Dollar Debt and the Inefficient Global Financial Cycle

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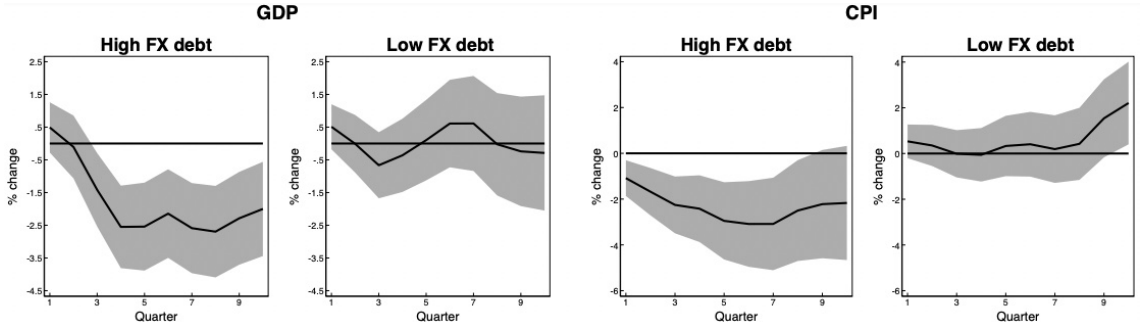
Yale SOM

2nd CEMLA/Dallas Fed workshop on Financial Stability

Motivation

- Global Financial Cycle — Rey (15)
  - U.S. monetary policy drives flows
  - Depreciations → Balance sheet effects — Cespedes et al. (04)
  - → Synchronized policy response
- Taper tantrum, recent round of EMEs tightening, ...

Fed Hikes & Balance Sheet Weakness



Source: Kalemli-Özcan & Unsal BPEA 2023

▸ More

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  - → Synchronized policy response
- Taper tantrum, recent round of EMEs tightening, ...
- EME central bank facing the GFC
  - Optimal monetary policy response?
  - Role of capital flows? Spillovers? Coordination?
  - Optimal ex-ante policy?

▸ Model Preview ▸ Results Preview ▸ Literature

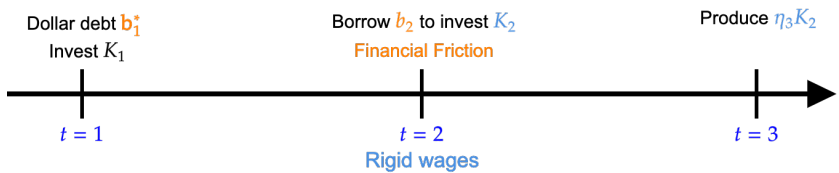
Outline

1. Model
2. (In)efficient Global Financial Cycle
3. Ex-Ante Policy

Layout

- Small Open Economy
- **Households**:
  1. Supply labor
  2. Wage rigidity → Aggregate demand effects
- **Entrepreneurs**:
  1. Borrow in dollars and pesos to invest
  2. Produce non-tradable goods
  3. Financial frictions → Balance sheet effects
- Central bank sets the domestic interest rate / exchange rate
  - No access to other instruments

Korinek (17), Itskhoki and Mukhin (22)



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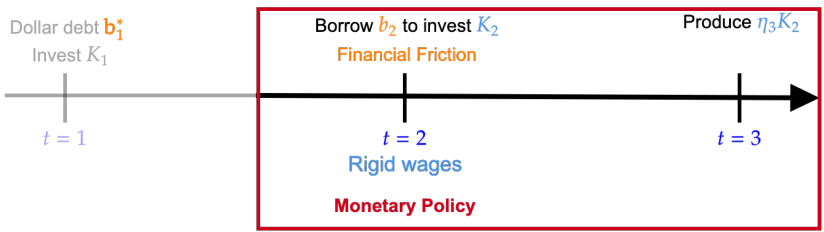

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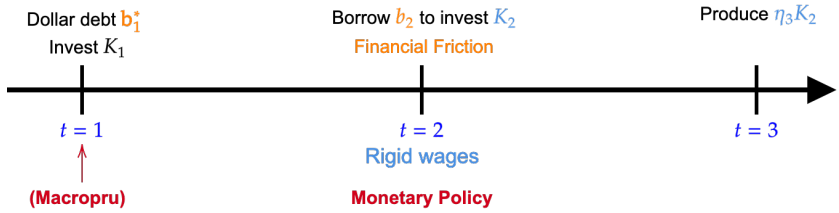


Time $t = 2$: Households & Production

- Goods: Tradables T & non-tradables N
- **Households**: ▸ Details

$$U_2 = \frac{1}{1-\sigma}\left(\phi(c_2^T)^{1-\sigma} + (1-\phi)(c_2^N)^{1-\sigma}\right) + \beta\left(c_3^N + c_3^T\right)$$

