A Macroprudential Theory of Foreign Reserve Accumulation

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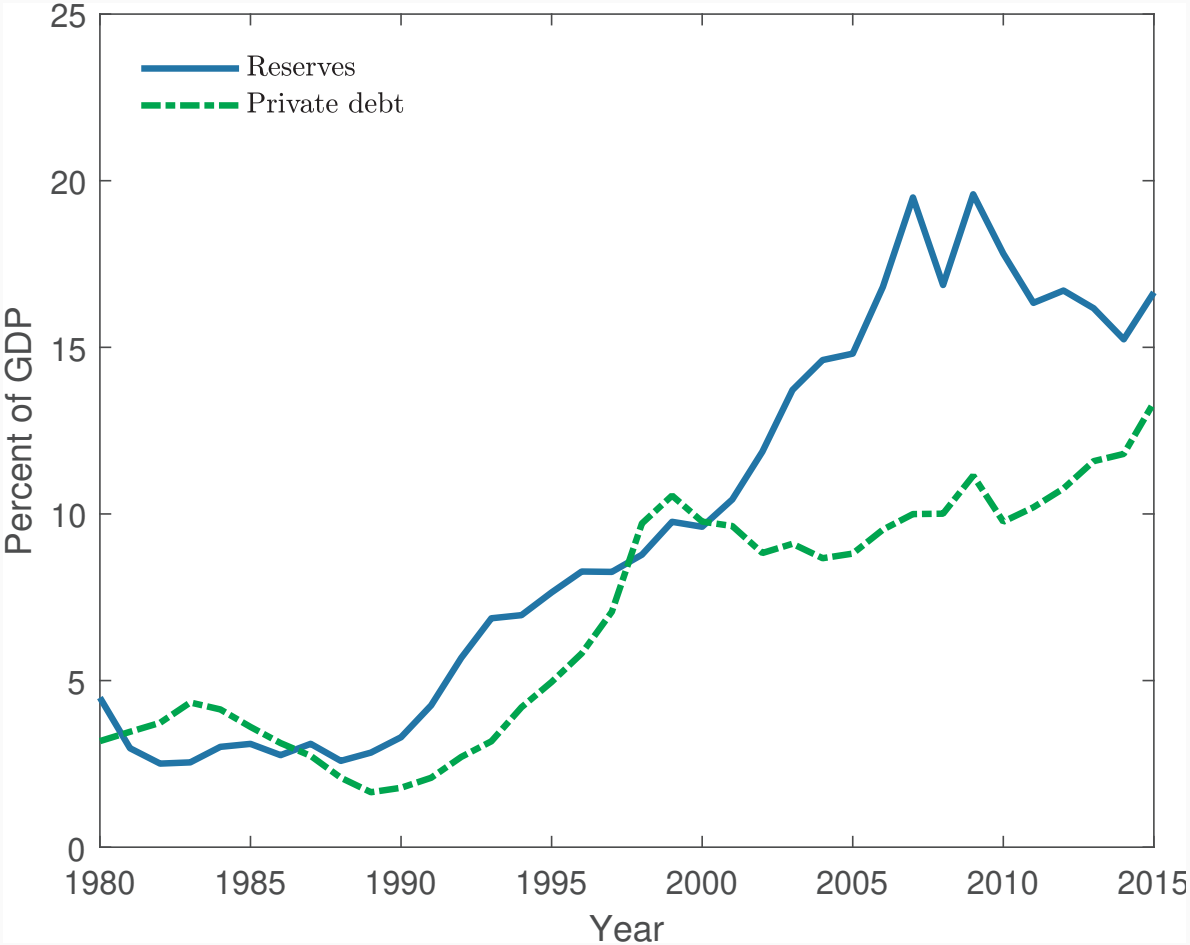
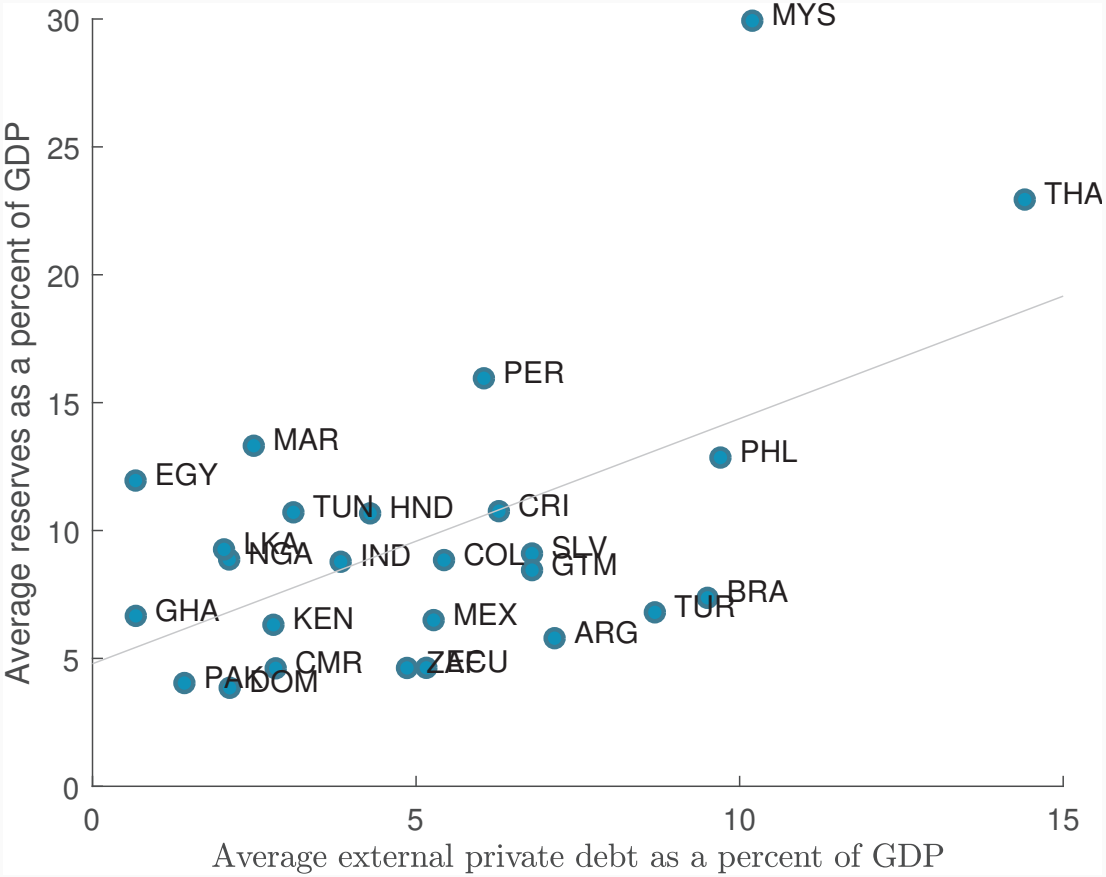
Fact 1: Private External Debt & Foreign Reserves over time



GDP weighted average reserves to GDP & private external debt to GDP in middle income countries (excluding China) for 1980-2015.

