Does It Matter How Central Banks Accumulate Reserves? Evidence from Sovereign Spreads

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Motivation

- Large literature on the benefits of reserve accumulation
  - Liquidity
  - Hedging
  - Mercantilism
- Very little literature on whether these effects change depending on how reserves are accumulated.
  - External liabilities
  - Domestic liabilities
  - Unsterilized purchases
- This paper tries to fill this gap: focus on sovereign spreads

What do we do?

- Provide simple **sovereign default** model with (potentially) state-contingent **long-term debt** and **reserves**
    - **Result:** reserve accum. w/ contingent debt is associated to lower spreads (intuition: cont. debt gives you a *break* in bad states of nature)
    - Improves on Alfaro-Kanczuk

- We test this in a panel of countries
    - **Result:** accumulating debt with domestic currency liabilities reduces spreads, with foreign debt it does not.

- We test the result using exogenous shocks (shocks to the VIX index)
    - **Result:** the more countries build their reserves with foreign (domestic) liabilities the larger (smaller) the increase in spreads.

Main Elements of the Model

- Equilibrium default model à la Eaton-Gersovitz (Aguiar-Gopinath; Arellano) with long-term debt and reserves (Bianchi-Hatchondo-Martinez), (Bianchi-Sosa Padilla)

  Twist: allow for state-contingent debt

- Economy receives stochastic endowment y, follows a Markov process.
- Objective of the government: $\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} u(c)$; $u' > 0$, $u'' < 0$
- Government issues (potentially) state-contingent long-duration bonds (b) and saves in one-period risk free assets (a), all in units of tradable endowment
- Defaults are total and entail one-period exclusion and utility loss $\psi_d(y)$
- Risk averse foreign lenders $\rightarrow$ "risk-premium shocks"

Asset/Debt Structure

- Long-term bond (b):
  - state-contingent coupon, which decreases at rate δ

$$\mathcal{C}_t = \kappa \big[1 + \phi \left(y_t - \overline{y}\right)\big]$$

  - simple way of modeling state-contingent claims (similar to Roch and Roldan, 2021)
  - bond purchased in t pays $\{\mathcal{C}_{t+1}, (1-\delta)\,\mathcal{C}_{t+2}, (1-\delta)^2\,\mathcal{C}_{t+3}, ...\}$
  - price is q
- Reserves (a):
  - risk-free one-period asset which pays one unit of consumption
  - price is q_a

Foreign Investors

more

- Competitive, deep-pocketed foreign lenders, subject to "risk-premium" shocks:
  - SDF: $m(s, s')$ with $s = \{y, \nu\}$

- Not essential for the analysis, but helps to capture **global factors** and match **spread dynamics**

- Formulation follows Vasicek (77) and implies constant short-term risk-free rate:

$$q_a = \mathbb{E}_{s'|s} m(s, s') = e^{-r}$$

- Bond price given by:

$$q = \mathbb{E}_{s'|s} \left\{ m(s, s')(1 - d') \left[\mathcal{C}' + (1 - \delta)\, q' \right] \right\}$$

Model: recursive formulation

$$V(b,a,s) = \max_{d \in \{0,1\}} \Big\{ d\, V_1(a,s) + (1-d)\, V_0(b,a,s) \Big\}, \tag{1}$$

where

$$V_1(a,s) = \max_{a'} \Big\{ u\big(\underbrace{y + a - g - a' q_a}_{\text{consumption in def.}} \big) - \psi_d(y) + \beta \mathbb{E}_{s'|s} V\big(0, a', s'\big) \Big\}. \tag{2}$$

$$V_0(b,a,s) = \max_{b',a',c} \Big\{ u(c) + \beta\, \mathbb{E}_{s'|s} V(b',a',s') \Big\}, \tag{3}$$

subject to

$$c + g + \mathcal{C}(s) b + a' q_a = y + q(b',a',s)(b' - (1-\delta)b) + a \tag{4}$$

Calibration (1)

- Nothing new. Mexican data, annual frequency.
- Follow Bianchi-Hatchondo-Martinez (2012, AER) exactly → benchmark economy $\phi = 0$

