Reserve Accumulation and the Currency Composition of Sovereign Debt

Francisco Roldán
IMF

César Sosa-Padilla
Notre Dame

December 2021

A puzzle in risk

Three facts

1. International reserves help central banks hedge risks
2. Local-currency debt mitigates risks by promising lower real payments in bad times
3. Countries which issue LC debt also hold more reserves

How to make sense of this?

A puzzle in risk

Three facts

1. International reserves help central banks hedge risks
2. Local-currency debt mitigates risks by promising lower real payments in bad times
3. Countries which issue LC debt also hold more reserves

How to make sense of this?

Local currency debt is a two-edged sword

Two effects

LC debt reacts to RER

- RER depreciates in recessions
- $\implies$ LC debt builds in state-contingency

Gov't can affect RER

- Planner modulates demand
- $\implies$ LC debt boosts these incentives

- Affecting the RER costly: prefer to pay with reserves
- Affecting the RER costly ex-ante: prefer to accumulate reserves

Local currency debt is a two-edged sword

Two effects

LC debt reacts to RER

- RER depreciates in recessions
- $\implies$ LC debt builds in state-contingency

Gov't can affect RER

- Planner modulates demand
- $\implies$ LC debt boosts these incentives

- Affecting the RER costly: prefer to pay with reserves
- Affecting the RER costly ex-ante: prefer to accumulate reserves

Local currency debt is a two-edged sword

Two effects

LC debt reacts to RER

- RER depreciates in recessions
- $\implies$ LC debt builds in state-contingency

Gov't can affect RER

- Planner modulates demand
- $\implies$ LC debt boosts these incentives

- Affecting the RER costly: prefer to pay with reserves
- Affecting the RER costly ex-ante: prefer to accumulate reserves

A model of LC sovereign debt and reserves

Ingredients

- Small-open economy borrowing from RoW
- Two-sector structure, nominal rigidities
  - Aggregate-demand externality
  - Modulate labor demand (in all sectors) through consumption (of tradables)
- Government issues long-term debt, accumulates reserves
- No commitment to (*i*) repayment, (*ii*) future borrowing decisions

- Debt in domestic or foreign currency

- Compare with *synthetic* LC debt

A model of LC sovereign debt and reserves

Ingredients

- Small-open economy borrowing from RoW
- Two-sector structure, nominal rigidities
  - Aggregate-demand externality
  - Modulate labor demand (in all sectors) through consumption (of tradables)
- Government issues long-term debt, accumulates reserves
- No commitment to (*i*) repayment, (*ii*) future borrowing decisions

- Debt in domestic or foreign currency

- Compare with *synthetic* LC debt

A model of LC sovereign debt and reserves

Ingredients

- Small-open economy borrowing from RoW
- Two-sector structure, nominal rigidities
  - Aggregate-demand externality
  - Modulate labor demand (in all sectors) through consumption (of tradables)
- Government issues long-term debt, accumulates reserves
- No commitment to (*i*) repayment, (*ii*) future borrowing decisions
- Debt in domestic or foreign currency
- Compare with *synthetic* LC debt

Main findings

1. Significant reserve holdings to curtail time-inconsistency
    - Synthetic LC debt issuer holds twice as many reserves as LC debt issuer
2. Incentives vs. insurance
    - FC debt $\rightarrow$ LC debt $\sim$ 0.15% of permanent consumption
    - 0.46% to move to *synthetic* LC debt

Relation to the literature

- **Sovereign debt and default with nominal rigidities**
  - Bianchi, Ottonello, and Presno (2020); Anzoategui (2020); Roldán (2020); Arellano, Bai, and Mihalache (2020)
- **Reserves for macroeconomic stabilization**
  - Bianchi and Sosa-Padilla (2020); Sosa-Padilla and Sturzenegger (2021)
- **Currency composition of sovereign debt**
  - Ottonello and Perez (2019); Engel and Park (2018); Korinek (2009); Fanelli (2017); Du, Pflueger, and Schreger (2019)