  - Inelastic supply of labor $l_2 \leq \bar{n}$
  - Peso-denominated bonds a_3 at i_2 → $a_3 = 0$ in equilibrium
  - Dollar-denominated bonds a_3^* at i_2^* → set by the Fed
- **Production**:
  - Perfectly competitive continuum of firms
  - Linear technology $y_2^N = l_2$ to produce NT
  - Fully rigid wages at $\bar{w} = 1$ → involuntary unemployment
- T endowment y_2^T, law of one price: $p_t^T = e_t$

Time $t = 2$: Entrepreneurs

- Entrepreneurs enter with:
  - Capital stock K_1 producing η_2 of NT per unit
  - Peso debt b_1
  - Dollar debt b_1^*
- Entrepreneurs net worth:

$$n_2 = \eta_2 K_1 - b_1 - \mathbf{e_2} b_1^*$$

- After production, entrepreneurs hit by random shocks: Boissay et al. (23)
  - Fraction κ still productive
  - Can produce at $t = 3$ if maintain capital stock: productivity ρ
  - Must invest s of non-tradables per unit
  - Remaining $1 - \kappa$ unproductive: capital fully depreciates

Time $t = 2$: Financial Friction

- Productive entrepreneurs need to pay $s \cdot k_2$
- Can borrow from other unproductive entrepreneurs
- Classic monitoring problem (Tirole 10)

$$b_2 \leq \rho_0 k_2$$

  - ρ_0 pledgeable part of the project
  - $\rho_0 < s < 1$

- Constrained entrepreneurs:

$$k_2 = \frac{n_2}{s - \rho_0}$$

- Net worth multiplier $\implies$ role for monetary policy
  - Increase in domestic rate i_2 $\implies$ appreciates currency
  - Lowers the debt burden of entrepreneurs
  - Net worth multiplier $\implies$ more investment

▸ Currency Mismatch

Financial Wedge

- Dollar savings intermediated by domestic banks — Montamat (20)
  - Perfectly competitive banks
  - Opportunity costs of holding reserves:

$$c_{\$,j} = (1 + i_2)^{\psi}$$

- Effective dollar interest rate on savings:

$$(1 + \hat{i}_2^*) = (1 + i_2^*)(1 + i_2)^{-\psi}$$

- Frictional UIP condition: — Itskhoki & Mukhin (21)

$$1 + i_2 = \left((1 + i_2^*)\frac{e_3}{e_2}\right)^{\frac{1}{1+\psi}}$$

▸ Data ▸ References

Monetary Policy Tradeoff

- Central bank seeks to maximize welfare of the representative consumer
- **Aggregate demand effects**:

$$c_2^N = \left(\frac{\phi}{1-\phi} \frac{(1+\mathbf{i_2})}{(1+\hat{i}_2^*)} \right)^{-1/\sigma} c_2^T$$

  - Usual expenditure switching
  - With rigid wages, lowers employment
  - **Decreases** N output at $t = 2$
- **Balance sheet effects**:
  - UIP condition:

$$(1+\mathbf{i_2}) = \left((1+i_2^*) \frac{e_3}{e_2} \right)^{\frac{1}{1+\psi}}$$

  - Net worth multiplier (assume constrained entrepreneurs):

$$\frac{dK_2}{d\mathbf{i_2}} = \frac{e_2 \kappa b_1^*}{s - \rho_0}$$

  - **Increases** N output at $t = 3$

▸ Currency Mismatch

Domestic Monetary Policy

- Dollar debt threshold $\tilde{b}^*(i_2^*)$
- Central bank allows under-employment when $b_1^* > \tilde{b}^*$

Optimal Interest Rate

Central bank trades off aggregate demand and balance sheet effects:

$$1 + i_2^{opt} = \Omega \left(\frac{(1 + i_2^*) b_1^*}{s - \rho_0} \right)^{\frac{\sigma}{2\sigma - 1 + \sigma\psi}}$$

- with $\Omega = \left(\sigma(1+\psi)\rho\kappa\beta^{\frac{1-\sigma\psi}{\sigma}} \right)^{\frac{\sigma}{2\sigma-1+\sigma\psi}}$
- Consequences:
  - i_2 strictly increasing in b_1^*
  - Involuntary unemployment: $l_2 < \bar{l}$
  - i_2 strictly increasing in i_2^*
  - **Synchronization $\implies$ GFC**

Illustration

Setup: World Economy

- Continuum of identical and symmetric SOEs
  - Nominal interest rate $i_{2,j}$
  - Dollar debt $b^*_{1,j}$
- Continuum of SOEs small relative to rest of the world
  - Price of tradables in dollars still set to 1
  - Spillovers not coming from tradable inflation
  - Fornaro & Romei (2022) ; Itskhoki & Mukhin (2022) ; Bianchi & Coulibaly (2023)
- Each SOE takes decisions given world equilibrium
- Frictional global financial markets

