Inflation, Default Risk and Nominal Debt

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January 25th, 2023

Motivation

- Recent switch of many EM sovereigns to local-currency borrowing
- New issue arises
  - Strategic inflation as a way to alleviate debt burden
  - In addition to outright default
- Strategic inflation with nominal debt
  - Ex-post insurance benefits
  - Ex-ante time-consistency costs
- Joint behaviour of inflation and default spreads
  - Key for welfare implications of nominal debt
  - Linked to fiscal-monetary policy interaction in EM

Empirical Observations

- Asset price derivatives contain information on both risks, separately

- Common "printing press" argument does not hold
  - Default & inflation risks co-exist

- Default risk co-moves
  - With expected inflation
  - With realised inflation

...and this holds
  - Across countries, in long run
  - Within country, at short run frequencies

Theoretical Implications

Use facts to discipline quantitative sovereign default model with

- Default as a binary choice
- Inflation as a continuous instrument
  - dilutes real value of debt
  - generates seigniorage revenues

Dilution motive alone is counterfactual

- Inflation and default are substitutes
- Low incentive to inflate in bad times

Revenue motive reconciles model with data

- Seignorage flexible source of funding in bad times
- Inflation & default risks co-move

Related Literature

Time-consistent policy with nominal/real debt & default

- Aguiar et al. (2014, 2015), Corsetti-Dedola (2016), Sunder-Plassman (2020), Na et al. (2018), Nuno-Thomas (2019), Roettger (2019), Espino et al. (2021)

Government debt currency denomination and "original sin"

- Eichengreen-Hausmann (1999, 2005), Du et al. (2016), Du-Schreger (2016, 2017), Engel-Park (2019), Ottonello-Perez (2018)

Time-consistent policy with default & nominal rigidities

- Na et al. (2018), Bianchi et al. (2019), Arellano et al. (2019)

Currency and balance of payment crises

- Krugman (1979), Obstfeld (1986), Burnside et al. (2001)

Empirical Facts

Data Description

- Period: Jan 2004 - Feb 2019, quarterly
- Countries: Brazil, Colombia, Indonesia, Mexico, Malaysia, Poland, Russia, Thailand, Turkey, South Africa
  - all with freely/managed-floating exchange rates (Ilzetzki et al., 2019)

[more data]

Asset Price Data

Default risk $\rightarrow$ Instrument: 5y Credit Default Swaps (CDSs)

- Insure against default losses on international-law debt
- USD denominated, no currency risk
- Back out implied risk-neutral default probability

[default probs] [more details]

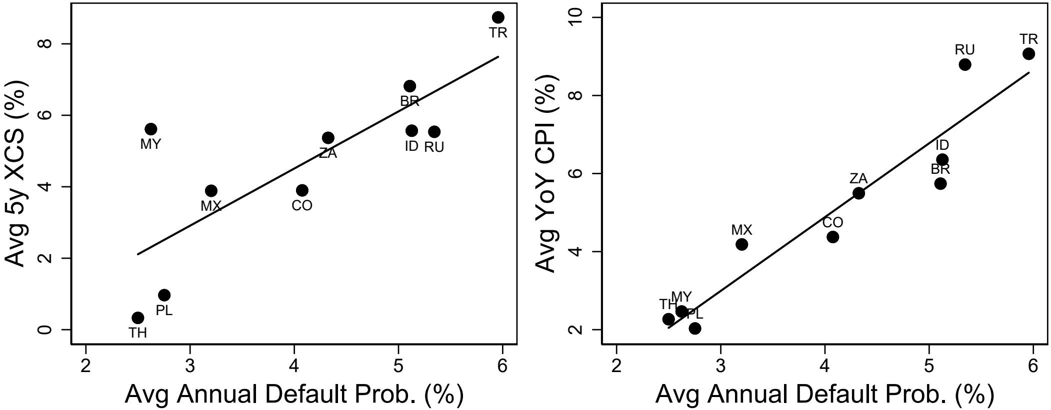
Inflation risk $\rightarrow$ Instrument: 5y Cross-Currency Swaps (XCSs)

- Fixed-for-fixed swaps built following Du-Schreger (2016)
- Proxy with currency risk
- No credit risk, fully collateralised OTC derivatives
- Long-term analogue of implied yield in ER forwards: $i - i^* = \frac{\text{Fwd}}{\text{Spot}}$
- Interpret $i - i^* \approx \mathbb{E}[\pi] - \mathbb{E}[\pi^*]$

