The United States as the International Lender of Last Resort

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Motivation

1. Banks finance long-term assets with short-term liabilities $\Rightarrow$ **maturity mismatch**

    * Solution: Lender of Last Resort (LoLR) to avoid “runs”

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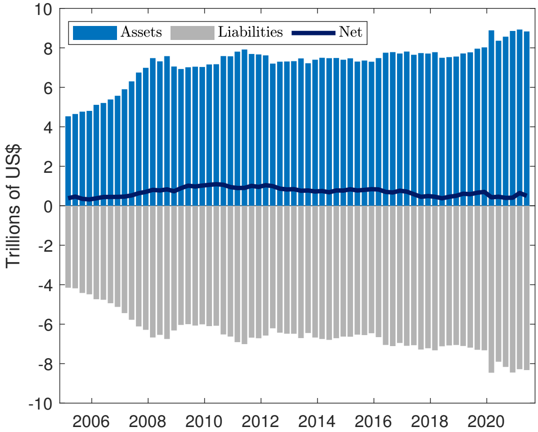
   * Solution: Lender of Last Resort (LoLR) to avoid "runs"
2. **Non-US Global Banks**: large cross-border $ operations ⇒ **maturity mismatch in** $

Motivation

Dollar assets and liabilities of non-US global banks



Note: G7 countries (ex. US): Canada, France, Germany, Italy, Japan, UK.

EU banks | US banks comparisson | Maturity mismatches

Motivation

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    * Solution: Lender of Last Resort (LoLR) to avoid "runs"
2. **Non-US Global Banks**: large cross-border \$ operations $\Rightarrow$ **maturity mismatch in \$**
    * During a **global crisis**, liquidity is scarce and the $\uparrow$ \$ $\Rightarrow$ difficult to roll-over short-term debt
    * Domestic LoLRs can provide mostly local currency

Dollar and liq.

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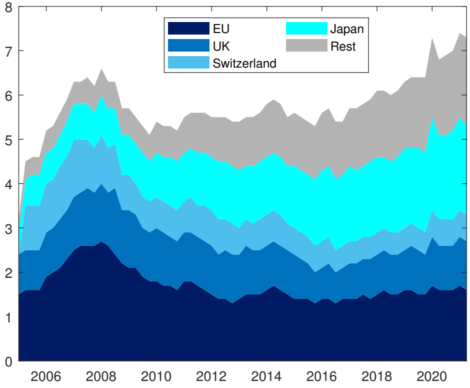
   - Solution: Lender of Last Resort (LoLR) to avoid "runs"
2. **Non-US Global Banks**: large cross-border \$ operations ⇒ **maturity mismatch in \$**
   - During a **global crisis**, liquidity is scarce and the ↑ \$ ⇒ difficult to roll-over short-term debt
   - Domestic LoLRs can provide mostly local currency
3. **Fed/US provided \$ liquidity** and acted as the **International Lender of Last Resort**
   - Why? Non-US global banks invest in US assets, and intermediate US deposits

Dollar and liq.

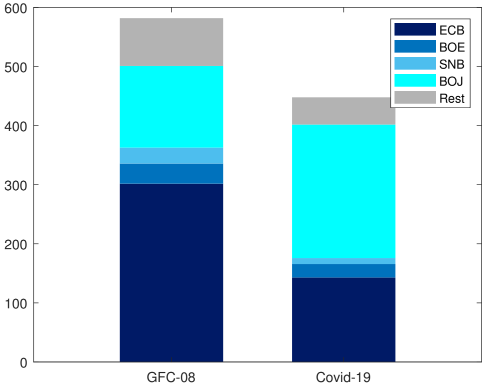
Motivation

US assets of non-US banks ($ trillions)



Source: BIS Consolidated Banking Statistics.

Outstanding Swap Lines usage ($ billions)



Source: New York Fed.