Source: World Bank, International Debt Statistics ▸ Details

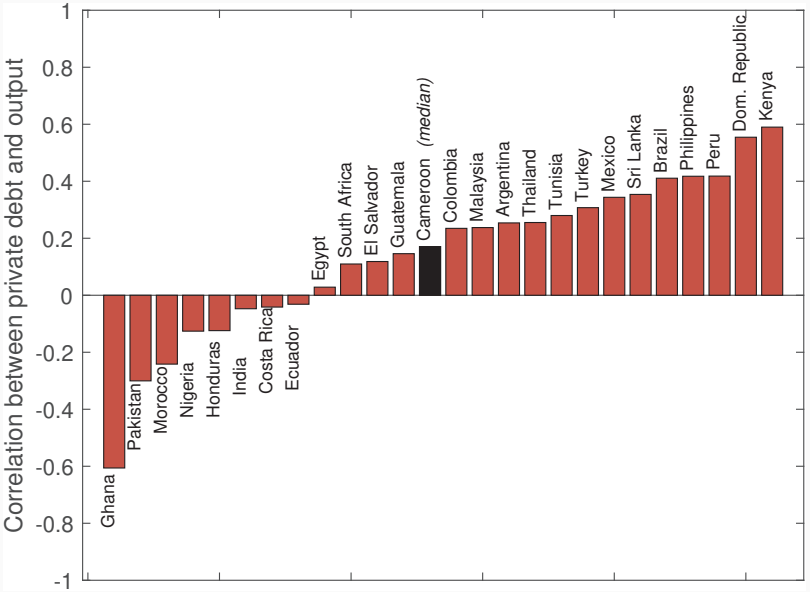
Fact 2: Private External Debt & Foreign Reserves in cross-section

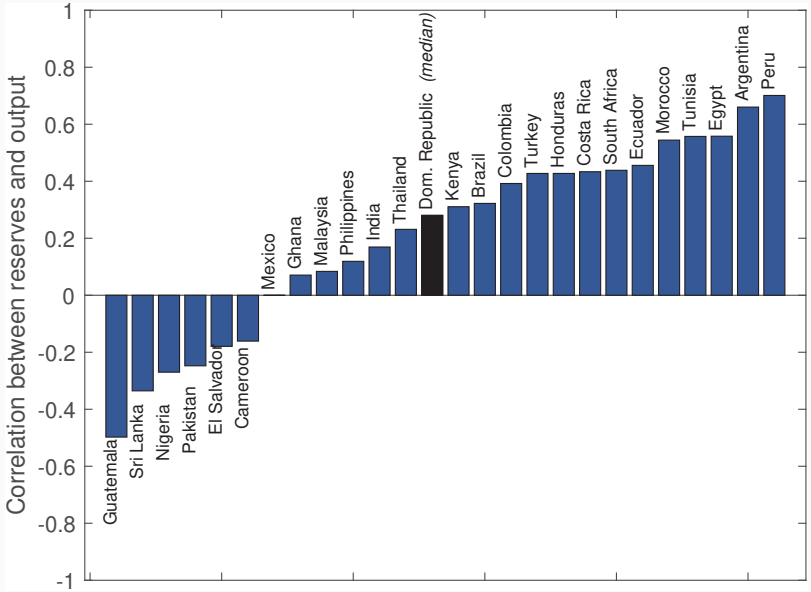


Average private external debt to GDP & average reserves to GDP (1980-2015).

Source: World Bank, Lane and Milesi-Ferretti (2007) ▸ Regression results

Fact 3: Private Debt & Foreign Reserves are procyclical

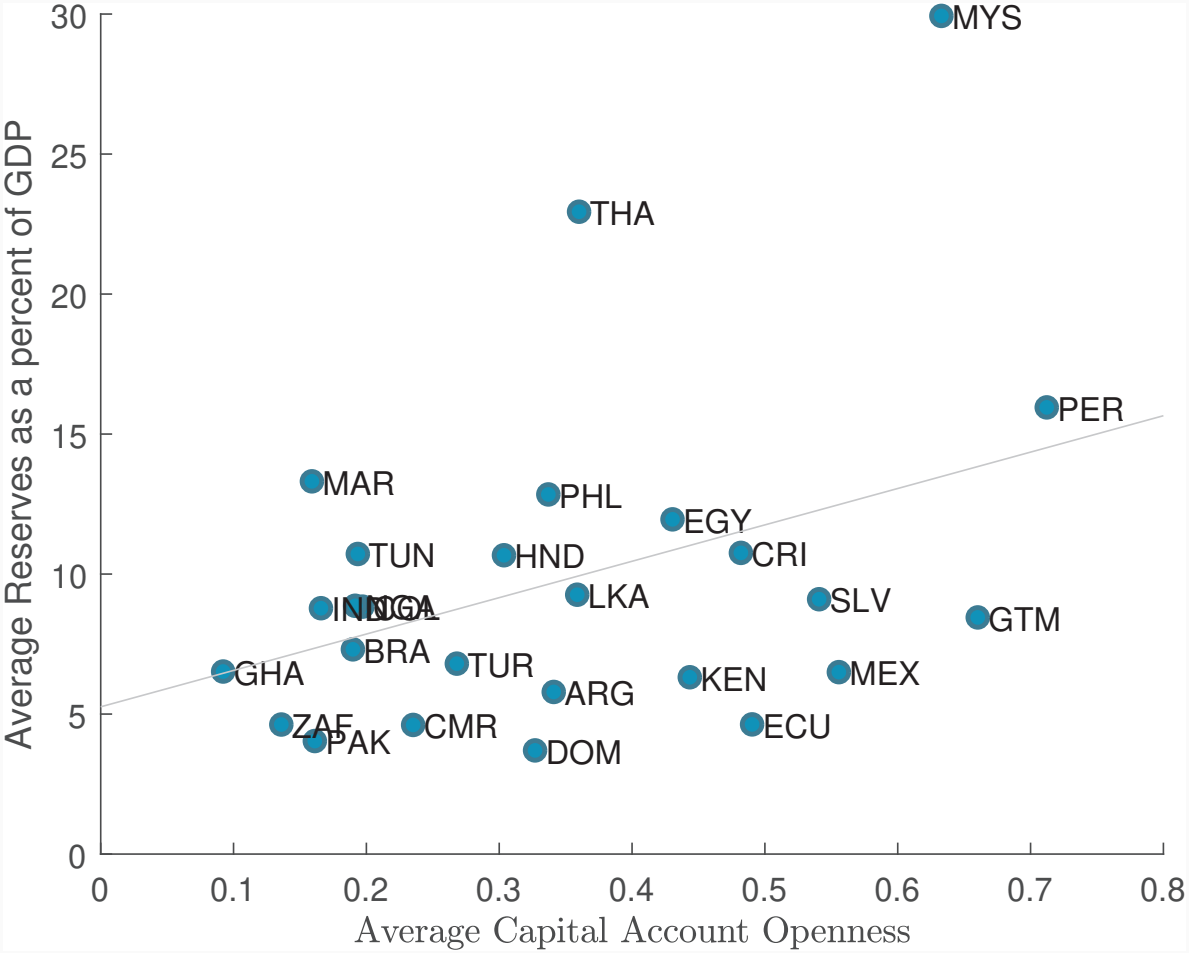




Correlation between the annual growth rates of private debt and reserves and real GDP (2000-2015).

Source: World Bank, International Debt Statistics

Fact 4: Financial Openness & Foreign Reserves



Average Chinn-Ito financial openness index & average reserves to GDP (1980-2015).

Source: Lane and Milesi-Ferretti (2007) and Chinn and Ito (2006)

A Macroprudential Theory of Foreign Reserve Accumulation

- Existing theories of foreign reserve accumulation: insurance against income shocks or government credit market access
  - Heller, 1966, Bianchi, Hatchondo and Martinez, 2018
- Data suggests link between private capital flows and official reserve accumulation
- This paper: A theory of reserve accumulation as a macroprudential policy

Preview

- Model of emerging market crises with pecuniary externalities expanded with reserve accumulation
- Theory: Show that reserve accumulation can implement constrained efficiency
    - Alternative to borrowing taxes/capital controls
- Quantitative analysis consistent with three facts presented:
    - Sizable average levels of reserve and private debt
    - Positive association between gross private debt and foreign reserves
    - Procyclical feature of optimal reserve accumulation policy

Main elements of the model

- Small-open endowment economy with 2 goods: tradables (T) and nontradables (N)
- Debt denominated in units of tradables
- Occasionally binding credit constraint depending on current income, and thus on real exchange rate (Mendoza, 2002)
- Government accumulates foreign reserves, in units of tradables

Households

Choose b_{t+1}, c_t^T, c_t^N to maximize

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

where $u(c(c^T, c^N)) = \frac{c(c^T, c^N)^{1-\sigma}}{1-\sigma}$,
$c(c^T, c^N) = [\omega(c^T)^{-\eta} + (1-\omega)(c^N)^{-\eta}]^{-\frac{1}{\eta}}$ $\eta > -1$, $\omega \in (0,1)$,

subject to budget constraint

$$\frac{b_{t+1}}{R} + c_t^T + p_t^N c_t^N = b_t + y_t^T + p_t^N y^N - T_t,$$

and credit constraint

$$-\frac{b_{t+1}}{R} \leq \kappa_t \left(y_t^T + p_t^N y^N \right).$$

Government

Government accumulates reserves $A \geq 0$ subject to budget constraint

$$\frac{A_{t+1}}{R} = T_t + A_t.$$

Equilibrium conditions

Household optimization

$$p_t^N = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1}$$

$$u_T(t) = \beta R \mathbb{E}_t u_T(t+1) + \mu_t$$

Market clearing for non-tradables

$$c_t^N = y^N$$

Resource constraint for tradables

$$c_t^T + \frac{A_{t+1} + b_{t+1}}{R} = y_t^T + A_t + b_t$$

Competitive equilibrium

Sequence of policies and prices such that:

(i) Households optimize

(ii) Market for non-tradable clears

(iii) Government budget constraint holds

Constrained-efficient planner (Bianchi, 2011)

Planner solves

$$\max_{b_{t+1}, c_t^T} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t),$$

subject to

$$\frac{b_{t+1}}{R} + c_t^T = b_t + y_t^T$$

$$c_t^N = y^N,$$

$$-\frac{b_{t+1}}{R} \leq \kappa_t \left(y_t^T + \overbrace{\frac{1-\omega}{\omega} \left(\frac{c_t^T}{y^N} \right)^{\eta+1}}^{p_t^N} y^N \right)$$

Recursive DE Problem | Recursive CE Problem | Recursive DE Equilibrium | Recursive CE Equilibrium

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Recursive DE Problem | Recursive CE Problem | Recursive DE Equilibrium | Recursive CE Equilibrium

Pecuniary Externality

When credit constraint does not bind

- Intertemporal Euler equation for households

$$u_T(t) = \beta R \mathbb{E}_t u_T(t+1)$$

- Intertemporal Euler equation for planner

$$u_T(t) = \beta R \mathbb{E}_t \left[u_T(t+1) + \mu_{t+1} \Psi_{t+1} \right]$$

with $\Psi_t \equiv \kappa_t (p_t^N c_t^N)/(c_t^T)\,(1+\eta)$.

Decentralization: Reserve Accumulation

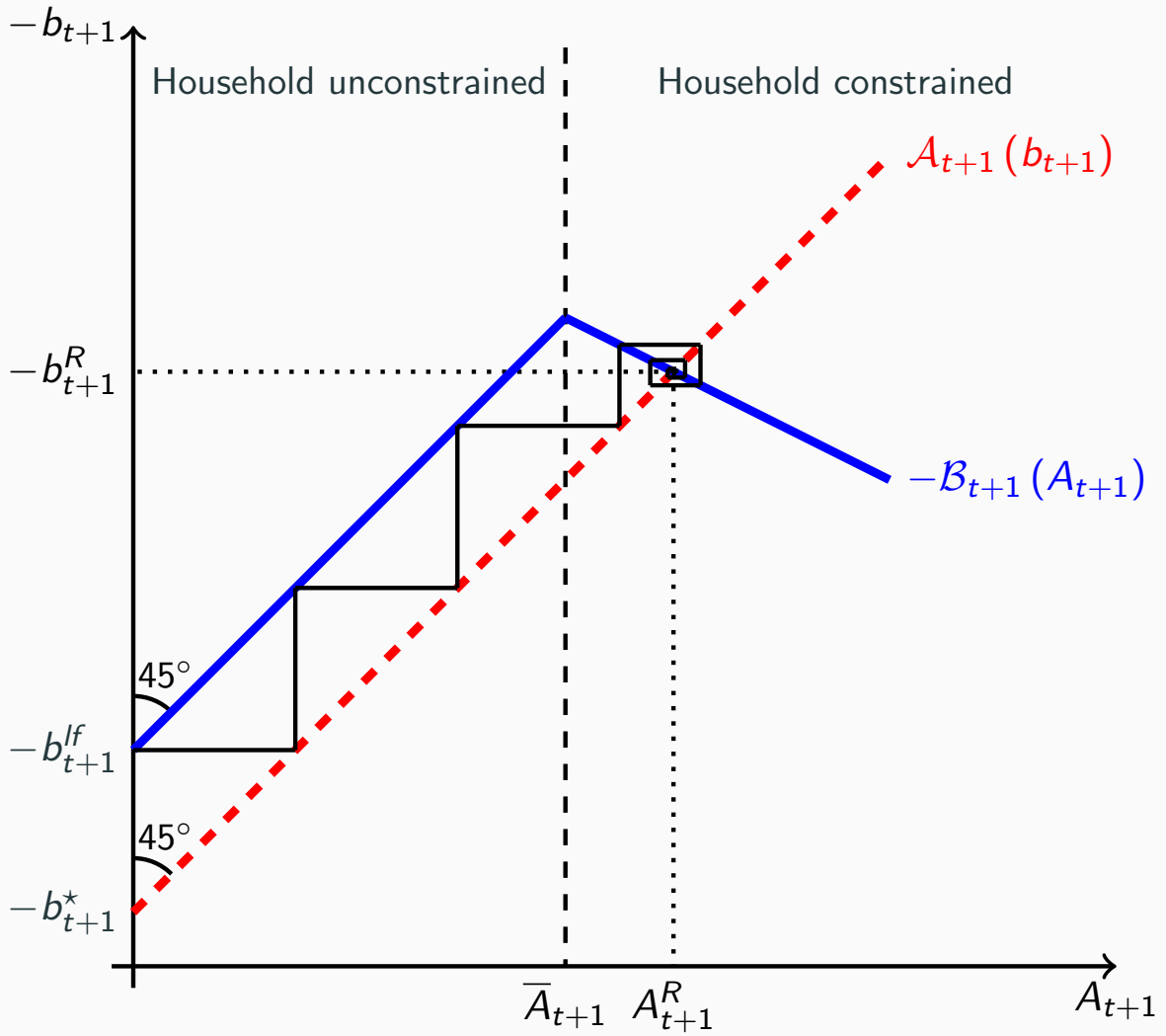
Proposition 1
Constrained efficiency is achieved if government follows reserve policy

$$A_{t+1}^R = b_{t+1}^\star + R\left[A_t^R + b_t - b_t^\star + \kappa\left(y_t^T + p_t^{\star N} y^N\right)\right],$$

in all periods, where $\star$ refer to variables in constrained-efficient allocation.

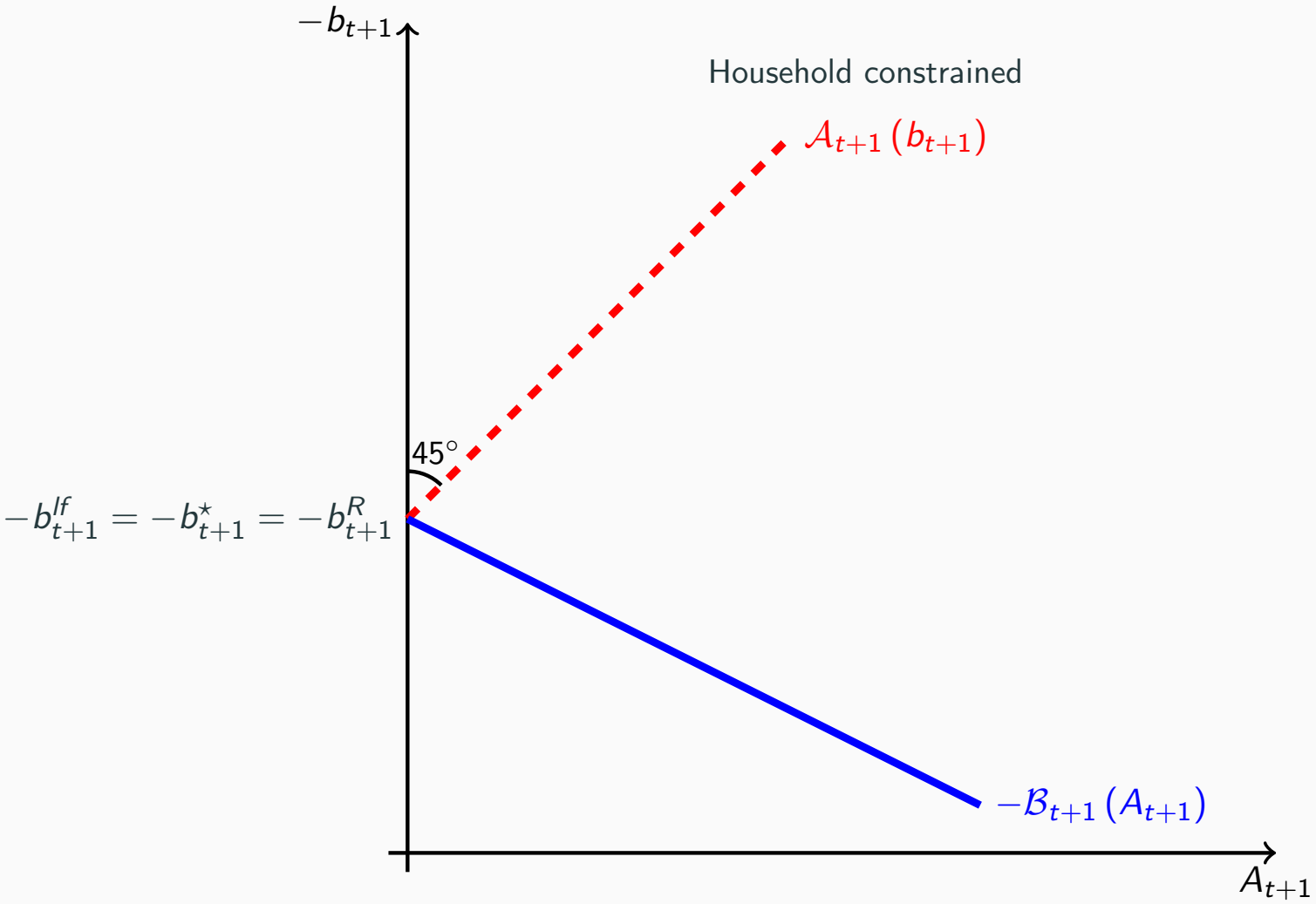
A technical condition that guarantees this result is that a unitary elasticity of substitution between T-NT and $\kappa(1-\omega) < 1$, but logic applies more broadly