[more details]

Fact 1: Long-Run, Across Countries

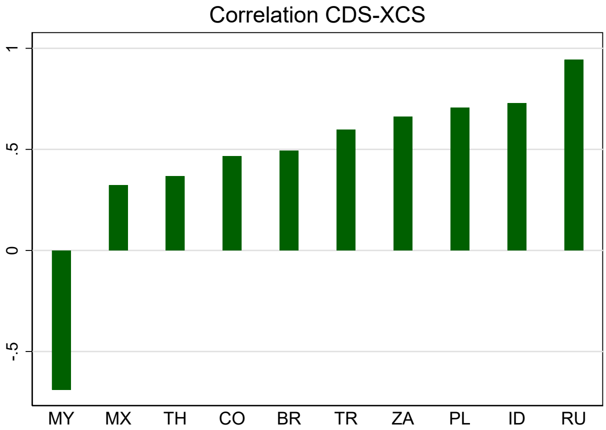
Cross-country averages for the period 2004q1-2018q4



[Post GFC] [IRS] [default probs]

Fact 2: Asset Price Correlation, Within Country

Time-series correlation between 5y default risk (CDS) & 5y currency risk (XCS)

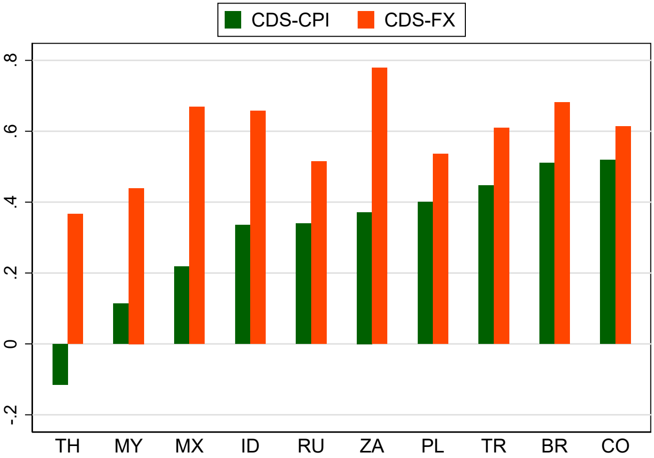


Panel: $\widehat{DP}_{i,t} = 0.437\ XCS_{i,t}$ (two-way FE, SE 0.096) [panel] [more correlations]

Fact 3: Macro Correlations, Within Country

Time series correlation between

- 5y default risk (CDS) & nominal exchange rate (FX) yoy changes
- 5y default risk (CDS) & consumer price index (CPI) yoy changes



Taking Stock

Document co-movement

- Among asset prices: default risk and currency risk
- With macro variables: default risk and inflation/exchange rate depreciation
- In short & long run

Model

Environment

Quantitative sovereign default model with

- Nominal debt
- Costly strategic inflation
- Endogenous government spending

Players

- Benevolent government
- Domestic households
- Foreign lenders

Government & Households

Government

- Benevolent, maximises households' utility

$$u(c, g) - v(\pi)$$

- Lacks commitment, chooses external debt, inflation, lump-sum taxes, spending
- Inflation
  - dilutes the real value of debt
  - generates seigniorage revenues $\sigma(\pi)$
- Lump-sum taxes
  - unrestricted (*baseline* model)
  - constrained by a fiscal limit (*constrained* model)

Households

- Receive exogenous income following $AR(1)$ process
- Consume, pay taxes and seigniorage

Government Problem

default decision and repayment problem

- Default decision

$$V(b,y) = \max\left\{V^R(b,y), V^D(b,y)\right\}$$

- Repayment problem

$$V^R(b,y) = \max_{\pi,c,g,\tau,b'} \quad u(c,g) - v(\pi) + \beta\mathbb{E}\left[V(b',y') \mid y\right]$$

subject to

$$\tau y + q(b',y)b' + \sigma(\pi) = \frac{b}{1+\pi} + g \qquad \text{(govt BC)}$$

$$c + \sigma(\pi) = y(1-\tau) \qquad \text{(hh BC)}$$

$$\tau \leq \overline{\tau} \qquad \text{(fiscal limit)}$$

Government

default problem

- Default implies
  - exogenous debt haircut $h \in (0,1)$
  - debt market exclusion: w.p. θ receive offer to repay $b(1-h)$ & re-enter
  - non-linear output cost $y^D(y) \leq y$