Roadmap

Evidence

Model

Quantitative Results

- Synthetic Debt

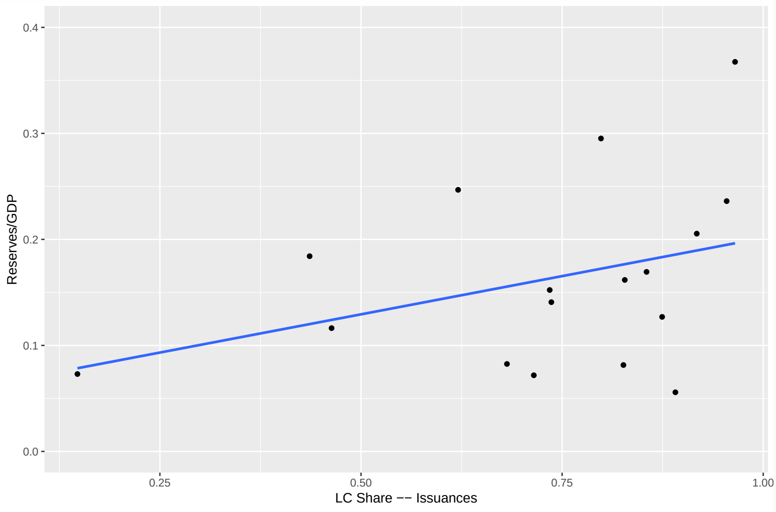
Concluding Remarks

Evidence

Local currency debt and reserves

Local currency share of debt issued from Ottonello and Perez (2019)

FX reserve holdings from IFS



Model

Two-sector small-open economy structure

Supply

- Traded goods
  - Exogenous endowment $y_T = \exp(z)$, can be exported/imported

$$z' = \rho_z z + (1 - \rho_z)\mu_z + \sigma_z \epsilon'$$

with $\epsilon \overset{iid}{\sim} \mathcal{N}(0, 1)$

- Nontraded goods, produced

$$y_N = h^\alpha$$

with labor supply h (inelastic up to $\bar{h}$) $= 1$

Demand

- Households consume both goods
  - Standard CRRA preferences $\frac{c^{1-\gamma}-1}{1-\gamma}$
  - CES aggregator

$$c = \mathcal{C}(c_N, c_T) = \left[\varpi_N c_N^{-\eta} + \varpi_T c_T^{-\eta}\right]^{-\frac{1}{\eta}}$$

- Intratemporal FOC gives relative price

$$p_N = \frac{\varpi_N}{\varpi_T}\left(\frac{c_T}{c_N}\right)^{1+\eta} p_T$$

with $p_T = 1$

Two-sector small-open economy structure

Supply

- Traded goods
  - Exogenous endowment $y_T = \exp(z)$, can be exported/imported

$$z' = \rho_z z + (1 - \rho_z)\mu_z + \sigma_z \epsilon'$$

with $\epsilon \overset{iid}{\sim} \mathcal{N}(0, 1)$

- Nontraded goods, produced

$$y_N = h^\alpha$$

with labor supply h (inelastic up to $\bar{h}$) $= 1$

Demand

- Households consume both goods
  - Standard CRRA preferences $\frac{c^{1-\gamma}-1}{1-\gamma}$
  - CES aggregator

$$c = \mathcal{C}(c_N, c_T) = \left[\varpi_N c_N^{-\eta} + \varpi_T c_T^{-\eta}\right]^{-\frac{1}{\eta}}$$

- Intratemporal FOC gives relative price

$$p_N = \frac{\varpi_N}{\varpi_T}\left(\frac{c_T}{c_N}\right)^{1+\eta} p_T$$

with $p_T = 1$

Aggregate Demand

Aggregate constraint: $w \geq \bar{w}$

- Labor demand of firms

$$p_N \underbrace{F'(h)}_{=\alpha h^{\alpha-1}} = w$$

- In equilibrium, $c_N = y_N$, and

$$h \leq \left(\frac{\varpi_N}{\varpi_T} \frac{\alpha}{\bar{w}} \right)^{\frac{1}{1+\alpha\eta}} c_T^{\frac{1+\eta}{1+\alpha\eta}} = \mathcal{H}(c_T, \bar{w})$$

Aggregate Demand

Aggregate constraint: $w \geq \bar{w}$

- Labor demand of firms

$$p_N \underbrace{F'(h)}_{=\alpha h^{\alpha-1}} = w$$

- In equilibrium, $c_N = y_N$, and

$$h \leq \left(\frac{\varpi_N}{\varpi_T} \frac{\alpha}{\bar{w}} \right)^{\frac{1}{1+\alpha\eta}} c_T^{\frac{1+\eta}{1+\alpha\eta}} = H(c_T, \bar{w})$$