Usage and costs | Liquidity needs | SL objectives | EU assets vs US | Assets purchases

This Paper

- **Questions**
  - What are the **macro implications** of the Fed's swap lines?
  - Are the **incentives of the US** always aligned with what the world needs?
- **Approach:** Stylized model of the world economy
  - Self-fulfilling crises Bocola & Lorenzoni (20) + Global Banks Gabaix & Maggiori (15)
  - **New:** maturity mismatches in $ in Adv.Econ. + international spillovers
- **Contribution**
  - Macro effects and incentives of the swap lines. Bahaj and Reis (21), Cesa-Bianchi et al. (22)
  - Framework to think about $ ↑ during a crisis. Maggiori (17), Gourinchas & Rey (22), Kekre & Lenel (23)

Literature

Preview of the results

1. **Self-fulfilling expectations** about the exchange rate can trigger **global financial crises**
   * Feedback loop between the ER and non-US global banks' short-term needs ($\longrightarrow$multiple eq.)
2. **Foreign Central Banks have limited ability** to prevent the crisis
   * Liquidity needs in \$, which endog. appreciates during a crisis
3. **Fed can provide \$ liquidity**, but might have **low incentives to act as the international LoLR**
   * US HH lose their deposits, and productive investment of global banks...
   * ...but they benefit from a stronger dollar and cheaper capital inflows

The Model

Main ingredients

- Two countries (EU, US (*)), two periods $t \in \{1, 2\}$
- 1 Tradable good, and 1 Non-Tradable in each country (numéraire)
- Agents: EU and US Households, Global Banks (EU-owned), Central Banks
  - Global Banks financially constrained

Main ingredients

- Two countries (EU, US (*)), two periods $t \in \{1, 2\}$
- 1 Tradable good, and 1 Non-Tradable in each country (numéraire)
- Agents: EU and US Households, Global Banks (EU-owned), Central Banks
  - Global Banks financially constrained
- *Euros* $\approx$ value of EU *NT* while *dollars* $\approx$ value of US *NT*
  - **Exchange rate** e_t: quantity of *euros* bought by one *dollar* ($\uparrow e_t \equiv \uparrow \$$)

US Households

- Consume in both periods,

$$\max_{C_t^*} \mathcal{U} = \ln(C_1^*) + \beta^* \mathbb{E} \ln(C_2^*)$$

$$\text{where } C_t^* \equiv \left[(C_t^{*N})^{\theta^*} (C_t^{*T})^{1-\theta^*} \right]$$

- Endowments Y_t^{*T} and Y_t^{*N}
- Pre-existing positions $L^* > 0$ with banks
- Bonds B^* in US NT goods, paying R^*:

$$L^* + Y_1^{*N} + p_1^* Y_1^{*T} = p_1^* C_1^{*T} + C_1^{*N} + B^*$$

$$R^* B^* + Y_2^{*N} + p_2^* Y_2^{*T} = p_2^* C_2^{*T} + C_2^{*N}$$

EU Households

- Similar preferences, endowments, and preexisting positions $L \geq 0$
- Receive banks' profits Π in $t = 2$
- Bonds: 1) B in EU NT with banks

$$L + Y_1^N + p_1 Y_1^T = p_1 C_1^T + C_1^N + B$$

$$R\,B + \Pi + Y_2^N + p_2 Y_2^T = p_2 C_2^T + C_2^N$$

EU Households

- Similar preferences, endowments, and preexisting positions $L \geq 0$
- Receive banks' profits Π in $t = 2$
- Bonds: 1) B in EU NT with banks 2) $\widetilde{B}$ in US NT with US HH

$$L + Y_1^N + p_1 Y_1^T = p_1 C_1^T + C_1^N + B + e_1 \widetilde{B}$$

$$e_2 R^* \widetilde{B} + R\, B + \Pi + Y_2^N + p_2 Y_2^T = p_2 C_2^T + C_2^N$$

- Trading across borders entails a small non-pecuniary cost, χ

FOCs

- **Euler equations:**

$$p_1 C_1^T = \frac{p_2 C_2^T}{\beta R} \qquad \text{and} \qquad p_1^* {C_1^*}^T = \frac{p_2^* {C_2^*}^T}{\beta^* R^*}$$