Global Intermediaries

- Frictional global financial markets: Gabaix & Maggiori (15)
  - Global arbitrageur intermediates capital flows $a^*_{3,j}$
  - Dollar-denominated bonds at rate i^*_2.
  - Global arbitrageur have access to the the Fed at $i^\$_2$
- Follow Fanelli & Straub (21)
  - Continuum of intermediaries g
  - Subject to net open position limit $\gamma > 0$
  - Heterogeneous participation costs g per dollar Alvarez et al. (09)
- Intermediary g solves:

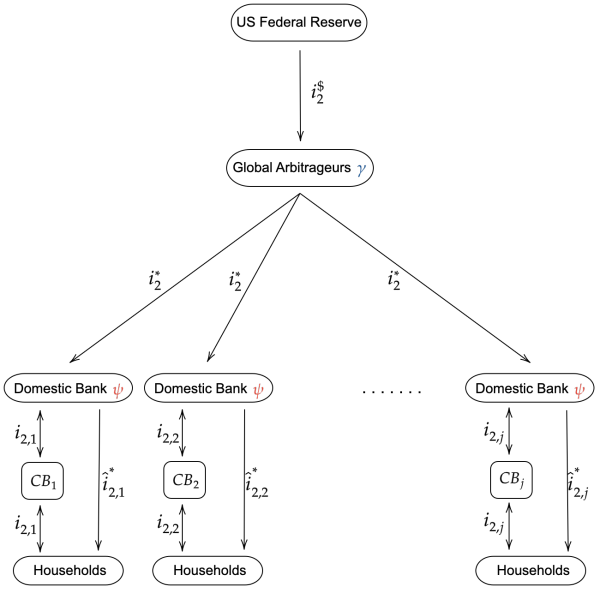
$$\max_{x_g \in [-\gamma, \gamma]} x_g(i^*_2 - i^\$_2) - g|x_g|$$

- Marginal intermediary verifies: $\bar{g} = |i^*_2 - i^\$_2|$
- World equilibrium relationship between interest rates and aggregate flows:

$$i^*_2 = i^\$_2 + \frac{\int_j \frac{a^*_{3,j}}{1+i^*_2} dj}{\gamma}$$

▸ Illustration

Architecture of the Global Financial System



Outline

1. Model
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Inefficient Global Financial Cycle

- Trickling up equilibrium conditions:
  1. Fed decision → depreciationary pressures
  2. Balance sheet effects → increase in EMEs policy rate
  3. Attract capital flows → increase in i_2^*
  4. Feeds back into depreciationary pressures

▸ Show

Congestion Externalities

Domestic decisions spill over to the world interest rate:

$$\mathscr{C}(i_2, i_2^*) = \frac{d \ln (1 + i_2^*)}{d \ln (1 + i_2)} = \frac{\psi}{\frac{\gamma\sigma}{(\beta\phi)^{\frac{1}{\sigma}}} \frac{(1+i_2^*)^{\frac{\sigma+1}{\sigma}}}{(1+i_2)^{\frac{\psi}{\sigma}}} + 1}$$

- **Necessary** ingredients:
  - γ: (frictional global markets) $\mathscr{C}(i_2, i_2^*) \xrightarrow[\gamma \to \infty]{} 0$ (Itskhoki & Mukhin 22)
  - ψ: (i_2 changes capital flows) $\mathscr{C}(i_2, i_2^*) \xrightarrow[\psi \to 0]{} 0$

▸ N-S preferences ▸ No Spillover Benchmark

Gains From Coordination

- Spillovers → need for coordination

Global Coordinated Equilibrium

Global Social Planner implements a lower interest rate:

$$1 + i_2^{SP} = \Omega_\psi \left(\frac{b_1^*(1 + i_2^*)}{s - \rho_0} \right)^{\frac{\sigma}{2\sigma - 1 + \sigma\psi}} \left(1 - \frac{1}{1 + \psi} \mathscr{C}(i_2^{SP}, i_2^*) \right)^{\frac{\sigma}{2\sigma - 1 + \sigma\psi}}$$

- Difference quantified by the congestion externality
- Coordination equilibrium characterized by:
  - Higher employment
  - Higher output
  - Less depreciation in EMEs
  - Lower i_2^*
- Dampens the GFC

▸ Illustration

Outline

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Macroprudential Policy

- Tax dollar debt issuance
  - Hike less at $t = 2$
  - Trade-off: more expensive to finance investment
  - GFC dampened

Show expressions

Macroprudential Policy Spillovers

$$\frac{d \ln (1 + i_2^*)}{d\tau} = \frac{\sigma(1+\psi)}{2\sigma(1+\psi) - 1} \mathscr{C}(i_2^{SP}, i_2^*) \frac{d \ln(b_1^*)}{d\tau}$$

- Positive Spillovers
  - Less hiking at $t = 2$
  - Less congestion in capital flows
  - No coordination required
- Ameliorates the trade-off that all central banks face in the future