Aggregate Demand

Aggregate constraint: $w \geq \bar{w}$

- Labor demand of firms

$$p_N \underbrace{F'(h)}_{=\alpha h^{\alpha-1}} = w$$

- In equilibrium, $c_N = y_N$, and

$$h \leq \left(\frac{\varpi_N}{\varpi_T} \frac{\alpha}{\bar{w}} \right)^{\frac{1}{1+\alpha\eta}} c_T^{\frac{1+\eta}{1+\alpha\eta}} = \mathcal{H}(c_T, \bar{w})$$

Aggregate Demand

Aggregate constraint: $w \geq \bar{w}$

- Labor demand of firms

$$p_N \underbrace{F'(h)}_{=\alpha h^{\alpha-1}} = w$$

- In equilibrium, $c_N = y_N$, and

$$h \leq \left(\frac{\varpi_N}{\varpi_T} \frac{\alpha}{\bar{w}} \right)^{\frac{1}{1+\alpha\eta}} c_T^{\frac{1+\eta}{1+\alpha\eta}} = \mathcal{H}(c_T, \bar{w})$$

Debt

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

Debt

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

Debt

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

Debt

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

Debt

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

Debt

Geometrically decaying coupons with currency

- One unit of (face value) debt issued at t promises payments
  - $\kappa(s)$ in $t+1$, state s
  - $(1-\delta)\kappa(s)$ in $t+2$
  - $(1-\delta)^2\kappa(s)$ in $t+3$
  - ...
  - $(1-\delta)^{k-1}\kappa(s)$ in $t+k$
- Debt issued yesterday $=$ $(1-\delta)$ of debt issued today
- Currency of denomination

$$\kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)$$

The planner's problem: modulation of aggregate demand

- In repayment

$$V^R(b,a,s) = \max_{b',a'} u(c_T, F(h)) + \beta \mathbb{E}\left[\mathcal{V}(b',a',s')\right]$$

$$\begin{aligned}\text{subject to} \quad & c_T + q_a a' + \kappa(s) b = a + y_T(s) + q_b(b',a',s)(b' - (1-\delta)b) \\ & h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\} \\ & \kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big)\end{aligned}$$

- In default

$$V^D(b,a,s) = \max_{a'} u(c_T, F(h)) - \varphi(y_T(s)) + \beta \mathbb{E}\left[\theta \mathcal{V}(b,a',s') + (1-\theta) V^D(b,a',s')\right]$$

$$\begin{aligned}\text{subject to} \quad & c_T + q_a a' = a + y_T(s) \\ & h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\}\end{aligned}$$

The planner's problem: modulation of aggregate demand

- In repayment

$$V^R(b,a,s) = \max_{b',a'} u(c_T, F(h)) + \beta\mathbb{E}\left[\mathcal{V}(b',a',s')\right]$$

$$\begin{aligned} \text{subject to} \quad & c_T + q_a a' + \kappa(s)b = a + y_T(s) + q_b(b',a',s)(b' - (1-\delta)b) \\ & h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\} \\ & \kappa(s) = (r+\delta)\Big(\xi + (1-\xi)p_N(s)\Big) \end{aligned}$$

- In default

$$V^D(b,a,s) = \max_{a'} u(c_T, F(h)) - \varphi(y_T(s)) + \beta\mathbb{E}\left[\theta\mathcal{V}(b,a',s') + (1-\theta)V^D(b,a',s')\right]$$

$$\begin{aligned} \text{subject to} \quad & c_T + q_a a' = a + y_T(s) \\ & h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\} \end{aligned}$$

The planner's problem: modulation of aggregate demand

- In repayment

$$V^R(b,a,s) = \max_{b',a'} u(c_T, F(h)) + \beta \mathbb{E}\left[\mathcal{V}(b',a',s')\right]$$

$$\begin{aligned} \text{subject to} \quad & c_T + q_a a' + \kappa(s) b = a + y_T(s) + q_b(b',a',s)(b' - (1-\delta)b) \\ & h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\} \\ & \kappa(s) = (r+\delta)\left(\xi + (1-\xi)\left(\frac{\varpi_N}{\varpi_T}\left(\frac{c_T}{F(h)}\right)^{1+\eta}\right)\right) \end{aligned}$$

- In default

$$V^D(b,a,s) = \max_{a'} u(c_T, F(h)) - \varphi(y_T(s)) + \beta \mathbb{E}\left[\theta \mathcal{V}(b,a',s') + (1-\theta) V^D(b,a',s')\right]$$

$$\begin{aligned} \text{subject to} \quad & c_T + q_a a' = a + y_T(s) \\ & h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\} \end{aligned}$$

