomes and future policies

- Forward-looking functions (Markov):
  - Bond price schedule $q(s, B')$
  - Expected marginal utility $H(s, B'), H^d(s)$

$$H(s, B') = \mathbb{E}_{s'|s} \left\{ (1 - d(s', B'))u_c(s', B', B'') + d(s', B')u_c^d(s') \right\}$$

$$u_c(s, B, B') = \beta[1 + i(s, B, B')]H(s, B')$$

Functional Forms

- Utility function. Greenwood, Hercowitz, and Huffman (1988)

$$u(c,\ell) = \frac{\left(c - \psi\frac{\ell^{1+\mu}}{1+\mu}\right)^{1-\sigma} - 1}{1-\sigma}$$

- Default productivity penalty, as in Chatterjee and Eyigungor (2012)

$$h(A_t) = A_t - \max\left\{0,\ \lambda_0 A_t + \lambda_1 A_t^2\right\}$$

Work-in-Progress: Calibration

	Value	Comment
σ	2.0	CRRA
β	0.98	Discounting
ψ	0.7	Normalization, mean ℓ
μ	1.0/0.7	Inverse of Frisch elasticity (GHH)
α	0.67	Returns to scale
θ	1.5	Working capital constraint
$\overline{G}$	0.15	Public spending
δ	0.05	5 year debt Macaulay duration
κ	$\delta + \mu_v$	Normalization
λ_0	-0.24	Penalty, linear
λ_1	$+0.27$	Penalty, quadratic
χ	1/8	Market return probability
ρ_x	0.74	Autocorrelation of pricing kernel factor
σ_x	0.0036	Volatility of factor
μ_v	$-8.3e^{-4}$	Average factor level
σ_v	0.011	Volatility of factor trend shocks
p	0.9672	Probability of renewal
λ_m	-0.236	Market price of risk
ρ_A	0.9	Autocorrelation of productivity
σ_A	0.005	Volatility of productivity shock
η_D	$1e^{-6}$	Default taste shock
η_B	$1e^{-5}$	Borrowing taste shock

	Model
Mean	
Spread	1.96
Debt to GDP	12.3
Standard Deviations	
Spread	1.37
GDP	3.91
Consumption	4.87
Domestic Rate	3.51
Correlations	
Spread and GDP	-24.1
Trade Balance/GDP and GDP	-67.4

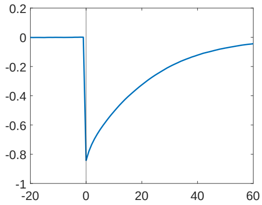
Stochastic IRFs

- Default model $\Rightarrow$ no steady state, but ergodic distribution
- *Where* to shock for IRFs?

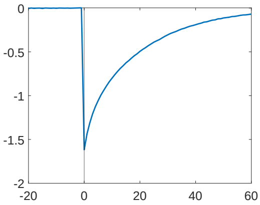
- Idea, based on Koop, Pesaran, and Potter (1996), ...
  - Simulate long and wide panel of model economies (independent)
  - Eventually, cross section $\Rightarrow$ ergodic distribution
  - Then, shock all panel units by the same amount
  - Trace out average responses

Equivalent to shocking everywhere and weighting by ergodic distribution

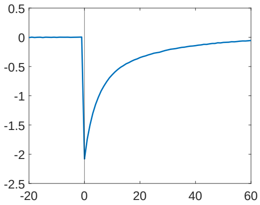
IRF: Productivity A_t



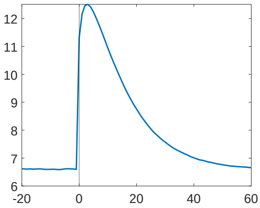
Productivity (A)



GDP



Consumption (c)