- Default problem

$$V^D(b,y) = \max_{\pi,c,g,\tau} \quad u(c,g) - v(\pi) + \beta \mathbb{E}\left[\theta V\left(\frac{b(1-h)}{1+\pi}, y'\right) + (1-\theta) V^D\left(\frac{b}{1+\pi}, y'\right) \mid y\right]$$

subject to

$$\tau y^D(y) + \sigma(\pi) = g \qquad \text{(govt BC)}$$

$$c + \sigma(\pi) = y^D(y)(1-\tau) \qquad \text{(hh BC)}$$

Lenders

- Risk-neutral, perfectly competitive, deep pockets
- Opportunity cost of funds R^*

- Zero-profit price of a unit of new government debt

$$q(b', y) = \frac{1}{R^*} \mathbb{E} \left[(1 - \delta(s')) \frac{1}{1 + \pi^R(s')} + \delta(s') \frac{q^D(s')}{1 + \pi^D(s')} \mid y \right]$$

where $s' = (b', y')$ [show q^D]

- Implied equilibrium default and inflation derivative prices:

$$DP(b, y) = \mathbb{E}[\delta(s') \mid y]$$
$$XCS(b, y) = \mathbb{E}[(1 - \delta(s'))\pi^R(s') + \delta(s')\pi^D(s') \mid y]$$

where $s' = (b'(b, y), y')$

[eqm definition]

Optimality Conditions

Repayment

- Resource constraint

$$c + g + \frac{b}{1+\pi} = y + q(b', y)b'$$

- FOC for inflation and taxes

$$\frac{b}{(1+\pi)^2}u_g + \sigma'(\pi)(u_g - u_c) = v'(\pi)$$

$$(u_g - u_c)(\overline{\tau} - \tau) = 0$$

- Inflation
  - Benefit: $\downarrow$ real value of debt due + $\uparrow$ revenues to finance g
  - Cost: $\downarrow$ welfare

- Euler equation for government debt

$$u_g\left(q + \frac{\partial q}{\partial b'}b'\right) = \beta\mathbb{E}\left[(1-\delta(s'))\frac{u_g(s')}{1+\pi(s')} + \delta(s')V_b^D(s') \mid y'\right]$$

Optimality Conditions

Default

- Resource constraint

$$c + g = y$$

- FOC for inflation and taxes

$$\beta \frac{b}{1+\pi} V_b^D(b,y) + \sigma'(\pi)(u_g - u_c) = v'(\pi)$$

$$(u_g - u_c)(\overline{\tau} - \tau) = 0$$

[backup]

- Inflation
  - Benefit: $\downarrow$ real value of debt due at re-entry + $\uparrow$ revenues to finance g
  - Cost: $\downarrow$ welfare

Quantitative Evaluation

- Preferences

$$u(c,g) - v(\pi) = \frac{c^{1-\gamma_c}}{1-\gamma_c} + \alpha_g \frac{g^{1-\gamma_g}}{1-\gamma_g} - \alpha_\pi \pi^2$$

- Seigniorage

$$\sigma(\pi) = \kappa \frac{\pi}{1+\pi}$$

- Default costs

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

- External parameters:

Variable		Value	Source
Private consumption utility curvature	γ_c	2	Conventional value
International risk-free rate	$R^* - 1$	0.00598	US Treasury rate
Log-output autocorrelation	ρ	0.9293	estimated
Log-output innovation st. dev.	σ_ϵ	0.0115	estimated
Re-entry probability	θ	0.282	Arellano (2008)
Recovery upon default	$1-h$	0.63	Cruces-Trebesch (2013)

[computation with taste shocks]