Illustration of Implementation



Implementation when private households are unconstrained in the absence of reserve accumulation.

Illustration of Implementation (when constraint binds)



Implementation when private households are constrained in the absence of reserve accumulation.

Quantitative Analysis: Calibration

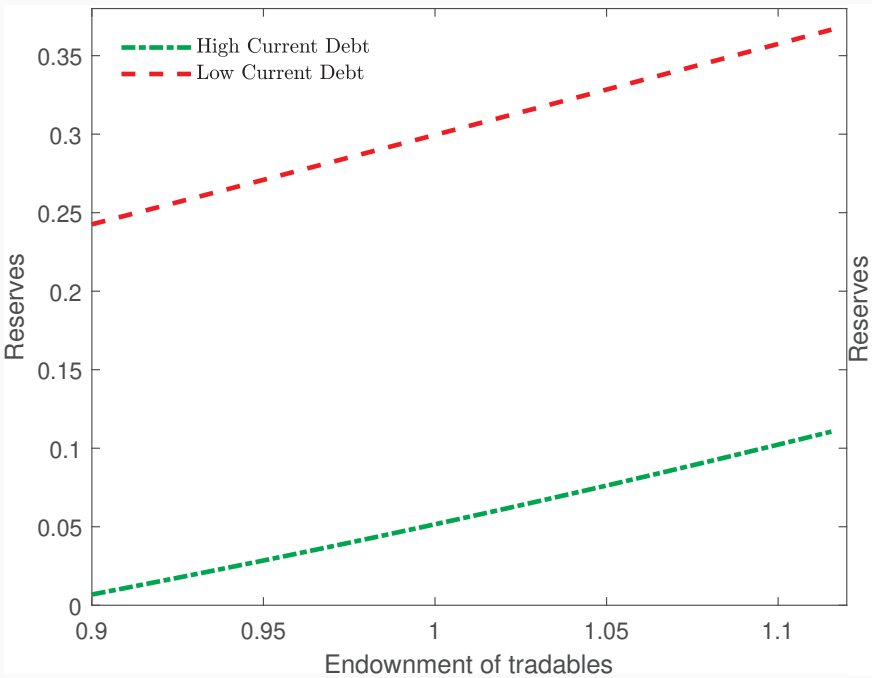
Calibration for Mexico, assuming laissez-faire for period 1970-2000.

	Value	Source/Targets
Interest rate	$r = 0.04$	Standard value
Risk aversion	$\sigma = 2$	Standard value
Elasticity of substitution	$1/(1+\eta) = 0.83$	Standard value
Weight tradables in CES	$\omega = 0.45$	Share of tradable output=45%
Discount factor	$\beta = 0.93$	Average NFA-GDP ratio $= -32.0\%$
Financial shock mean	$\bar{\kappa} = 0.35$	Frequency of crises $= 5.1\%$
Financial shock variance	$\sigma_\kappa = 0.033$	Std dev of CA/GDP $= 2.3\%$

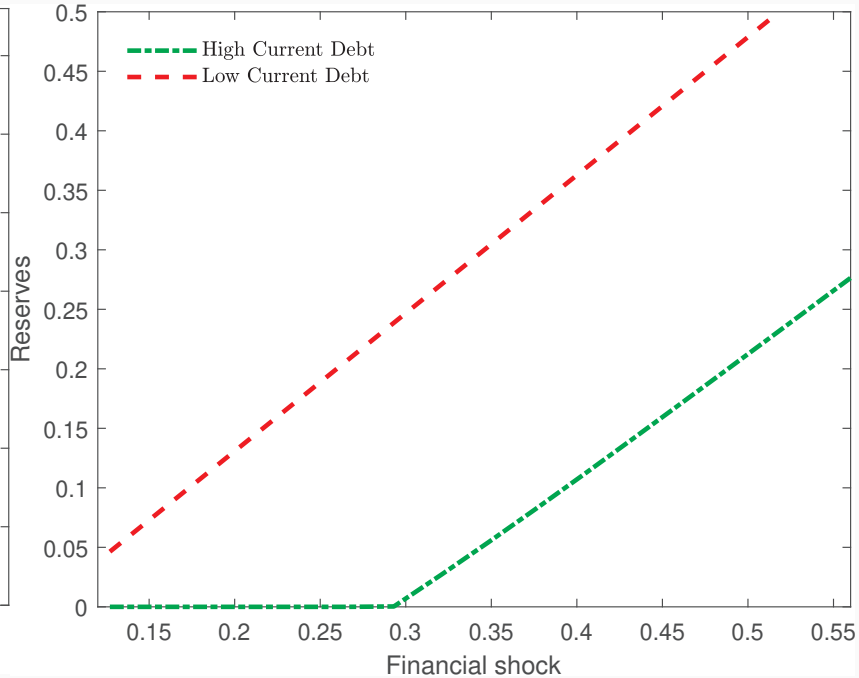
Quantitative Analysis: Reserve Policy

Government optimally accumulates more reserves

- the higher income,
- the laxer the financing conditions,
- the lower current debt.