The planner's problem: modulation of aggregate demand

- In repayment

$$
\begin{aligned}
V^R(b,a,s) &= \max_{b',a'} u(c_T, F(h)) + \beta \mathbb{E}\left[\mathcal{V}(b',a',s')\right] \\
\text{subject to} \quad & c_T + q_a a' + \kappa(s) b = a + y_T(s) + q_b(b',a',s)(b' - (1-\delta)b) \\
& h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\} \\
& \kappa(s) = (r+\delta)\left(\xi + (1-\xi)\left(\frac{\varpi_N}{\varpi_T}\left(\frac{c_T}{F(h)}\right)^{1+\eta}\right)\right)
\end{aligned}
$$

- In default

$$
\begin{aligned}
V^D(b,a,s) &= \max_{a'} u(c_T, F(h)) - \varphi(y_T(s)) + \beta \mathbb{E}\left[\theta \mathcal{V}(b,a',s') + (1-\theta) V^D(b,a',s')\right] \\
\text{subject to} \quad & c_T + q_a a' = a + y_T(s) \\
& h = \min\left\{1, \mathcal{H}(c_T, \bar{w})\right\}
\end{aligned}
$$

The planner's problem: choosing default

Planner receives *iid* EV1 preference shocks for repayment and default so that

$$\mathcal{P}(b, a, \mathsf{s}) = \frac{\exp(V^D((1-\hbar)b, a, \mathsf{s})/\sigma_V)}{\exp(V^D((1-\hbar)b, a, \mathsf{s})/\sigma_V) + \exp(V^R(b, a, \mathsf{s})/\sigma_V)}$$

and

$$\begin{aligned}\mathcal{V}(b, a, \mathsf{s}) &= \max\left\{V^R(b, a, \mathsf{s}) + \epsilon_R, V^D((1-\hbar)b, a, \mathsf{s}) + \epsilon_D\right\} \\ &= \sigma_V \log\left[\exp\left(V^R(b, a, \mathsf{s})/\sigma_V\right) + \exp\left(V^D((1-\hbar)b, a, \mathsf{s})/\sigma_V\right)\right]\end{aligned}$$

Foreign lenders

Risk-averse lenders with stochastic discount factor

$$m(s, s') = \exp\left(-r - \nu(\psi\epsilon' + 0.5\psi^2\sigma_\epsilon^2)\right)$$

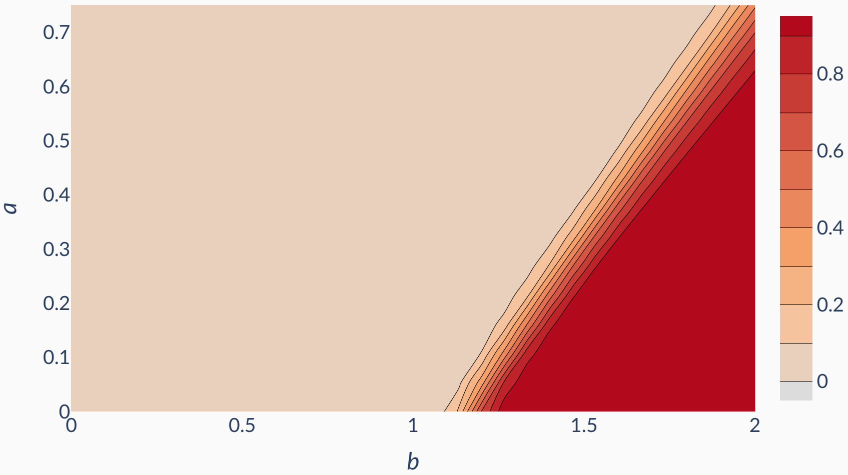
- ν follows a Markov chain with support $\{0, 1\}$
- ϵ is the innovation in tradable output

Price bonds as

$$q_b(b', a', s) = \mathbb{E}\left[m(s, s')\left(\mathbb{1}_{\mathcal{D}'}(1 - \hbar)q_b^D((1 - \hbar)b', a'', s') + (1 - \mathbb{1}_{\mathcal{D}'})(\kappa(s') + (1 - \delta)q_b(b'', a'', s'))\right)\right]$$