Baseline Model

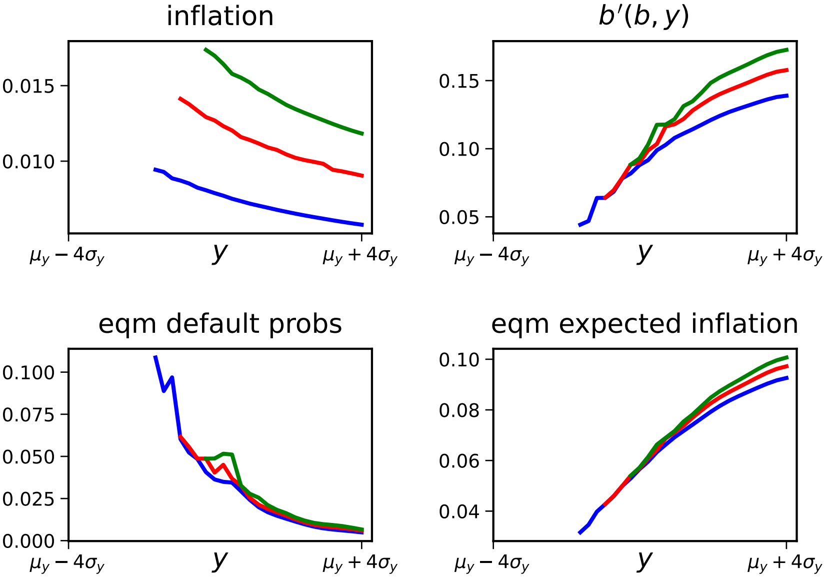
Assume: $\overline{\tau}$ never binding + public good utility equal to private ($\gamma_g = \gamma_c$)

- Govt can use τ to finance g at all times, seigniorage is irrelevant
- Inflation only used to inflate debt away, no intra-temporal distortions ($u_c = u_g$)

Parameters selected to match targets

Variable		Value	Target	Data	Model
Govt discount factor	β	0.88	External debt/GDP %	8.8	8.8
Inflation cost constant	α_π	4.79	YoY Inflation %	5.7	5.7
Public good utility constant	α_g	0.07	c/g ratio	3.6	3.6
% GDP default loss at y median	d_0, d_1	1.33	1y default prob. (mean) %	4.5	4.5
% GDP default loss at $\overline{y}$	d_0, d_1	2.82	1y default prob. (stdev.) %	2.0	2.0

Baseline Model: Equilibrium Policy and Prices



Non-Targeted Moments

Moment	Data	Baseline Model
$\boldsymbol{\rho(DP_t, XCS_t)}$	**0.5**	**-0.5**
$\rho(y_t, DP_t)$	-0.2	-0.6
$\rho(y_t, XCS_t)$	0.0	0.9
$\rho(DP_t, \pi_t)$	0.3	-0.4

Constrained Model

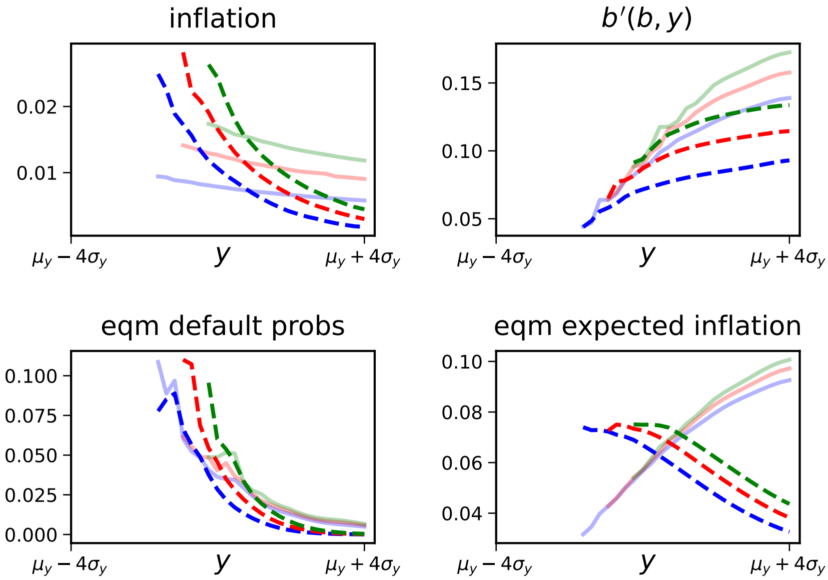
Assume: $\overline{\tau}$ binds + public good utility curvature larger than private ($\gamma_g = 4$)

- Fiscal capacity in EM typically low, hard to adjust
- Seignorage becomes useful as a flexible, countercyclical source of funding
- public-private consumption wedge: $u_g > u_c$

Parameters selected to match targets

Variable		Value	Target	Data	Model
Govt discount factor	β	0.85	External debt/GDP %	8.8	8.9
Inflation cost constant	α_m	20	YoY Inflation %	5.7	5.5
Public good utility constant	α_g	0.0034	c/g ratio	3.6	3.9
% GDP default loss at y median	d_0, d_1	1.9	1y default prob. (mean) %	4.5	4.4
% GDP default loss at $\overline{y}$	d_0, d_1	3.0	1y default prob. (stdev.) %	2.0	2.0
Tax ceiling, seigniorage param.	$\overline{\tau}, \kappa$	0.19, 1	DP-XCS correlation	0.5	0.6