- **NT demand:**

$$p_t = \frac{C_t^N}{C_t^T}^{\frac{1-\theta}{\theta}} \qquad \text{and} \qquad p_t^* = \frac{{C_t^*}^N}{{C_t^*}^T}^{\frac{1-\theta^*}{\theta^*}}$$

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Key mechanism: since LOP holds, $e_t = \dfrac{p_t}{p_t^*}$, then

$$\downarrow C_t^T \longrightarrow \overline{C}_t^N \longrightarrow \uparrow p_t \longrightarrow \uparrow e_t \quad \text{(euro depreciation)}$$

Global Banks in $t = 1$

- Pre-existing positions
  - **Short-term liabilities:** L^* and L, to be repaid in $t = 1$
  - **Long-term assets:** with gross returns A^* and A in $t = 2$

- **Roll-over condition** (in euros) to get profits Π in $t = 2$:

$$B + e_1 B^* \geq e_1 L^* + L$$

- **Financial Friction:** can **divert a fraction** $\gamma < 1$ of the funds they intermediate.
  - Households provide funding to banks only if:

$$\frac{\Pi}{R} \geq \gamma(B + e_1 B^*) = \gamma(e_1 L^* + L) \qquad \text{(IC)}$$

Global Banks in $t = 2$

Two possible outcomes:

1. **If banks operate** profits (in euros) are

$$\Pi = e_2 A^* + A - e_2 R^* B^* - RB$$

2. **If they cannot roll-over** their debt, they go bankrupt
   * Assets are liquidated $A^*, A \longrightarrow 0$ and debt is not repaid $L^*, L \longrightarrow 0$

$$\Pi = 0$$

Global Banks in $t = 2$

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$$\Pi = 0$$

UIP holds: $$\frac{e_2}{e_1} = \frac{R}{R^*}$$

Assets in tradables

Closing the model

Market clearing

- EU NT goods: $Y_1^N = C_1^N$ and $A + Y_2^N = C_2^N$
- US NT goods: $Y_1^{*N} = C_1^{*N}$ and $A^* + Y_2^{*N} = C_2^{*N}$
- Tradable goods: $Y_t^T + Y_t^{*T} = C_t^T + C_t^{*T}$

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Boost NT supply

Some considerations:

- Simplifications: $\beta = \beta^*, \theta = \theta^*$ and $Y_1^N = Y_1^{*N} = 1$
- Focus on \$ liabilities: $L = 0$
- EU gross savings: $\hat{B} \equiv B + e_t \tilde{B}$

Equilibrium and Self-fulfilling crises

Exchange rate and Banking crises

- A **necessary condition** for banks to operate is that

$$\underbrace{e_1\frac{A^*}{R^*}+\frac{A}{R}}_{\substack{\text{Discounted}\\ \text{gross profits}}} \geq \underbrace{(1+\gamma)(e_1L^*+L)}_{\substack{\text{Roll-over needs +}\\ \text{funds at risk}}} \qquad \text{(IC)}$$

Exchange rate and Banking crises

- A **necessary condition** for banks to operate is that

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- Focus on the case where **solvent in** \$ but **potentially illiquid in** \$:

$$\frac{A^*}{R^*} - L^* > 0 \qquad\qquad \frac{A^*}{R^*} - (1+\gamma)L^* < 0$$

↑ \$ tightens financial constraint

- Define $\bar{e}$ as the e_1 that makes the IC hold with equality. Then,
  - If $e_1 < \bar{e}$: **Banks operate** $\Rightarrow \Pi > 0$, investment materializes.
  - If $e_1 > \bar{e}$: **Banks collapse** $\Rightarrow \Pi = 0$, investment is lost.