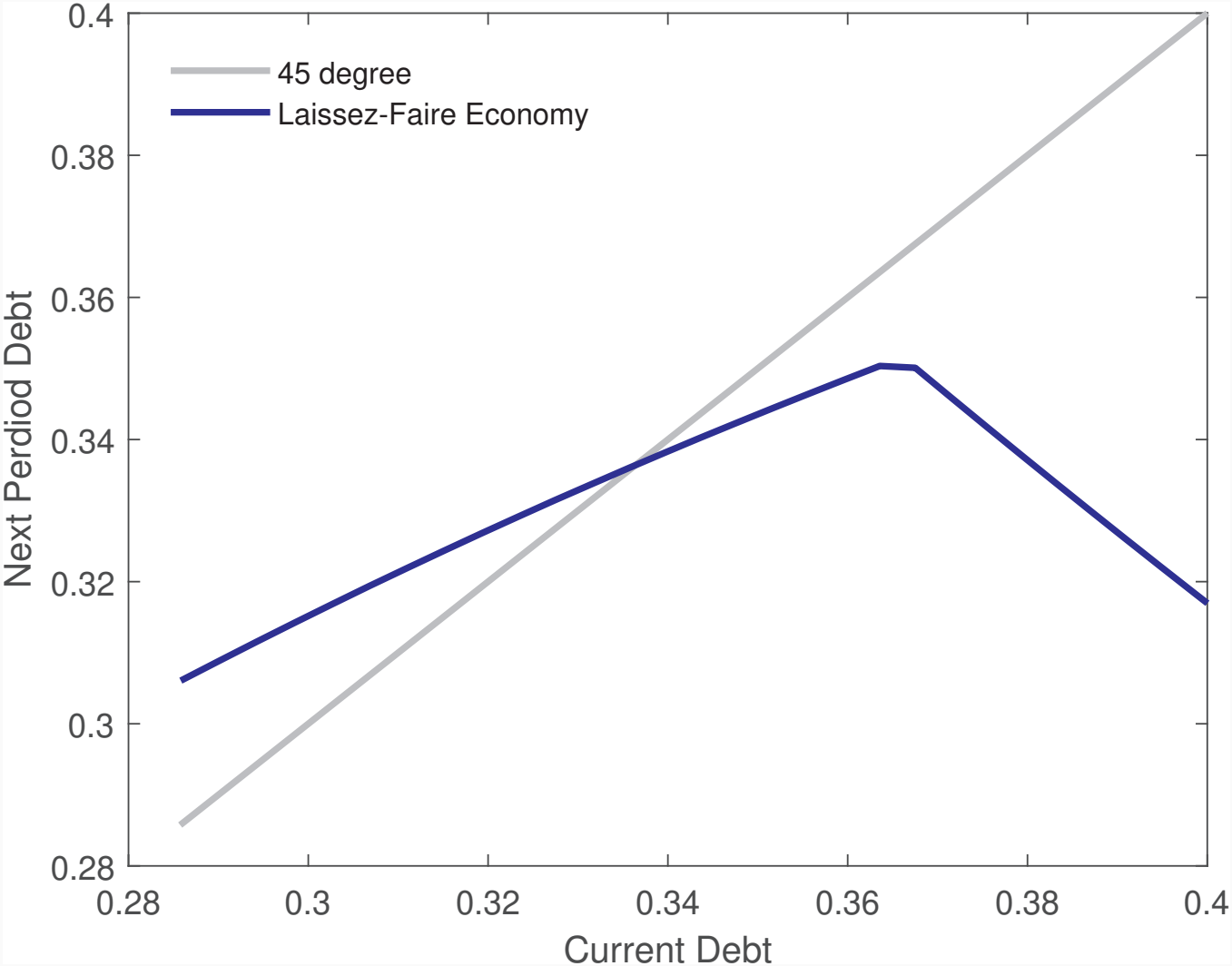


(a) Wrt income.



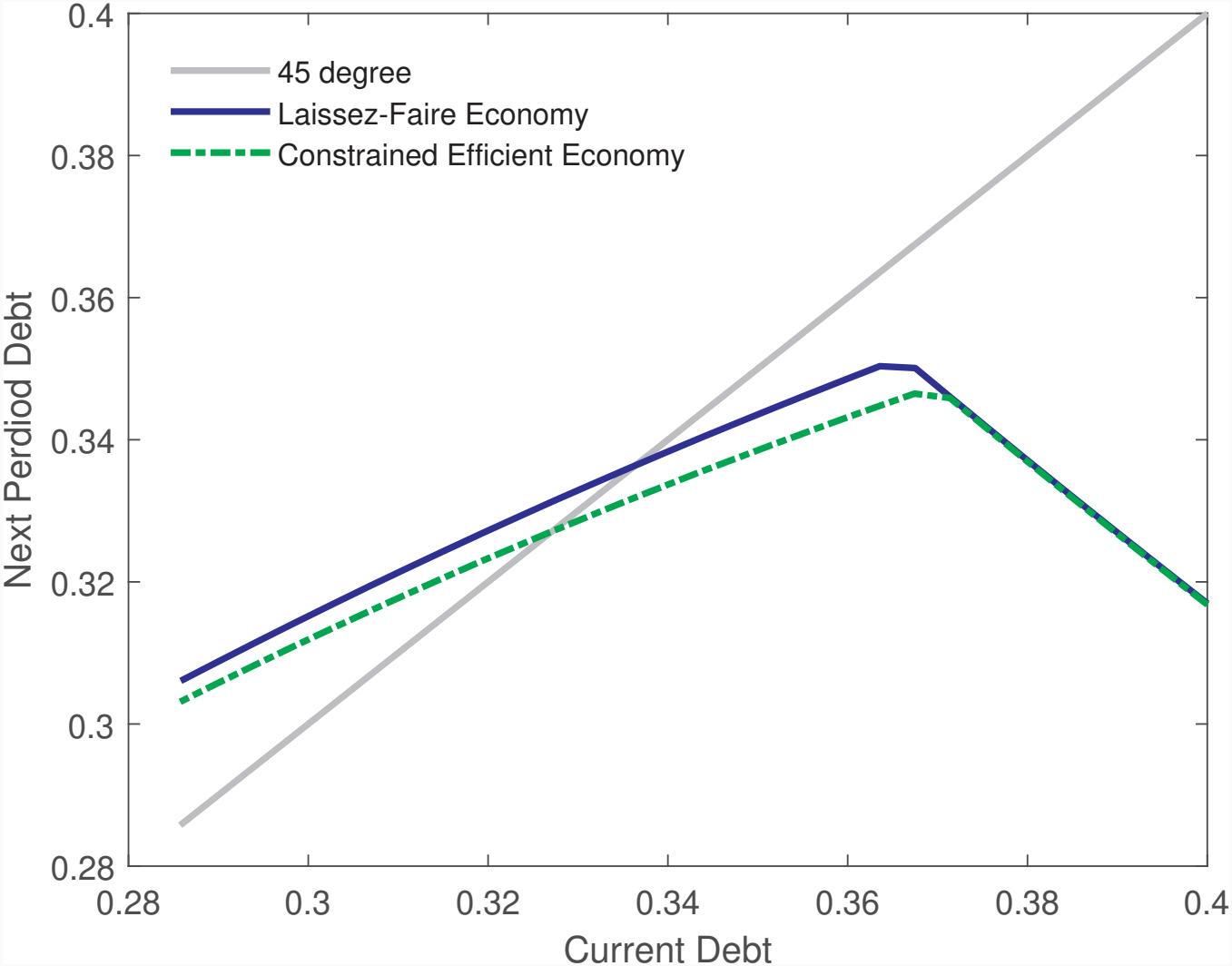
(b) Wrt financing conditions.