Utility function:

$$u(c) = \frac{c^{1-\gamma} - 1}{1 - \gamma}, \text{ with } \gamma \neq 1$$

Utility cost of defaulting:

$$\psi_d(y) = \psi_0 + \psi_1 log(y)$$

Tradable income process:

$$\log(y_t) = (1 - \rho)\mu_y + \rho log(y_{t-1}) + \varepsilon_t$$

with $|\rho| < 1$ and $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$

Calibration (2)

Parameter	Description	Value
r	Risk-free rate	0.04
β	Domestic discount factor	0.92
π_{LH}	Prob. of transitioning to high risk premium	0.15
π_{HL}	Prob. of transitioning to low risk premium	0.8
σ_{ε}	Std. dev. of innovation to $\log(y)$	0.034
ρ	Autocorrelation of $\log(y)$	0.66
μ_y	Mean of $\log(y)$	$-\frac{1}{2}\sigma_{\varepsilon}^2$
g	Government consumption	0.12
δ	Coupon decaying rate	0.2845
κ	Avg. coupon size	$(r+\delta)e^{-r}$
	Parameters set by simulation	
γ	Coefficient of relative risk aversion	3.3
ψ_0	Default cost parameter	2.45
ψ_1	Default cost parameter	19
ω	Pricing kernel parameter	23

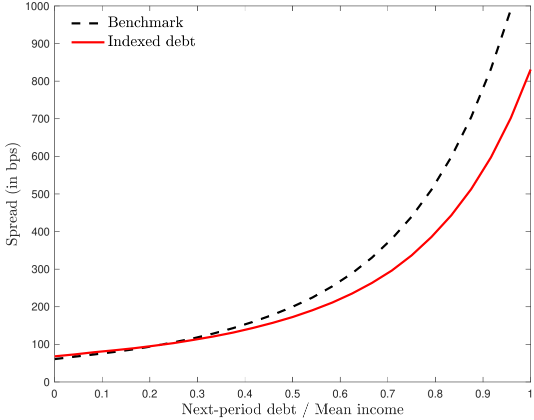
Model simulations

	Data	Model	
		Benchmark ($\phi = 0$)	Indexed debt ($\phi = 1$)
Targeted			
Mean debt (b/y)	43.5	43.3	54.2
Mean r_s (in %)	2.4	2.4	2.6
Δr_s w/ risk-prem. shock	2.0	2.2	2.8
$\sigma(c)/\sigma(y)$	1.0	1.0	0.9
Non-Targeted			
$\sigma(r_s)$ (in %)	0.9	2.0	2.5
$\rho(r_s, y)$	-0.5	-0.7	-0.8
$\rho(c, y)$	0.8	0.9	0.9
Mean Reserves (a/y)	8.5	6.0	11.9

Using contingent debt:

1. gov holds more b (55% vs. 44%) and uses it to finance the $\uparrow$ a (12% vs. 6%)
2. only a slightly higher average spread $\rightarrow$ more res. and contingent coupons
3. portfolio in line w/ data, $a/b \approx 20\%$ (improvement over Alfaro-Kanczuk 2019)

State contingent debt and spreads



Testable implication: for a given debt level, financing reserves with contingent debt allows the country to pay lower spreads.

Taking the model to the data

- We'll test these model implications in a panel of emerging economies
- Two approaches:
    1. Fixed effects regressions
    2. Exogenous events (↑ VIX)
- **Preview:** results are consistent with the model.
    1. The way reserves are financed matters
    2. Using contingent debt helps reducing the spread, foreign debt doesn't.

- **Warm-up exercise:** holding debt (and other controls) constant, higher reserves are associated with lower spreads.