Constrained Model: Equilibrium Policy and Prices



Non-Targeted Moments

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$\rho(y_t, XCS_t)$	0.0	0.9	-0.7
$\rho(DP_t, \pi_t)$	0.3	-0.4	0.3

[graphs on π cyclicality]

Takeaways

Counter-cyclical inflation

- Consistent with empirical evidence in EM
- In bad times, strong motive to finance g with π-tax
- Matches co-movement of [default risk]$\leftrightarrow$[inflation risk]$\leftrightarrow$[realised inflation]

Co-movement of inflation & default spreads

- Exacerbates time inconsistency $\rightarrow$ debt is costly when most needed
- Key trade-off: insurance benefit vs. time-consistency cost. Matters for
  - Debt denomination
  - Central bank independence vs. fiscal flexibility

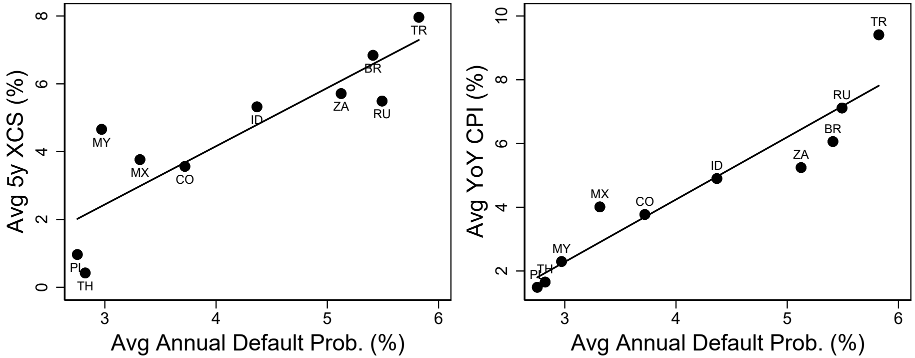
Conclusion

- Default risk co-moves with inflation risk & realised inflation (and exchange rates)
- Monetary financing to match data, debt dilution alone not enough
- Implications for debt denomination and fiscal-monetary interactions

Appendix

Fact 1: Long-Run, Cross-Country

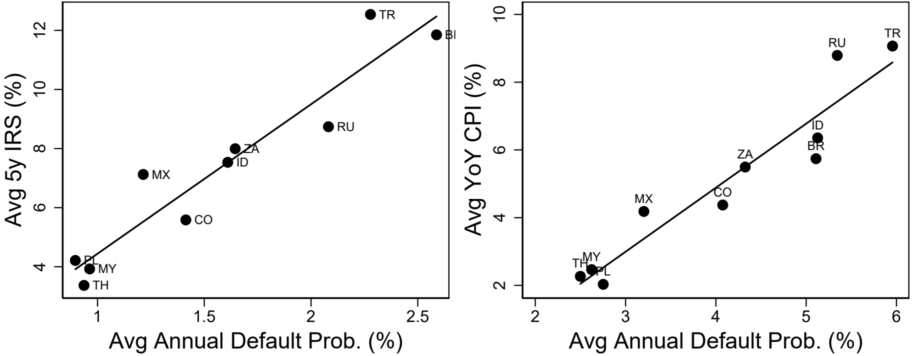
Cross-country averages for the period 2010q1-2018q4



[back]

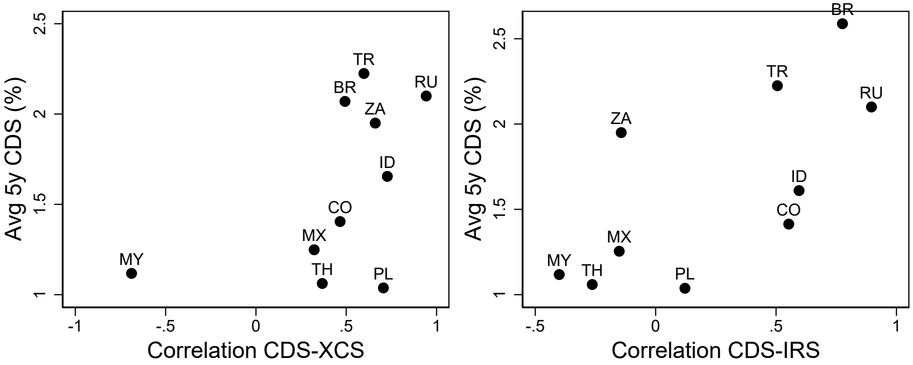
Fact 1: Long-Run, Cross-Country

Cross-country averages for the period 2004q1-2018q4



[back]