Quantitative Analysis: Reserve & Overborrowing



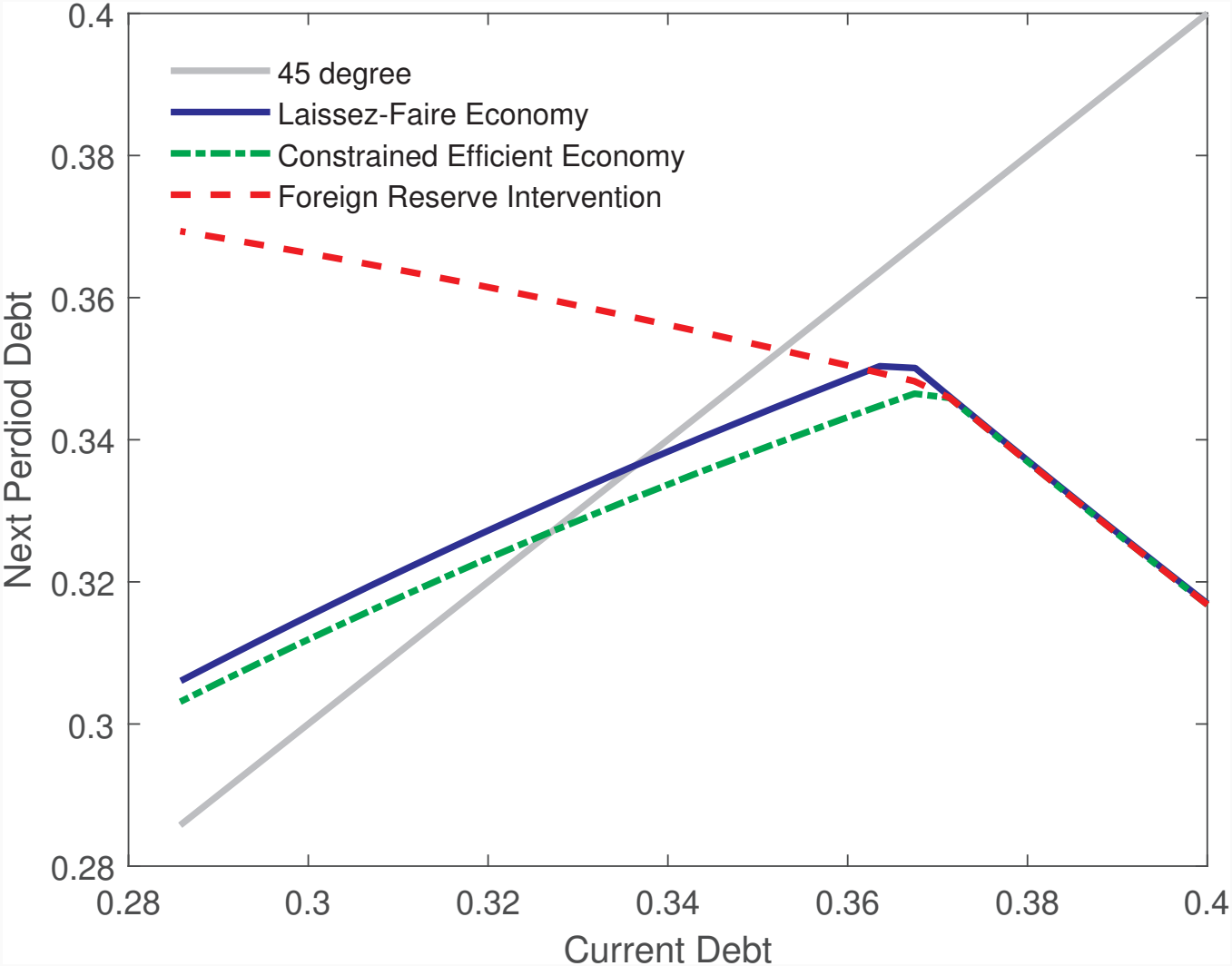
Private external debt choice as function of current external debt.

Quantitative Analysis: Reserve & Overborrowing



Private external debt choice as function of current external debt.

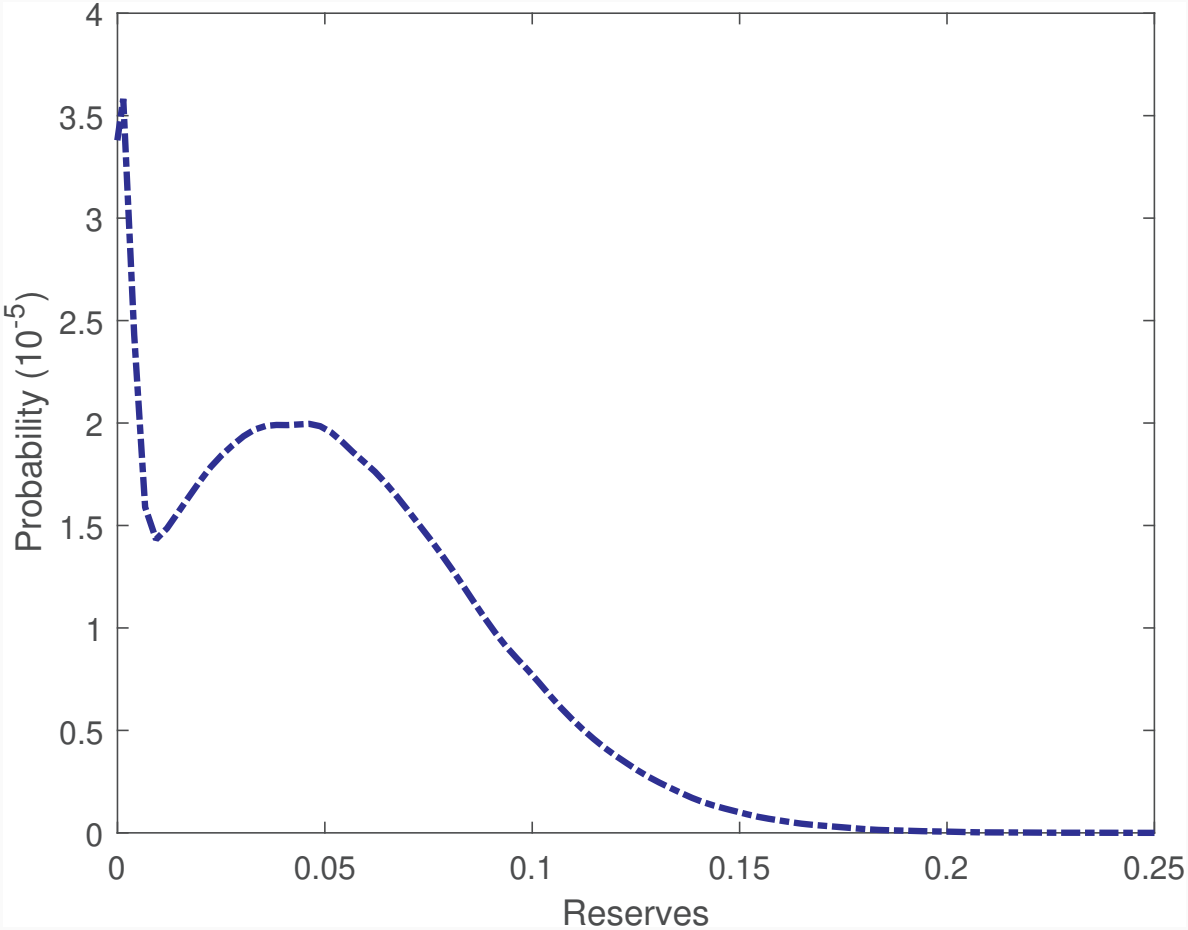
Quantitative Analysis: Reserve & Overborrowing



Private external debt choice as function of current external debt.

Quantitative Analysis: Long-run Distribution of Reserves

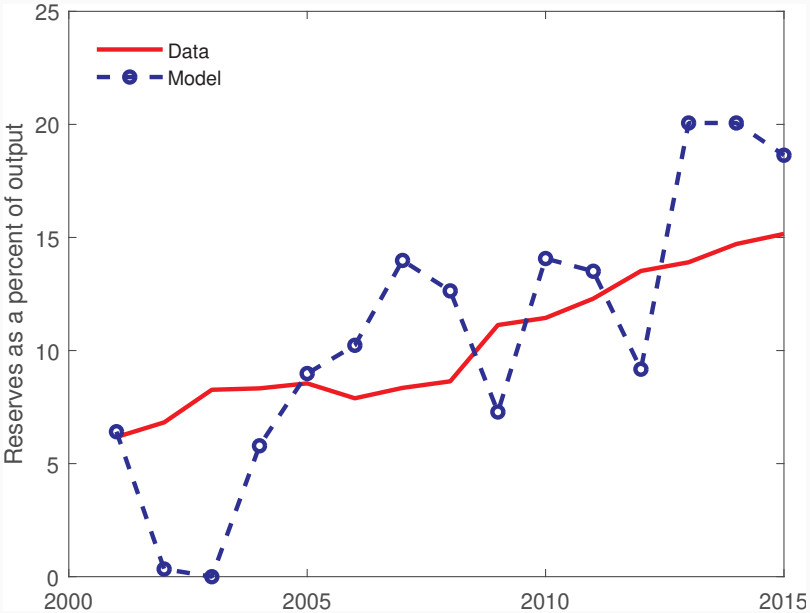
In simulations, long-run mean of reserves (to GDP) is 4.8%, vs 10.3% in 2001-2015 Mexican data



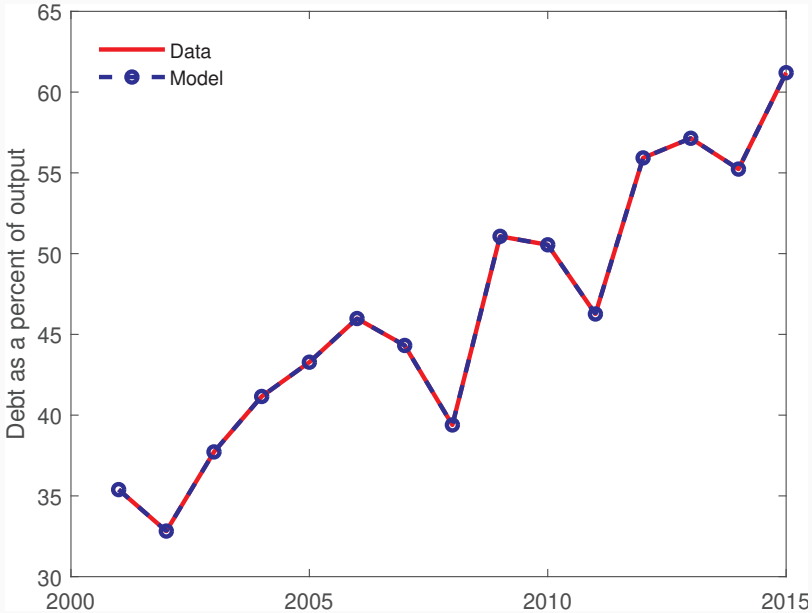
Ergodic distribution of reserves.