Debt Issuance Moral Hazard

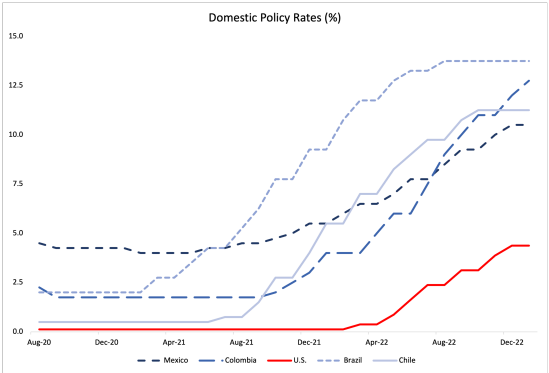
Conclusion

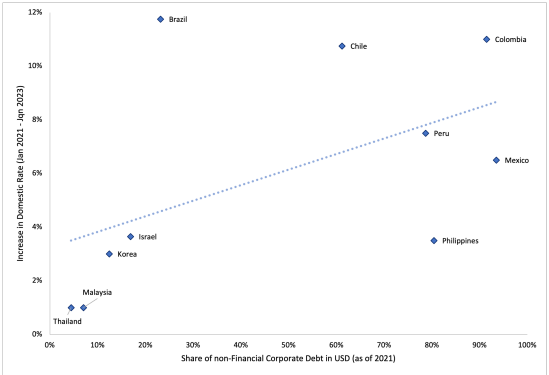
1. Dollar debt in EMEs $\Longrightarrow$ Congestion Externalities
   - Requires **frictional** global financial markets

2. Inefficient GFC, requires monetary policy coordination

3. Macroprudential policy: positive spillovers to discourage dollar issuance
   - **Dampens** the GFC

Appendix Slides


Domestic Policy Rates (%)
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Aug-20
Dec-20
Apr-21
Aug-21
Dec-21
Apr-22
Aug-22
Dec-22
Mexico
Colombia
U.S.
Brazil
Chile


Increase in Domestic Rate (Jan 2021 - Jqn 2023)
12%
10%
8%
6%
4%
2%
0%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Share of non-Financial Corporate Debt in USD (as of 2021)
Brazil
Chile
Colombia
Peru
Mexico
Israel
Philippines
Korea
Malaysia
Thailand

Return

This Paper

- Small Open Economies model:
  - Entrepreneurs borrow in dollars
  - Nominal rigidities → Aggregate demand effects
  - Financial friction → Balance sheet effects

- Imperfect global financial markets: Gabaix & Maggiori (15)
  - Global arbitrageur intermediates capital flows with the U.S.
  - Size of flows determines the interest rate

- Central banks:
  - Set the domestic nominal interest rate
  - No access to other instruments Korinek (17), Itskhoki and Mukhin (22)
  - Ex-ante policy?

▸ Motivation

Results Preview

1. Corporate dollar debt ties the hands of central banks
   - Trade-off aggregate demand and balance sheet effects
   - Involuntary unemployment and output gap
   - EMEs must respond to U.S. monetary policy
     - Synchronized response of EMEs → **GFC**

2. GFC is inefficient when global markets are frictional
   - EMEs seek to attract capital flows at the expense of one another
   - Congestion externality
   - Gains from monetary policy coordination
     - Coordinated equilibrium: higher employment and output
     - Dampens the GFC

3. Macroprudential policy optimal
   - Discourage dollar-denominated issuance
     - Solves moral hazard
     - Dampens the GFC
   - Positive spillovers
     - Does not necessarily require coordination

▸ Motivation

References

- Global Financial Cycle:
  - Facts: Rey (15); Miranda-Agrippino & Rey (20); Miranda-Agrippino & Rey (22); Obstfeld & Zhou (23)
  - Theories: Miranda-Agrippino & Rey (22); Bianchi, Bigio & Engel (21), Gopinath & Stein (21); **Jiang, Krishnamurthy and Lustig (21)**; Farhi & Maggiori (18); Kekre & Lenel (21); Gourinchas & Rey (22)
  - Dollar-denominated corporate borrowing in EMEs: Bruno & Shin (15); McCauley, McGuire & Sushko (15); Maggiori, Neiman & Schreger (20)

- Policy under foreign-denominated debt:
  - Balance sheet effects: Krugman (99), Cespedes, Chang & Velasco (2004), Aghion, Bacchetta & Banerjee (04), ; Chamon & Hausmann (05); Wang (19)
  - Monetary Policy: Matsumoto (21); Coulibaly (21); Bianchi & Lorenzoni (21)

- Spillovers:
  - U.S. Monetary Policy Spillovers : Gourinchas (18); Kalemli-Özcan (19); **Jiang, Krishnamurthy and Lustig (21)** ; **Akinci & Queralto (21)**
  - Cooperation : Obstfeld & Rogoff (2002); Benigno & Benigno (06); **Korinek (17)**; Acharya & Bengui (18) ; **Fornaro & Romei (19)**; Fornaro & Romei (22); Caballero & Simsek (20); Caballero, Farhi & Gourinchas (21)
  - Imperfections in Global Financial Markets : Gabaix & Maggiori (15); **Fanelli & Straub (21)**; Itskhoki & Mukhin (21); **Itskhoki and Mukhin (22)**