Panel regressions: extending Levy-Yeyati and Gomez (2020)

	Dependent variable: log(spread)	
	(1)	(2)
Reserve Ratio	−2.58***	−2.76***
	(0.11)	(0.55)
Rating	−0.36***	−0.35***
	(0.03)	(0.11)
Sovereign Debt	1.53***	1.56***
	(0.05)	(0.53)
Private Debt	0.74***	1.01***
	(0.05)	(0.31)
Risk Aversion	0.76***	0.78***
	(0.02)	(0.06)
World Rate	−0.29***	−0.17
	(0.02)	(0.11)
Constant	2.29***	
	(0.15)	
Fixed effects?	No	Yes
Observations	4,497	4,497
Adjusted R^2	0.52	0.57

Taking the model to the data (2)

Use standardize CB balance sheet data:

Balance Sheet

Claims on non-residents (1)	Liabilities to non-residents (a)
Claims on others depository corporations (2)	Monetary base (b)
Net Claims on Central Government (3)	Other Liabilities To Other Depository Corporations (c)
	Deposits and Securities other than Shares Excluded from Monetary Base (d)
	Loans (e)
	Financial Derivatives (f)
	Shares and equity (g)
	Other items (h)

Taking the model to the data (2)

Reserve Ratio = (1) / GDP
External Liabilities = (a) / GDP
Remunerated Domestic Liabilities = [(c)+(d)+(e)+(f)] / GDP
Unsterilized Purchases = (b)/GDP
Other Balance Sheet = [(g)+(h)-(2)-(3)]/GDP

$$\Downarrow$$

CB Balance Sheet

Reserve Ratio	External Liabilities
	Remunerated Domestic Liab.
	Unsterilized Purchases
	Others

How reserves are financed matters!

▸ more

	Dependent variable: log(spread)		
	(6)	(7)	(8)
Reserve Ratio	−0.25	−3.24***	−2.85***
	(1.04)	(0.43)	(1.08)
Remunerated Domestic Liabilites	−3.27**		-0.43
	(1.46)		(1.18)
Unsterilized Purchases	-2.54	0.43	
	(1.56)	(1.29)	
External Liabilities		4.74***	4.32***
		(1.16)	(0.97)
Others Balance Sheet	−1.89*	1.51**	1.10
	(1.05)	(0.60)	(1.04)
Other controls?	**Yes**	**Yes**	**Yes**
Fixed effects?	Yes	Yes	Yes
Year dummies?	Yes	Yes	Yes
Observations	4,497	4,497	4,497
Adjusted R^2	0.62	0.63	0.63

How reserves are finance matters!

	Dependent variable: log(spread)		
Using:	*EL*	*DL*	*UP*
Reserve Ratio	-0.25	-3.24^{***}	-2.85^{***}
	(1.04)	(0.43)	(1.08)

Take home message:

1. How reserves are financed matters.
2. Accum. w/ domestic (contingent) liabilities helps reduce the spread, while using external liabilities does not. → **consistent w/ model**

Robustness of our empirical results (1)

- Theory: benefits of contingent debt are higher for **high debt** and/or **high spread**
  → Consistent w/ the data

	Dependent variable: log (spread)					
	External Liab.	Domestic Liab.	Unsterilized	External Liab.	Domestic Liab.	Unsterilized
	High Debt			Low Debt		
	-0.33	-3.47^{***}	-0.24	0.20	-1.26	-1.16
	(1.18)	(0.89)	(1.01)	(1.37)	(0.77)	(1.75)
N	1,188	1,188	1,188	1,734	1,734	1,734
	High Spread			Low Spread		
	0.67	-2.92^{***}	-0.98	-0.06	-1.35	-5.52^{***}
	(1.57)	(0.51)	(0.69)	(1.21)	(1.47)	(1.42)
N	2,517	2,517	2,517	1,980	1,980	1,980

Robust SE in parentheses. All specifications include country and year FEs. *p<0.1; **p<0.05; ***p<0.01

Robustness of our empirical results (2)

▸ more

Prev. point holds more generally: contingent debt more beneficial in **distress** scenarios

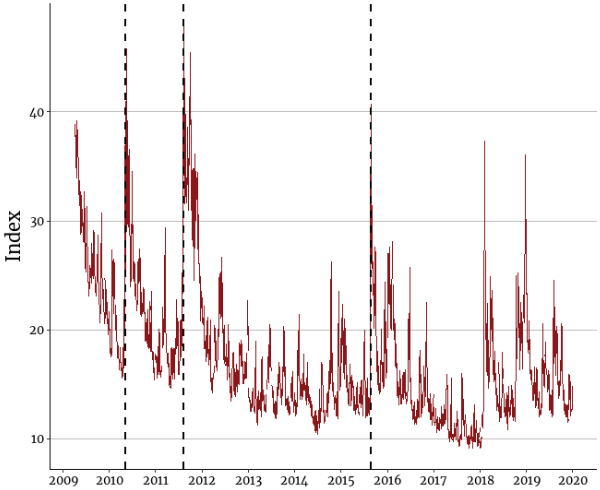
- holds for: Devaluation rate, Fiscal deficit, Dollarization.