Quantitative Analysis: Accounting for Observed Reserve Holdings in Mexico (2001-2015)

Experiment: suppose Mexico in laissez-faire until 2000, feed observed income shocks, financial shocks to replicate private debt path for 2001-2015, what does reserve path look like?



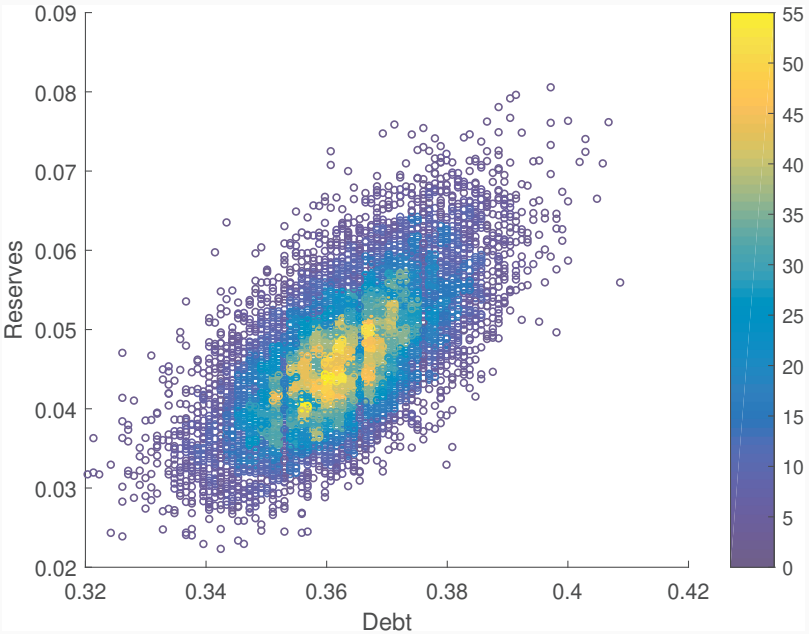
(a) Path of reserves.



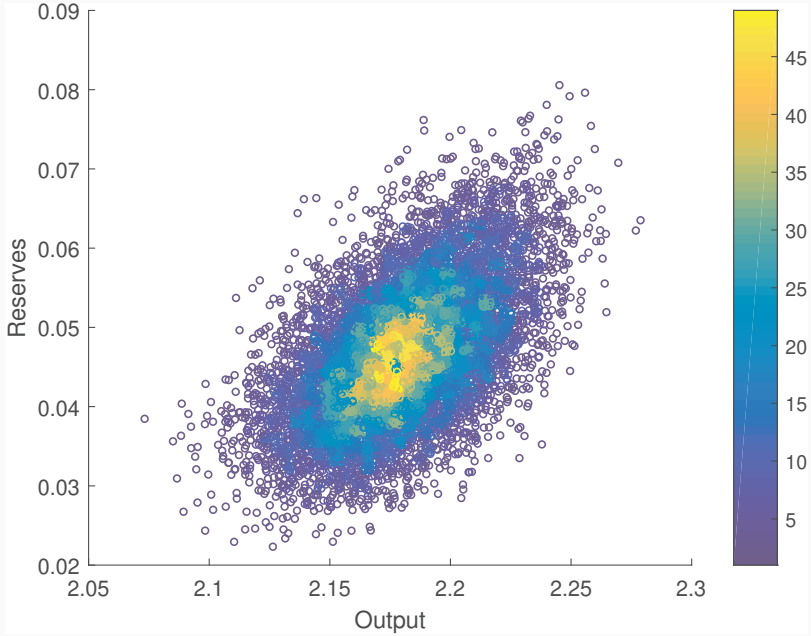
(b) Path of private debt.

Quantitative Analysis: Cross-sectional Implications

Experiment: simulate large number (30,000) of samples of 30 years each, compute average debt, average reserves and average output for each sample



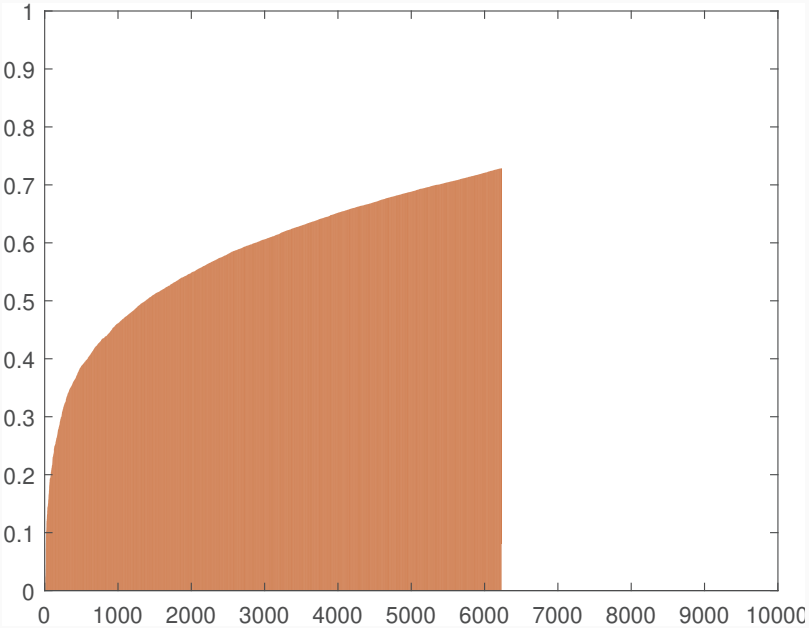
(a) Reserves and private debt.



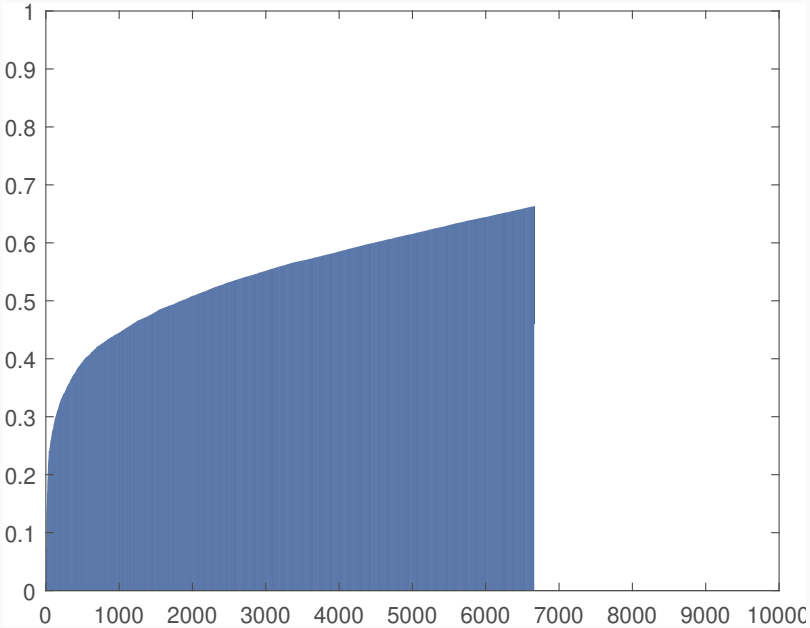
(b) Reserves and output.