References: Extended

- Dollar Issuance : McKinnon and Pill (98); Burnside, Eichenbaum and Rebelo (01); Schneider and Tornell (04); Caballero and Krishnamurthy (03); Jeanne (2002); Bocola and Lorenzoni (20); Coppola, Krishnamurthy and Xu (23); Eren, Malamud and Zhou (23)

- Monetary Policy under financial fragility : Boissay, Collard, Galí and Manea (21); Farhi and Werning (20); Asriyan, Fornaro, Martin and Ventura (21)

- Macroprudential policy in open economies : Bianchi (11); Farhi and Werning (16); Bianchi and Mendoza (18); Jeanne and Korinek (19). Under-borrowing : Benigno, Chen, Otrok, Rebucci and Young (13); Acharya and Bengui (18); Schmitt- Grohé and Uribe (21)

▸ Main Literature ▸ Motivation

Households: Details

$$U_2 = \frac{1}{1-\sigma}\left(\phi(c_2^T)^{1-\sigma} + (1-\phi)(c_2^N)^{1-\sigma}\right) + \beta\left(c_3^N + c_3^T\right)$$

- Linearity delivers closed-form solutions
- Budget constraints:

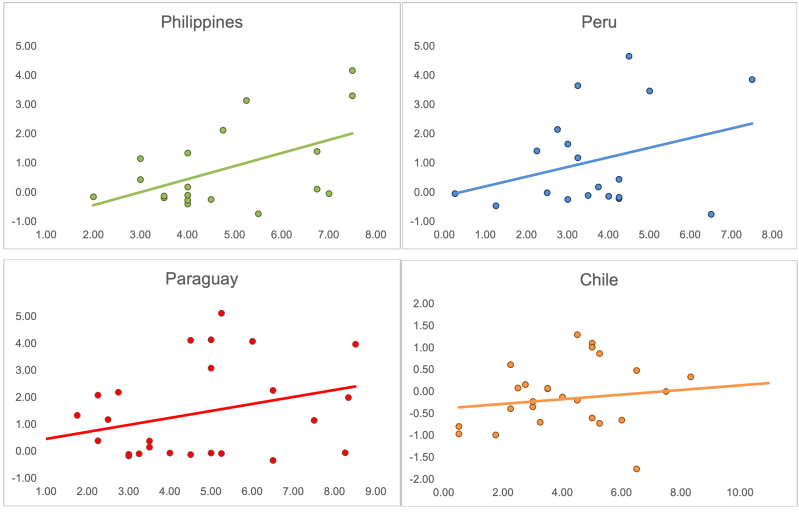
$$p^T c_2^T + p^N c_2^N = e_2 y^T + w_2 l_2 + \frac{1}{1+i_2} a_3 + \frac{1}{1+i_2^*} e_2 a_3^*$$
$$p_3^N c_3^N + p_3^T c_3^T + a_3 + e_3 a_3^* = p_3^T y_3^T + \bar{w}\bar{l} + \Pi_3$$

- Optimization for NT demand:

$$c_2^N = \left(\frac{\phi}{1-\phi}\frac{p_2^N}{p_2^T}\right)^{-1/\sigma} c_2^T = \left(\frac{\phi}{1-\phi}\frac{\bar{w}}{e_2}\right)^{-1/\sigma} c_2^T$$

Return

ψ in the Data



$$i^* - \hat{i} = \psi i$$

▸ Return

Financial Wedge: References

$$c_{\$,j} = (1 + i_2)^{\psi}$$

- Speech by Schnabel (23):

  The reason is that monetary policy tightening typically reduces intermediaries' risk-bearing capacity, thereby raising the compensation they require for warehousing risk, over and beyond changes in the quality of borrowers' balance sheet.

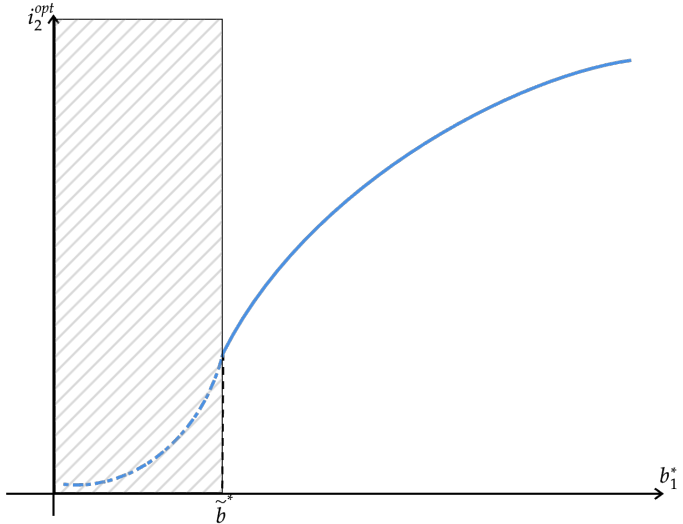
  - Money Market Contact Group meeting, 2023