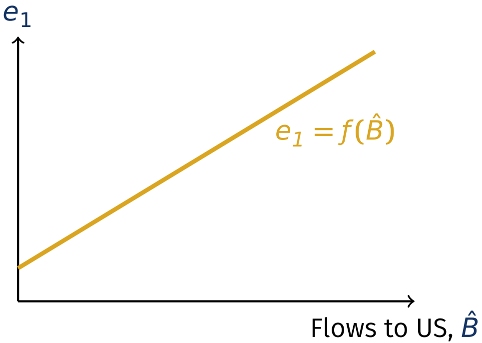
Capital Flows and ER in $t = 1$

Larger **capital flows to US** ($\uparrow \hat{B}$) in $t = 1$

↪ require **stronger EU trade balance**

↪ achieved by a **euro depreciation** $\uparrow e_1$

$$(1) \quad e_1 = \underbrace{\frac{\eta_1^*}{\eta_1}}_{\text{Endowment component}} + \underbrace{\hat{B} \cdot \frac{\theta}{1-\theta} \cdot \frac{1}{\eta_1}}_{\text{Capital flows component}}$$



Capital Flows and ER in $t = 2$

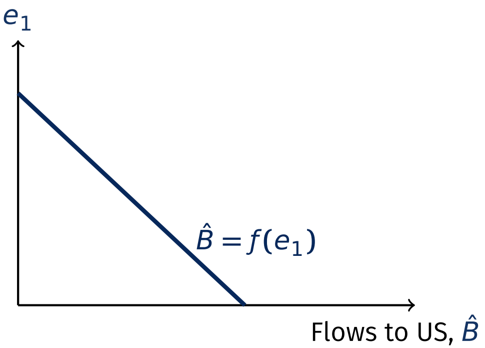
Larger **capital flows to US** ($\uparrow \hat{B}$) in $t = 1$

$\hookrightarrow$ allows for **higher consumption** in $t = 2$, $C_2^T \uparrow$

$\hookrightarrow$ to smooth consumption, $C_1^T \uparrow$

$\hookrightarrow$ leads to euro appreciation $\downarrow e_1$

$$(2) \quad \hat{B} = \frac{1-\theta}{\theta}\beta\underbrace{\left(\eta_2^* - e_1\eta_2\right)}_{\text{Endowment component}} - e_1\underbrace{\left(\frac{A^*}{R^*} - L^*\right)}_{\$\text{profits}>0}$$



Capital Flows and ER in $t = 2$

What if banks collapse?

- Impact on EU households through **financial markets**:
  - **Lose banks' profits Π** $\longrightarrow$ **negative wealth shock** in $t = 2$ $\longrightarrow$ $\uparrow$ savings in $t = 1$

Capital Flows and ER in $t = 2$

What if banks collapse?

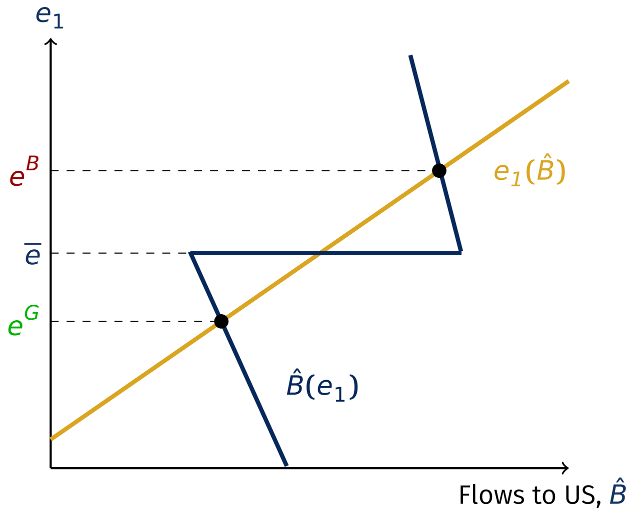
- Impact on EU households through **financial markets**:
  - **Lose banks' profits** $\Pi \longrightarrow$ **negative wealth shock** in $t = 2 \longrightarrow \uparrow$ savings in $t = 1$
- Equilibria defined by