Quantitative Results

Default Sets



Price of Debt

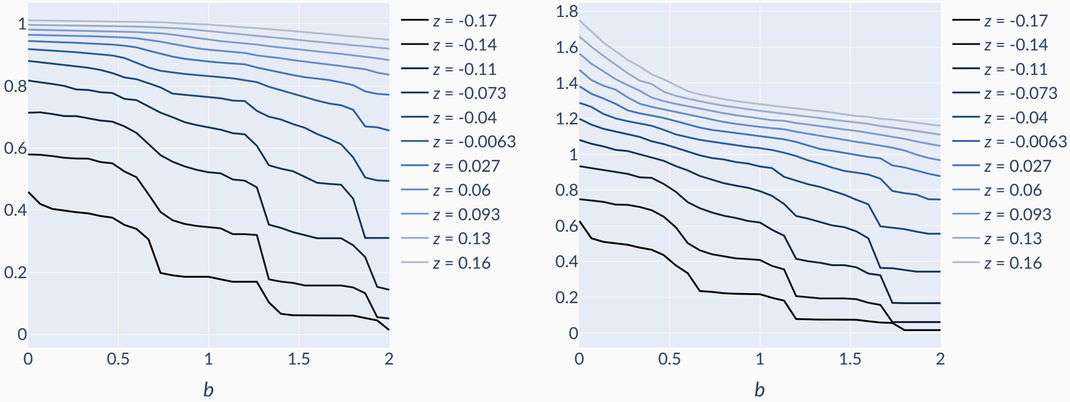


Figure: q_b for dollar debt (left) and peso debt (right)

Real Exchange Rate

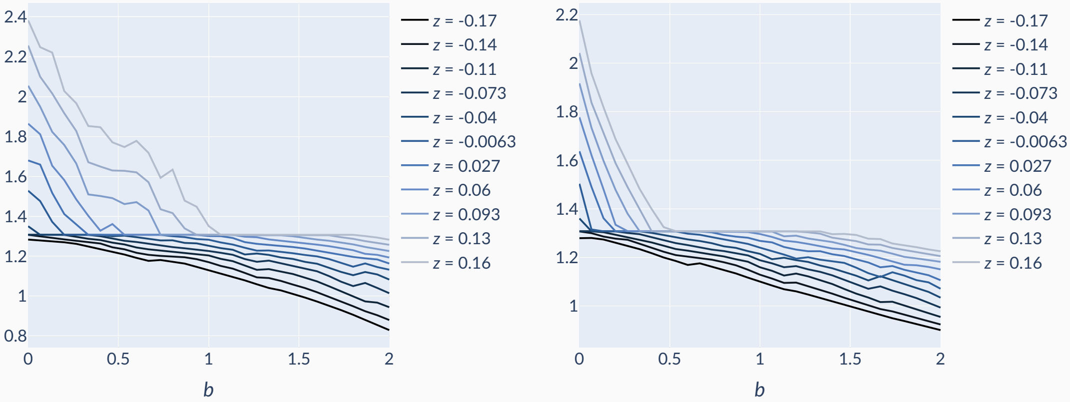


Figure: p_N for dollar debt (left) and peso debt (right)

A synthesized LC bond

Idea: fix the hedging properties of LC debt while taking out incentives

1. Solve the model with FC debt
2. Record the state-dependent payments

$$\kappa^{synth}(b,a,s) = (r+\delta)p_N(b,a,s)$$

   or

$$\kappa^{exog}(b,a,s) = (r+\delta)p_N(0,0,s)$$

3. Fix the state-contingent bond with coupon payments κ^i and resolve

Comparative statics

Statistic	Dollar debt	Peso debt	Exogenous SCI	Full SCI
mean a/y	9.98%	4.57%	2.32%	2.79%
mean b/y	23.9%	12.8%	9.76%	10.3%
mean ds/y	13.5%	18.7%	13.3%	13.2%
mean a/ds	75.4%	24.7%	18.8%	20.5%
corr c,y	75.9%	27.1%	64.2%	73.7%
vol c/vol y	25.8%	21.2%	23.7%	20.5%
std RER	18.9%	20.2%	19.4%	21.2%
mean unemp	2.4%	2.55%	1.94%	1.98%
default freq	2.32%	2.26%	2.13%	2.04%
$\mathcal{V}$	-8.089	-8.0738	-8.0425	-8.0572
Welfare gain	-	0.15%	0.46%	0.31%

Concluding Remarks

Concluding Remarks

- Motivated by empirical association between high reserves and local-currency debt
- Model emphasizes dual role of LC debt
- Time-inconsistency erodes most of the gains from indexation
  - … and induces high reserves compared to synthetic SCIs