- Also models of Gertler & Karadi (11), Adrian & Shin (14), and Vayanos & Vila (21)

- Drechsler, Savov & Schnabl (17): model with market power in deposit markets.
  - show that when the Fed funds rate rises, banks widen the spreads they charge on deposits

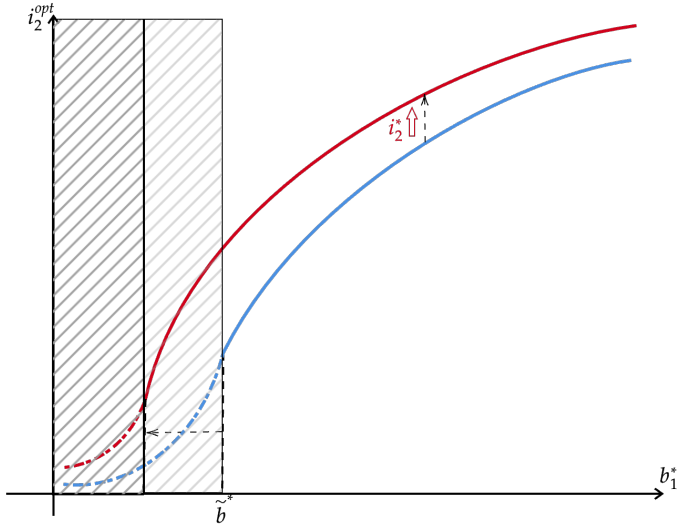
Return

Dollar Debt and Optimal Monetary Policy



Optimal Monetary Policy for a given level of dollar debt b_1^*

Dollar Debt and Optimal Monetary Policy



Optimal Monetary Policy for a given level of dollar debt b_1^*

Benchmark: No Spillover

- Assume $\psi = 0$ here
- Non-separable preferences:
  - Consumption of T:

$$c_{2,j}^T = \left(\frac{\phi}{1-\phi}\frac{1+i_2}{1+i_2^*}\right)^{\frac{1}{\sigma}} \left(\frac{(1-\phi)\beta}{1+i_2}\right)^{\frac{1}{\sigma}}$$

  - Independent of policy rate i_2
- Capital flows independent of policy rate

$$\frac{1}{1+i_2^*} a_{3,j}^* = \left(\beta\phi\frac{1}{1+i_2^*}\right)^{\frac{1}{\sigma}} + b_{1,j}^* - y_{2,j}^T$$

- No spillover → (constrained) efficient GFC
- Efficiency breaks when i_2 impacts capital flows
  - Non-separable preferences
  - Financial wedge (tractable!)

▸ Return
▸ Appendix
Today

Non-Separable Preferences

$$U_2 = \frac{1}{1-\rho}\left(\phi(c_2^T)^{1-\sigma} + (1-\phi)(c_2^N)^{1-\sigma}\right)^{\frac{1-\rho}{1-\sigma}} + \beta\left(c_3^N + c_3^T\right)$$

- Similar intuition but more involved
  1. Fed decision → depreciationary pressures
  2. Balance sheet effects → increase in EMEs policy rate
  3. Attract capital flows → increase in i_2^*
  4. Feeds back into depreciationary pressures
- Now step (2) → (3) comes from preferences rather than ψ
- Congestion externality:

$$\mathscr{C}(i_2, i_2^*) = \frac{(\rho-\sigma)(1-\phi)(c_2^N)^{1-\sigma}\frac{c_2^T}{\gamma(1+i_2^*)}}{(\rho-\sigma)(1-\phi)(c_2^N)^{1-\sigma}\frac{c_2^T}{\gamma(1+i_2^*)} + C\left(1 - \frac{c_2^T}{\gamma(1+i_2^*)} - (\rho-\sigma)\right)}$$

- Disappears if $\rho = \sigma$
  - Also when $\gamma \to \infty$

▸ Benchmark ▸ Congestion with ψ

Currency Mismatch

- Assumption in main framework is extreme currency mismatch
  - Entrepreneurs' production at $t = 2$ is in NT only
  - $n_2 = \eta_2 K_1 - b_1 - \mathbf{e_2} b_1^*$
  - Exchange rate moves only costs
- General currency mismatch:
  - Entrepreneurs' capital yields η_2 of NT and $\iota\eta_2$ of T
  - $n_2 = \eta_2 + \mathbf{e_2}\iota K_1 - b_1 - \mathbf{e_2} b_1^*$
  - Exchange rate moves income and costs
- Net worth multiplier (assume constrained entrepreneurs):