	Dependent variable: log (spread)					
	External Liab.	Domestic Liab.	Unsterilized	External Liab.	Domestic Liab.	Unsterilized
		High Rate Devaluation			Low Rate Devaluation	
	-0.26	−3.72***	−3.04***	-1.69	-1.29	-0.83
	(1.08)	(0.95)	(0.89)	(2.82)	(1.11)	(2.06)
N	2,683	2,683	2,683	1,814	1,814	1,814
		With Deficit			Without Deficit	
	−2.36***	−7.37***	−4.49***	-0.61	−2.20***	-2.33
	(0.50)	(0.85)	(0.83)	(1.94)	(0.83)	(2.31)
N	1,166	1,166	1,166	1,471	1,471	1,471
		Dollarizated Countries			Non-Dollarizated Countries	
	-0.41	−4.23***	−3.58***	−2.30*	−3.21***	-1.54
	(0.78)	(1.06)	(1.26)	(1.23)	(0.60)	(0.98)
N	2,005	2,005	2,005	1,908	1,908	1,908

Exogenous shocks

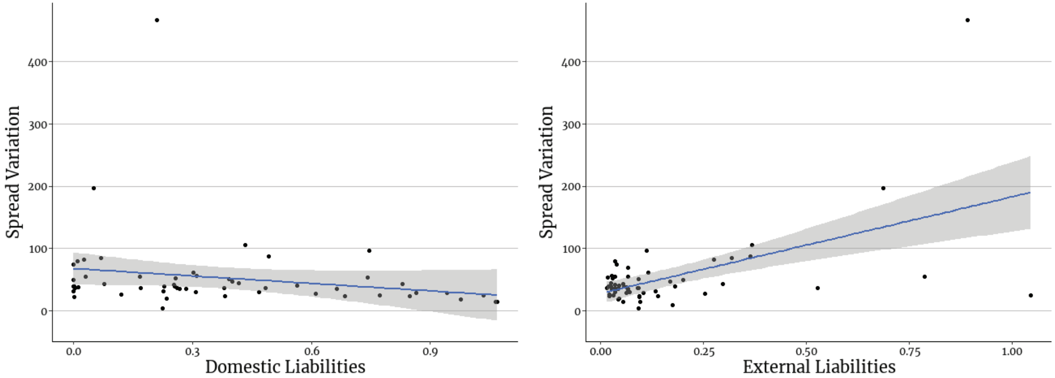
- Panel regressions $\rightarrow$ endogeneity concerns (even w/ country and time FE)
- Use global (exogenous) shocks: sharp increases in the VIX (Rey 2013; Acharya and Krishnamurthy 2019)
- Identify events as any date in which
  1. $\Delta VIX > 20$ (wrt to avg. value in window of prior 5-10 days), and
  2. Avg. increase in sovereign spreads $\geq$ 10 bps

Exogenous shocks: large increases in VIX



- May 7, 2010: flash crash in the US stock market (previous day),
- August 8, 2011: "Black Monday" of 2011 (S&P downgrades the US debt), and
- August 24, 2015: a second flash crash of the US stock market

Exogenous shocks: large increases in VIX



Punchline: the more a country financed its reserves with domestic liabilities, the smaller the ↑ spread.

Exogenous shocks: large increases in VIX

▸ more

	Dependent variable: Spread Variation		
	Domestic Liabilities	External Liabilities	p-value difference
Pooled	−39.80**	155.00	0.06*
	(19.70)	(100.00)	
First Event	−37.60***	45.10	0.00***
	(9.70)	(28.00)	
Second Event	−58.00**	208.00***	0.00***
	(27.40)	(37.30)	
Third Event	-22.30	180.00	0.24
	(36.90)	(167.00)	

Note: Robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01

Conclusions

- We show that the way reserve accumulation is financed matters.
- Focus: the effect on sovereign spreads.
    - Accum. w/ dollar debt provides liquidity but no hedge.
    - Domestic debt (either in LCU or indexed to domestic outcomes) provides both

  $\Longrightarrow$ differential impact on default incentives (and spreads)
- Model's testable implications hold in the data: both panel regressions and exogenous shocks.
- Policy implications: reserve buildup programs *should* rely more on contingent debt.