$$e_1 = e(\hat{B}) = \frac{\eta_1^*}{\eta_1} + \hat{B} \cdot \frac{\theta}{1-\theta} \frac{1}{\eta_1} \tag{1}$$

$$\hat{B} = \mathcal{B}(e_1) = \begin{cases} \frac{1-\theta}{\theta}\beta\left(\eta_2^* - e_1\eta_2\right) - e_1\left(\frac{A^*}{R^*} - L^*\right) & \text{if } e_1 < \overline{e} \\ \frac{1-\theta}{\theta}\beta\left(\eta_2^* - e_1\eta_2\right) & \text{if } e_1 > \overline{e} \end{cases} \tag{2}$$

Multiple equilibria

Figure Multiple Equilibria

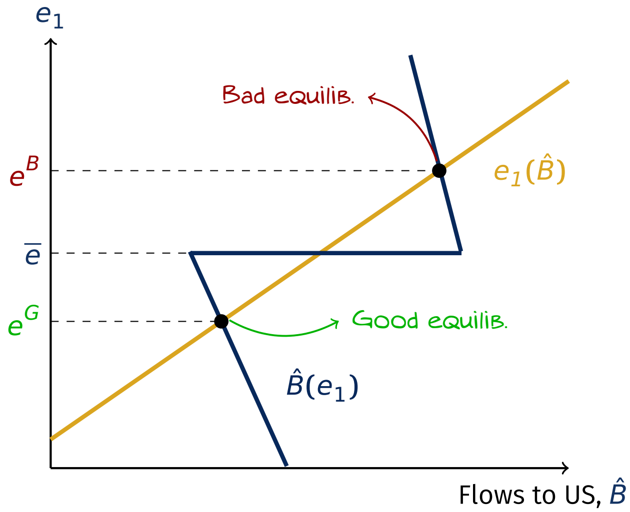


Comparative stat.

More cases

Multiple equilibria

Figure Multiple Equilibria



Comparative stat.

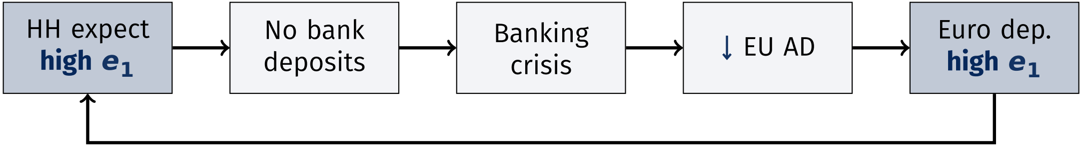
More cases

Multiple Equilibria

- A **crisis is possible** ($e^G < \overline{e} < e^B$) when: Proposition 1
  - Initial $ debt is high ($\uparrow L^*$)
  - financial markets are tight ($\uparrow \gamma$)
  - return on assets is low ($\downarrow A, A^*$)...

Multiple Equilibria

- A **crisis is possible** ($e^G < \bar{e} < e^B$) when: Proposition 1
  - Initial \$ debt is high ($\uparrow L^*$)
  - financial markets are tight ($\uparrow \gamma$)
  - return on assets is low ($\downarrow A, A^*$)...
- **Self-fulfilling mechanism** defines the equilibrium:



Numerical ex.

Lending of Last Resort

Intervention by the ECB

- **Main idea:** Central Bank can rule out the "bad" equilibrium, if it commits to provide the required liquidity to banks, **even if the ER is high.**
- Follow Bocola & Lorenzoni (2020): CB transfers NT goods to banks, financed with linear taxes τ on households' NT endowment, Y^N.