Fact 2: More Time-Series Correlation



[back]

Data: Local-Currency Debt Focus

	Total Debt (% of GDP)	Foreign-Currency Debt (% of Total Debt)
Brazil	66.4	5.5
Colombia	39.2	28.6
Indonesia	33.2	41.0
Mexico	33.8	27.4
Malaysia	48.1	6.6
Poland	50.2	25.5
Russia	13.9	30.4
Thailand	27.3	2.3
Turkey	38.4	34.2
South Africa	38.7	11.4

Source: World Bank Quarterly Public Sector Debt database.

- LC defaults as frequent as FC defaults
  - (post'97: 40 events, 35% FC, 25% LC, 32% both)
  - (post'75: 63 events, 43% FC, 33% LC, 24% both)
- Moody's sector in-depth (April 2nd, 2019)
  - Same credit ratings on LC & FC debt

[back]

Descriptive Statistics (2004m1-2019m2)

[back]

	CPI yoy	FX yoy	IRS 5y	CDS 5y	Debt/GDP (%)	FC Debt Share (%)	Ext Debt Share (%)
BR	5.7 (1.8)	3.1 (19.3)	9.2 (1.9)	2.2 (1.3)	66.4	5.5	13.3
CO	4.4 (1.7)	1.3 (15.1)	6.5 (1.8)	1.8 (1)	39.2	28.6	37.7
ID	6.4 (3.4)	3.9 (9.8)	8.4 (2.3)	2.0 (1.2)	33.2	41.0	55.1
MX	4.2 (1)	4.4 (11)	7.1 (1.6)	1.2 (0.6)	33.8	27.4	30.6
MY	2.5 (1.6)	0.8 (8.2)	3.8 (0.4)	1.1 (0.4)	48.1	6.6	27.1
PL	2.0 (1.7)	0.7 (15.4)	4.2 (1.6)	1.1 (0.6)	50.2	25.5	44.7
RU	8.8 (3.7)	6.6 (20.3)	8.0 (3.2)	2.2 (1.3)	13.9	30.4	29.2
TH	2.3 (2.2)	-1.5 (6)	3.0 (1)	1.1 (0.5)	27.3	2.3	11.0
TR	9.1 (3)	9.6 (16.5)	11.3 (3.8)	2.4 (0.9)	38.4	34.2	30.2
ZA	5.5 (2.3)	5.1 (14.8)	8.0 (1.1)	1.6 (0.8)	38.7	11.4	27.7

Variance Decompositions

Country	R^2	IRS %	CDS %	Covariance %
BR	0.68	64	14	22
CO	0.50	78	6	15
ID	0.71	72	4	24
MX	0.86	100	0	0
MY	0.54	91	6	3
PL	0.82	85	7	8
RU	0.20	12	50	38
TH	0.73	98	1	1
TR	0.78	59	10	31
ZA	0.91	93	1	6

Table: Time series regression and variance-covariance decomposition of 5y LC bond yields monthly changes, for the period Jan 2004 - Feb 2019. HAC robust standard errors used in all regressions, significance levels indicated by *** ($p<0.01$), ** ($p<0.05$), * ($p<0.1$).

Asset Price Details: Default Risk

CDSs:

- Pay a periodic premium (spread) in exchange for default "insurance"
- Credit event: change in interest, principal, postponement of interest/principal, change in currency or seniority
- Upon credit event: protection buyer has option to deliver to seller an **acceptable** bond in a **permitted** currency
- Deliverable currencies typically include USD, EUR, YEN; GBP, CHF, CAD, AUD

[back]

CDS-Implied Default Probabilities

- Survival prob. with default intensity $\lambda(t)$: $S(t) = Pe^{-\int_0^t \lambda(u)du}$
- Premium leg: PV of all premium payments

$$PV_{prem} = \mathbb{E}\int_0^T DF(t)U_{par}\mathbb{1}[T_1 > t] = U_{par}\int_0^T DF(t)S(t)\mathrm{d}t$$

- Protection leg: PV of LGD, at random time $T_1|T_1 < T^{expiry}$

$$PV_{prot} = \mathbb{E}\Big[DF(T_1) \times LGD \times \mathbb{1}[T_1 \leq T]\Big] = LGD\int_0^T DF(t)S(t)\lambda(t)\mathrm{d}t$$