$$\frac{dK_2}{\mathbf{i_2}} = (1-\iota)\frac{e_2 \kappa b_1^*}{s - \rho_0}$$

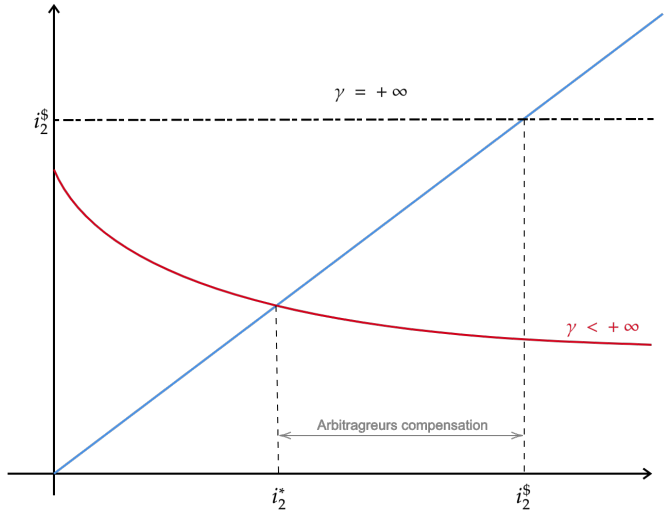
▸ Literature Review ▸ Financial Friction ▸ MP Trade-off

References: Currency Mismatch

- Harvey and Roper (1999) : Balance sheet effects driven by high leverage in foreign currency and subdued profitability played a significant role in propagating the Asian financial crisis.
- Aguiar (2005) : Studies the case of the Mexican peso crisis of 1994 and finds that firms with heavy exposure to short-term foreign currency debt before the devaluation experienced relatively low levels of post-devaluation investment.
- Kim, Tesar and Zhang (2015) : Holdings of foreign-currency denominated debt negatively affected the economic performance of small firms during the 1997–1998 crisis.
- Bruno and Shin (2020) : "Currency Depreciation and Emerging Market Corporate Distress". Nonfinancialfirms that exploit favorable global financing conditions to issue U.S. dollar bonds are also those whose share price is most vulnerable to local currency depreciation.
- Amado (2022) : Nontradable firms that do not use FX derivatives in Peru. 30% of loans to small firms are in dollars and more than 50% for large firms.
- Garcia, Levin-Konigsberg, Lopez & Stein (2023) : Narrow framing in hedging decisions.

▸ General Currency Mismatch ▸ Financial Friction ▸ MP Trade-off

Interest Rate Intermediation



Aggregate Capital Flows and Equilibrium Interest Rate

▸ Return

Inefficient Global Financial Cycle: Equations

- Trickling up equilibrium conditions:
  1. Fed decision → depreciationary pressures
  2. Balance sheet effects → increase in EMEs policy rate
  3. Attract capital flows → increase in i_2^*
  4. Feeds back into depreciationary pressures

$$1 + i_{2,j} = \Omega_\psi \left(\frac{b^*_{1,j}(1 + i^*_2)}{s - \rho_0} \right)^{\frac{\sigma(1+\psi)}{2\sigma(1+\psi)-1}} \tag{1}$$

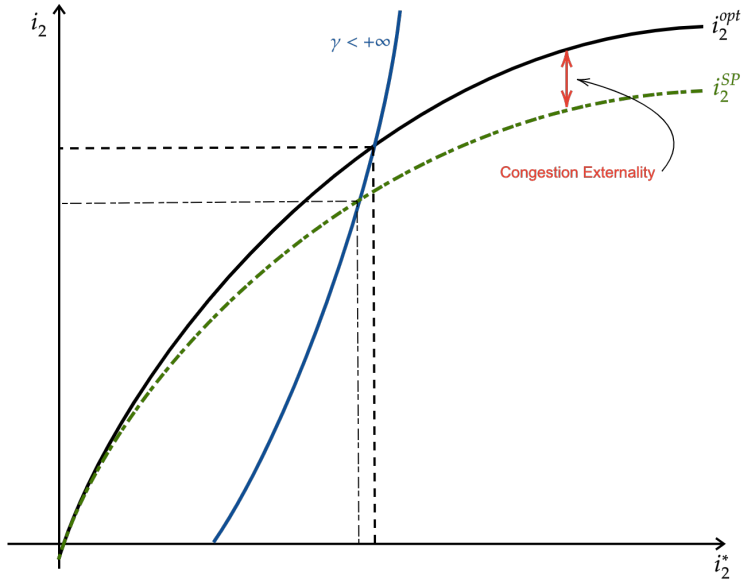
$$1 + \hat{i}^*_{2,j} = (1 + i^*_2)(1 + i_{2,j})^{-\psi} \tag{2}$$

$$\frac{a^*_{3,j}}{1 + \hat{i}^*_{2,j}} = \left(\frac{\beta\phi}{1 + \hat{i}^*_{2,j}} \right)^{\frac{1}{\sigma}} + b^*_{1,j} - y^T_{2,j} \tag{3}$$

$$i^*_2 = i^\$_2 + \frac{\int_j \frac{a^*_{3,j}}{1+\hat{i}^*_{2,j}} dj}{\gamma} \tag{4}$$