Gracias !

Foreign Investors' SDF – details

back

- Pricing kernel: a function of innovation to domestic income (ε) and a global factor $\nu = \{0, 1\}$ (assumed to be independent)

$$m_{t,t+1} = e^{-r-\nu_t(\omega\varepsilon_{t+1}+0.5\omega^2\sigma_\varepsilon^2)}, \quad \text{with} \quad \omega \geq 0,$$

- Functional form + normality of ε $\rightarrow$ constant short-term rate:

$$\mathbb{E}_{s'|s}m(s, s') = e^{-r} = q_a, \qquad \text{with} \quad s = \{y, \nu\}$$

- Bond price given by: $q = \mathbb{E}_{s'|s}\{m(s, s')(1 - d')[\mathcal{C}' + (1 - \delta) q']\}$
- Bond becomes a worse hedge if $\nu = 1$ and gov. tends to default with low ε

$\implies$ positive risk premium

- Even worse hedge w/ contingent coupon

The difference in coeffs is statistically significant

back

	Reserve Ratio	p-value	Reserve Ratio	p-value
	EL - DL	0.00***	EL - DL	0.01***
	DL - U	0.70	DL - U	0.74
Year FE	No		Yes	

Robustness of our empirical results

back

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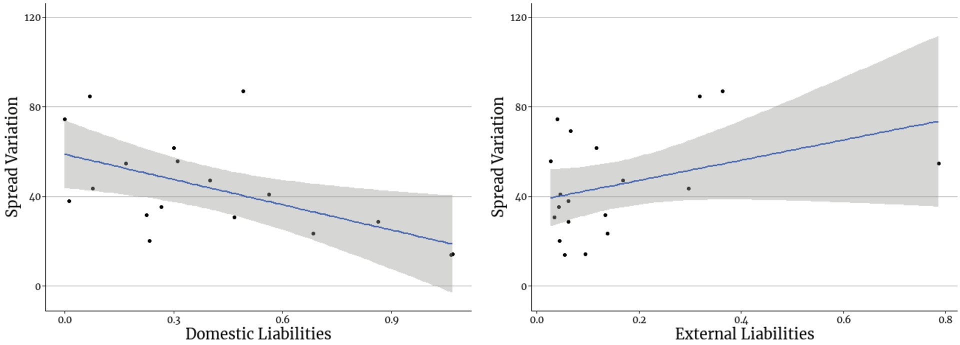
First event

back

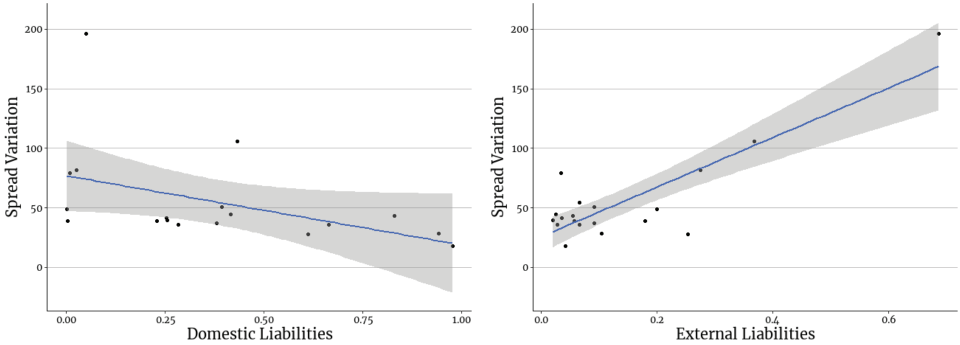
First Event (May 7, 2010)



Second event

back

Second Event (August 8, 2011)



Third event

back

Third Event (August 24, 2015)