- Par spread is given by

$$U_{par} = \frac{LGD\ \int_0^T DF(t)\ S(t)\lambda(t)\mathrm{d}t}{\int_0^T DF(t)S(t)\mathrm{d}t}$$

- Assume constant hazard rate $\lambda(t) = \lambda$, we get $\lambda = \frac{U_{par}}{LGD}$
- Default probability thus given by $\text{DefProb}_t = 1 - S(t) = 1 - e^{-\lambda t} = 1 - e^{-\frac{U_{par}}{LGD}t}$

[back to LR Facts] [back to CDS]

Asset Price Details: Inflation Risk

IRSs:

- pay/receive periodic fixed rate for local LIBOR ($\approx$ key CB rate)
- constant maturity, fully collateralised OTC derivatives

Fixed-for-Fixed Cross-Currency Swaps (Du-Schreger, 2016):

- when Non-Deliverable Cross-Currency Swaps are available
  - NDS fixed-for-floating: LC fixed $\leftrightarrow$ USD LIBOR
  - Plain USD IRS: USD LIBOR $\leftrightarrow$ USD fixed
- when Cross-Currency Swap Basis is available
  - Plain LC IRS: LC fixed $\leftrightarrow$ LC LIBOR
  - XC Basis: LC LIBOR $\leftrightarrow$ USD LIBOR
  - Plain USD IRS: USD LIBOR $\leftrightarrow$ USD fixed

[back]

Debt Prices

- Price of debt in repayment

$$q(b',y) = \frac{1}{R^*}\mathbb{E}\left[(1-\delta(s'))\frac{1}{1+\pi_R(s')} + \delta(s')\frac{q_D(s')}{1+\pi_D(s')}|y\right]$$

where $s' = (b', y')$

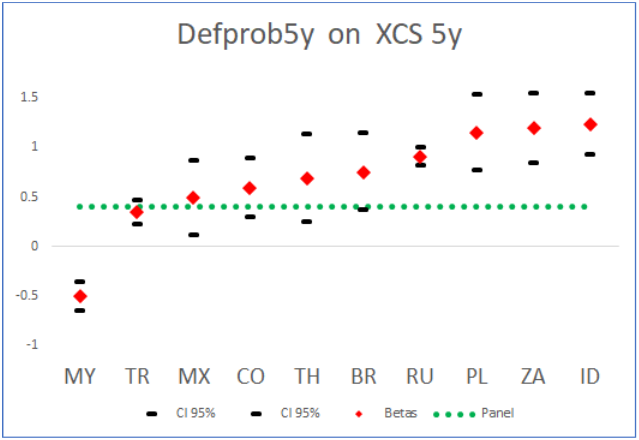
- Price of a unit-of-goods-worth of **defaulted** government debt

$$q^D(b,y) = \frac{1}{R^*}(1-\theta)\mathbb{E}\left[\frac{q^D(s'_n)}{1+\pi^D(s'_n)}\right] + \frac{1}{R^*}\theta\,\mathbb{E}\left[\delta(s'_o)\frac{1-h}{1+\pi^D(s'_o)}q^D(s'_o) + (1-\delta(s'^o))\frac{1-h}{1+\pi^R(s'_o)}\right]$$

where $s'_n = \left(\frac{b}{1+\pi^D(b,y)}, y'\right)$; $s'_o = \left(\frac{b(1-h)}{1+\pi^D(b,y)}, y'\right)$

[back]

Controlling for a Global Factor



[back]