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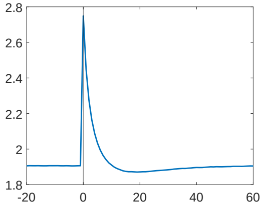
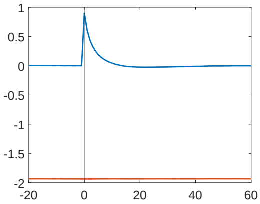
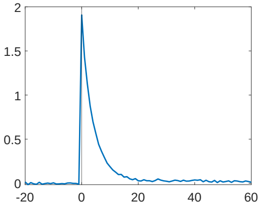


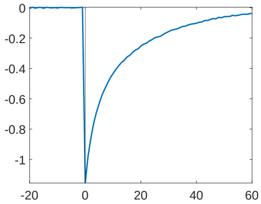
Spread



Yields

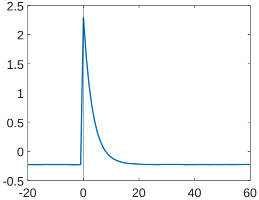


Domestic Rate (i)

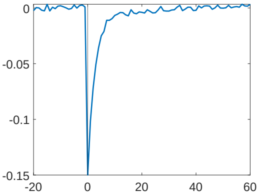


Labor (ℓ)

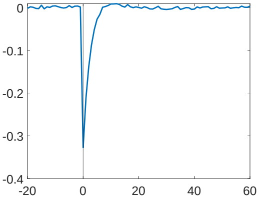
IRF: SDF Factor x_t



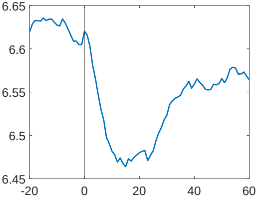
Factor (x)



GDP



Consumption (c)



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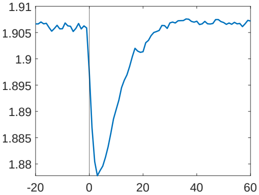

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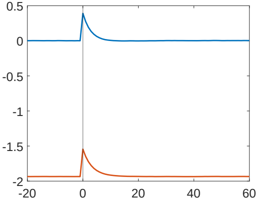

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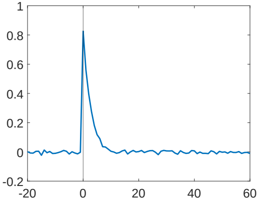
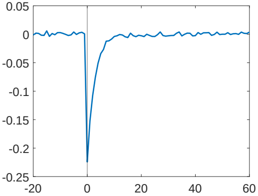
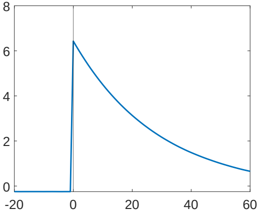


Domestic Rate (i)

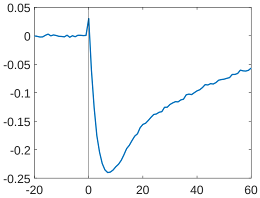


Labor (ℓ)

IRF: SDF Trend ν_t



Trend (ν)



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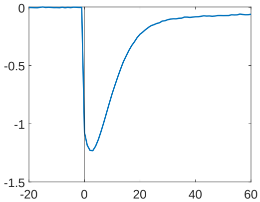
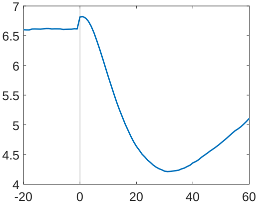


Consumption (c)



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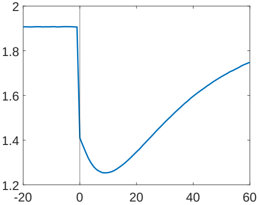

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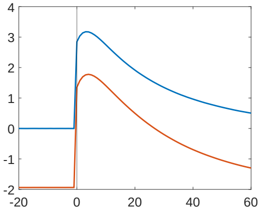