Return

Coordinated and Uncoordinated Equilibria



▸ Return

Dollar Debt Issuance

- Go back to $t = 1$
- Entrepreneurs:
  - Must finance fixed size K_1
  - Can issue in pesos (b_1) or dollars (b_1^*)
  - Interest rate $\hat{i}_1$ or $\hat{i}_1^*$
- Lenders compensated with a premium

$$\frac{b_1^*}{1+\hat{i}_1^*} = \omega^*(\hat{i}_1^* - i_1^*) \quad \text{and} \quad \frac{b_1}{1+\hat{i}_1} = \omega(\hat{i}_1 - i_1)$$

- Minimize repayments:

$$\min_{b_1, b_1^*} \quad b_1 + \mathbf{e_2} b_1^*$$

$$\text{s.t.} \quad \frac{b_1}{1+\hat{i}_1} + \frac{e_1 b_1^*}{1+\hat{i}_1^*} = K_1$$

▸ Solution

Moral Hazard

- $\gamma \to \infty$
- Complements:
  - b_1^* ties the hands of the central bank
  - Raising i_2 makes it more attractive to issue in dollars

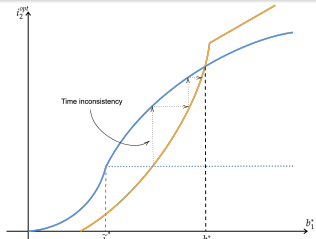
Dollar Debt Issuance Externalities

Dollar issuance reduces future employment in equilibrium:

$$\frac{dl_2}{db_1^*} = -\frac{c_2^N}{b_1^*(2\sigma - 1 + \sigma\psi)}$$

$$b_1^* = \omega^* \frac{K_1\left(K_1 + \omega^* e_1(1+i_1^*) + \omega(1+i_1)\right)}{\left(\omega \frac{e_2^{opt}}{e_1} + e_1\omega^*\right)^2}$$

$$e_2^{opt} = \Omega_e {b_1^*}^{-\frac{\sigma}{2\sigma-1+\sigma\psi}}$$



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Debt Issuance: Expressions

- Equilibrium interest rates:

$$1 + \hat{i}_1 = \frac{K_1 + \omega(1 + i_1) + e_1\omega^*(1 + i_1^*)}{\omega + e_1\omega^* \frac{e_1}{e_2}}$$

and:

$$1 + \hat{i}_1^* = \frac{K_1 + e_1\omega^*(1 + i_1^*) + \omega(1 + i_1)}{\omega \frac{e_2}{e_1} + e_1\omega^*}$$

- Dollar debt issuance:

$$b_1^* = \omega^* \frac{K_1 + e_1\omega^*(1 + i_1^*) + \omega(1 + i_1)}{\left(\omega \frac{e_2}{e_1} + e_1\omega^*\right)^2} \left(K_1 + \omega\left(1 + i_1 - \frac{e_2}{e_1}(1 + i_1^*)\right)\right)$$

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Macropru: Expressions

- The amount of dollar debt that needs to be paid back at $t = 2$ is given by:

$$b_1^* = \omega^* \frac{K_1 + e_1\omega^*(1+i_1^*) + \omega(1+i_1) - \tau\omega\frac{e_2}{e_1}}{\left(\omega\frac{e_2}{e_1} + e_1\omega^*\right)^2}\left(K_1 + \omega\left(1 + i_1 - \frac{e_2}{e_1}(1+i_1^*+\tau)\right)\right)$$

- Peso debt to pay back is:

$$b_1 = \omega \frac{K_1 + \omega(1+i_1) + e_1\omega^*(1+i_1^*) + \tau e_1\omega^*\frac{e_1}{e_2}}{\left(\omega + e_1\omega^*\frac{e_1}{e_2}\right)^2}\left(K_1 + e_1\omega^*\left(1 + i_1^* - \frac{e_1}{e_2}(1+i_1-\tau)\right)\right)$$

- The optimal tax on dollar issuance lowers the amount issued in dollars, b_1^*, such that:

$$\frac{1-\phi}{2\sigma - 1 + \sigma\psi}\left(\beta\Omega_\psi\left(\frac{1+i_2^\$}{s-\rho_0}\right)^{\frac{\sigma}{2\sigma-1+\sigma\psi}}\right)^{-\frac{1-\sigma}{\sigma}}(b_1^*)^{-\sigma\frac{1+\psi}{2\sigma-1+\sigma\psi}} = \frac{\beta\rho\kappa}{s-\rho_0}\frac{dn_2}{db_1^*}$$

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