Quantitative Analysis: Correlations in the Cross-section

Correlations between log changes in output, debt, and reserves



(a) Private debt and output



(b) Reserves and output

▸ Fact 4: Reserves vs Taxes on debt

Conclusion

- Propose new theory of reserve accumulation based on a macroprudential motive
- Theory can account for
  - sizable reserve holding,
  - increasing reserves post EM crisis episodes of the 1990s,
  - positive association between reserves and private external debt,
  - positive correlation between accumulation of reserves and private external debt and real GDP growth

Details

- Data source: International Debt Statistics from the World Bank.
- Private external debt is non-publicly guaranteed external debt.
- Country list (26): Argentina, Brazil, Cameroon, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Ghana, Guatemala, Honduras, India, Kenya, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Peru, Philippines, South Africa, Sri Lanka, Thailand, Tunisia and Turkey.

▸ Back

Regressions results (Fact 2)

Table 1: Panel regressions of Reserves to GDP on Private External Debt to GDP (in logs)

	Reserves	Reserves	Reserves	Reserves
Private External Debt	0.183***	0.176***	0.0526***	0.0553***
	(0.0237)	(0.0227)	(0.0203)	(0.0207)
Publicly Guaranteed Debt		−0.450***		-0.0379
		(0.0480)		(0.0541)
GDP Growth Rate		0.00254		-0.000146
		(0.00194)		(0.00175)
Constant	1.691***	3.118***	1.027***	1.139***
	(0.117)	(0.193)	(0.138)	(0.210)
Observations	874	874	874	874
Countries	26	26	26	26
Pooled OLS/ Fixed Effects	Pooled	Pooled	FE	FE

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

▸ Back

Recursive decentralized problem

Given exogenous state $s = (y^T, \kappa)$, household solves:

$$V^R(b, B, A, s) = \max_{b', c^T, c^N} \frac{c(c^T, c^N)^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_{s'|s} V^R(b', B', A', s')$$

Subject to:

$$b' + c^T + p^N(B, A, s)c^N = y^T + p^N(B, A, s)y^N + Rb + T(B, A, s)$$

$$b' \geq -\kappa(y^T + p^N(B, A, s)y^N)$$

$$B' = \Gamma(B, A, s); \qquad A' = \Lambda(B, A, s)$$

Government chooses A' to maximize household's welfare taking its policy functions as given Back

Recursive constrained efficient problem

Given exogenous state $s = (y^T, \kappa)$, the planner solves::

$$V^\star(b, s) = \max_{b', c^T} \frac{c(c^T, y^N)^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_{s'|s} V^\star(b', s)$$

Subject to:

$$c(c^T, y^N) = [\omega (c^T)^{-\eta} + (1-\omega)(y^N)^{-\eta}]^{\frac{-1}{\eta}}$$

$$b' + c^T = y^T + Rb$$

$$b' \geq -\kappa (y^T + \frac{(1-\omega)}{\omega} (\frac{c^T}{y^N})^{\eta+1} y^N)$$

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Recursive Decentralized Equilibrium

A decentralized Recursive Decentralized Equilibrium is a list of:

1. A pricing function $p^N(B, A, s)$
2. A perceived law of motion $\Gamma(B, A, s)$
3. A law of motion of $\Lambda(B, A, s)$
4. Decision rules:

   $\hat{b}'(b, B, A, s), \hat{c}^N(b, B, A, s), \hat{c}^T(b, B, A, s), \hat{A}'(B, A, s)$

5. A value function $\hat{V}^R(b, B, A, s)$

Recursive Decentralized Equilibrium

Such that:

1. Given p, Γ, A, the value and policy functions, $\hat{V^R}, \hat{b'}, \hat{c}^N$ and $\hat{c}^T$, solve the household's problem

2. The households policy function $\hat{b'}$ is consistent with Γ

3. The government policy function $\hat{A'}$ is consistent wit Λ

4. Markets clear : $$y^N = \hat{c}^N(b, B, A, s)$$

$$y^T + RB + RA = \hat{c}^T(b, B, A, s) + \Gamma(B, A, s) + \Lambda(B, A, s)$$

Back

Recursive Constrained Efficient Equilibrium

A Recursive Constrained Efficient Equilibrium is a list of:

1. Decision rules: $\tilde{b}'(b,s), \tilde{c}^N(b,s), \tilde{c}^T(b,s)$
2. A value function $\tilde{V}^\star(b,s)$

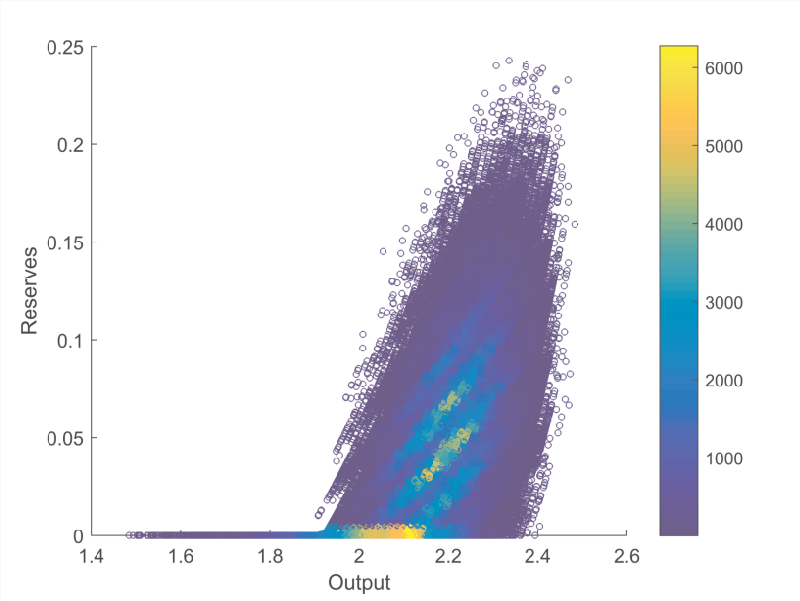
Such that:

1. The value and policy functions, $\tilde{V}^\star, \tilde{b}', \tilde{c}^N$ and $\tilde{c}^T$, solve the planner's problem
2. Markets clear : $y^N = \tilde{c}^N(b,s)$
   $y^T + Rb = \tilde{c}^T(b,s) + \tilde{b}'(b,s)$

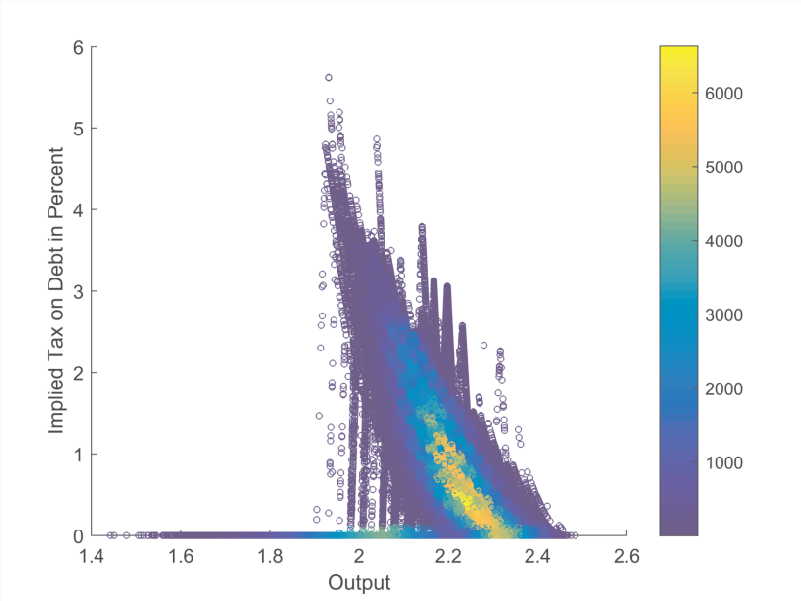
Back

Quantitative Analysis: Long rung simulations and equivalent tax on debt

Long run distribution of reserves and output. Reserves are procyclical, taxes are counter cyclical



(a) Reserves and output



(b) Tax on debt and output.

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