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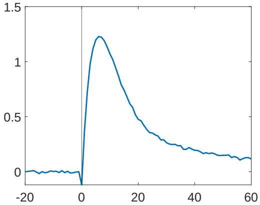
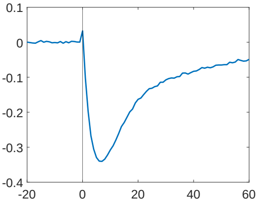
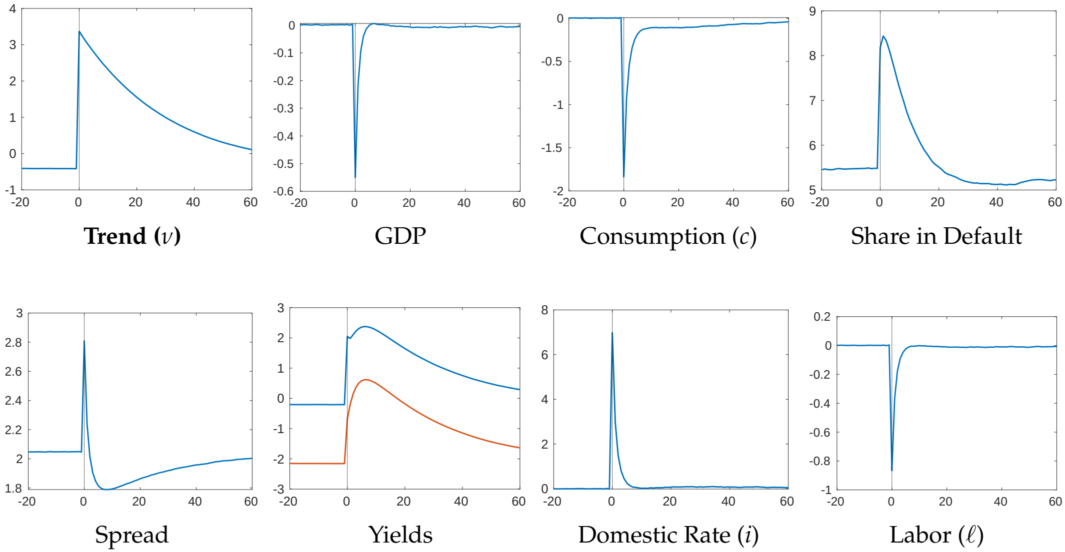


Domestic Rate (i)



Labor (ℓ)

IRF: SDF Trend ν_t, Short-Term Debt (4q)

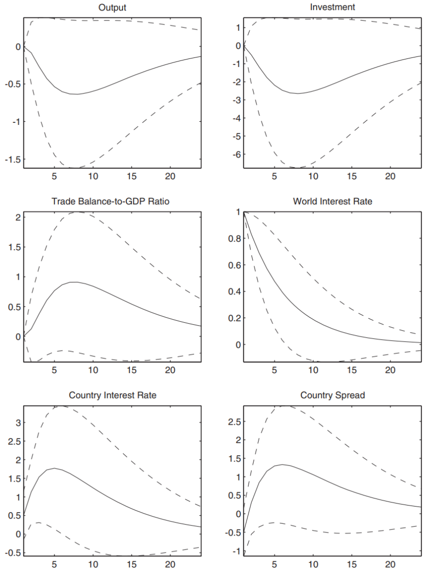


Summing Up

- Theory highlights spreads ambiguity: shock persistence and predictability
- Preliminary evidence on anticipated movements for US yield curve
- Quantitative model
  - Financial frictions key for output response
  - Domestic interest rate volatility is a costly side-effect of sovereign borrowing
  - A "puzzle:" spreads fall, except if maturity is low (too willing to drop B'?)

Appendix

Panel VAR, Uribe Yue 2006



Impulse responses to a 1% increase in the financial center rate (Uribe Yue, 2006)

- *Depressed output* and investment
- Current Account reversal
- Higher yields *and spreads*

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