Optimality Conditions

default

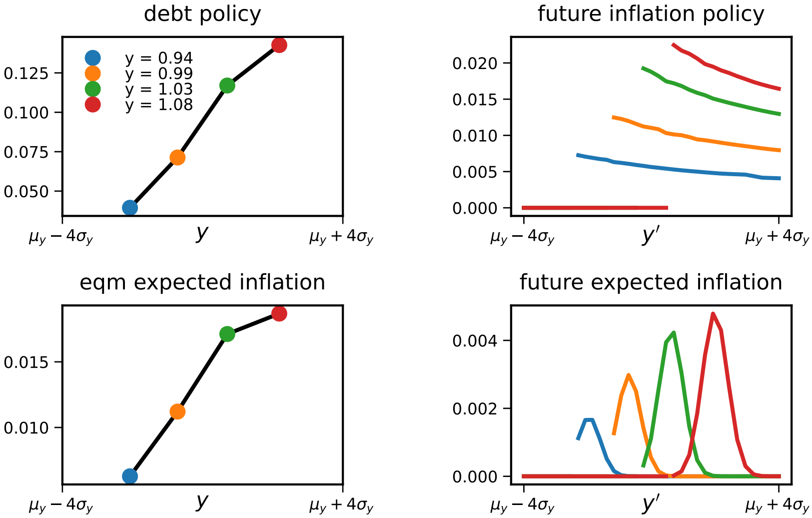
Envelope condition for debt b

$$V_b^D(b,y) = \beta \mathbb{E}\left[\theta V_b\left(\frac{b(1-h)}{1+\pi}, y'\right)\left(\frac{1-h}{1+\pi}\right) + (1-\theta)V_b^D\left(\frac{b}{1+\pi}, y'\right)\left(\frac{1}{1+\pi}\right) \mid y\right]$$

[back]

Inflation Expectations Cyclicality

baseline model



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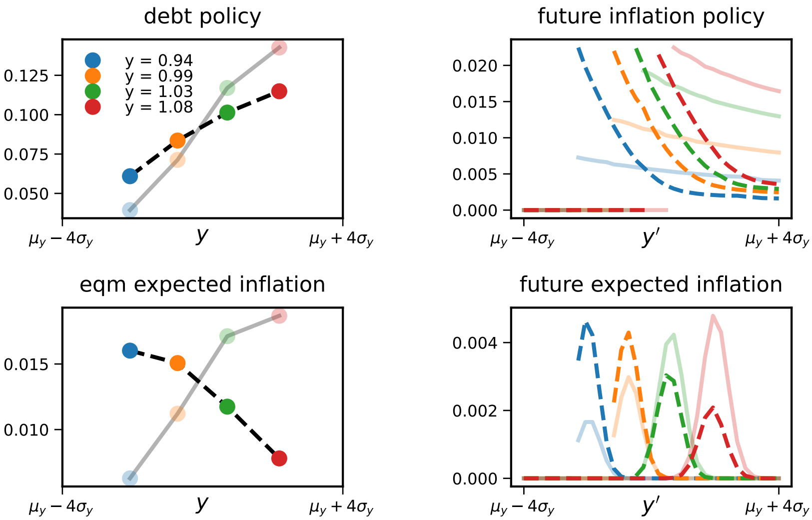
Inflation Expectations Cyclicality

constrained model



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Equilibrium Definition

Given the aggregate state $\{b, y\}$, a Markov-perfect recursive equilibrium consists of

- Government value functions $V(b, y), V^R(b, y), V^D(b, y)$,
- Associated policy functions $\delta(b, y)$, $g(b, y)$, $\tau(b, y)$, $\pi(b, y)$ and $b'(b, y)$
- Debt price functions $q(b', y)$, $q^D(b, y)$

such that:

- Value and policy functions solve the government problem, given the debt price functions q, q^D
- The debt price functions solve the lenders' problem, given the government value and policy functions

[back]

Computation with Taste Shocks 1/2

Government recursive problem

- Default choice

$$V(b, y, \{\epsilon_R, \epsilon_D\}) = \max_{\delta \in \{0,1\}} \left\{(1-\delta)[V^R(b,y) + \rho_\delta \epsilon_R] + \delta[V^D(b,y) + \rho_\delta \epsilon_D]\right\}$$

- Repayment value

$$V^R(b, y, \{\epsilon_{b'}\}) = \max_{b'} \left\{W^R(b, y;\ b') + \rho_{b'} \epsilon_{b'}\right\}$$

- Default value

$$V^D(b, y, \{\epsilon_\pi\}) = \max_{\pi} \left\{W^D(b, y;\ \pi) + \rho_\pi \epsilon_\pi\right\}$$

Computation with Taste Shocks 2/2

- $\{\epsilon_R, \epsilon_D, \epsilon_{b'}, \epsilon_\pi\} \sim^{iid} \text{Gumbel}(-\bar{\mu}, 1)$
- Choice probabilities for policy choice x

$$\mathbb{P}(x|b,y) = \frac{\exp\left[W^i(b,y,x)/\rho_x\right]}{\sum_x \exp\left[W^i(b,y,x)/\rho_x\right]}$$

- Expected values:

$$V^i(b,y) = \rho_x \log\left\{\sum_x \exp\left[W^i(b,y,x)/\rho_x\right]\right\}$$

[back]