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- Follow Bocola & Lorenzoni (2020): CB transfers NT goods to banks, financed with linear taxes τ on households' NT endowment, Y^N.
- ECB transfers euros to cover banks' \$ liquidity needs,

$$\underbrace{\tau \cdot Y^N}_{\textbf{Transfer}} = \underbrace{e_1 \cdot L^*}_{\textbf{\$ debt}} = f(e_1)$$

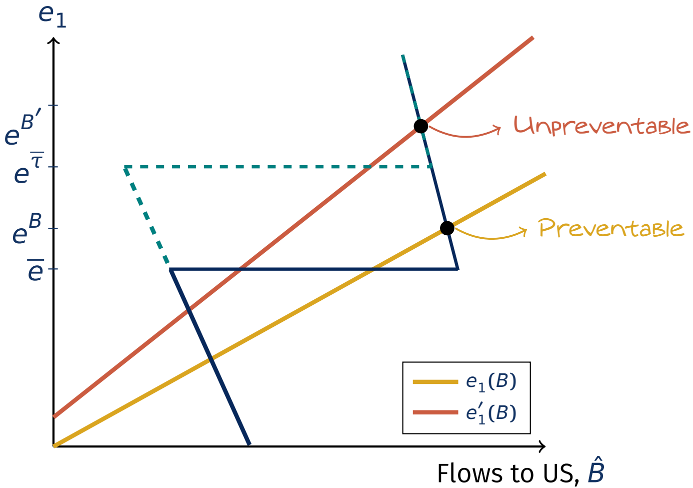
- Assume **limited fiscal capacity:** $\tau < \overline{\tau}$. Intervention is **not feasible** if

$$\underbrace{\overline{\tau} \cdot Y^N}_{\substack{\textbf{Max}\\ \textbf{Transfer}}} \quad < \quad \underbrace{e_1^B \cdot L^*}_{\substack{\textbf{\$ debt}\\ \textbf{during crisis}}}$$

T interv. Liq. operations

Intervention by the ECB

Figure Intervention by ECB



Intervention by the Fed (Swap Lines)

- Similar intervention, but with tax on US HH. Same **limited fiscal capacity:** $\tau^* < \overline{\tau}$.
- Fed transfers \$ to cover banks' \$ liabilities,

$$\tau^* Y^{*N} = L^* \neq f(e_1)$$

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Proposition 2

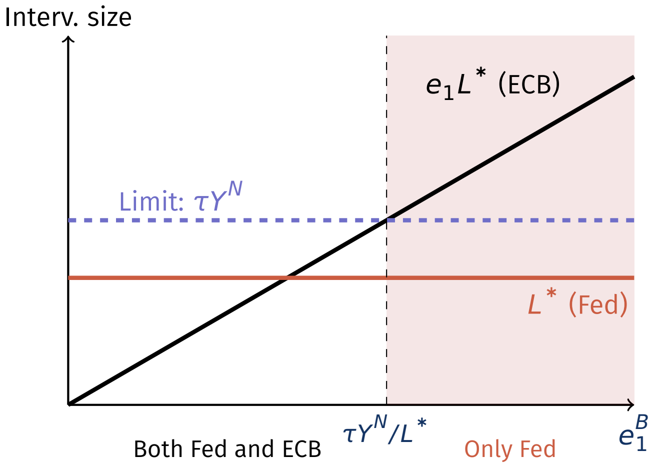
Consider both countries face the same tax limit $\overline{\tau}$ and that $Y^N = Y^{*N}$. ***Only the Fed can eliminate the "bad" equilibrium*** *if $e_1^B L^* > \overline{\tau} Y^N > L^*$ such that*

$$\underbrace{\frac{\eta^*}{\eta} \cdot L^*}_{\text{Liq. needs in euros}} > \underbrace{\overline{\tau} Y^N}_{\text{Maximum intervention}} > \underbrace{L^*}_{\text{Liq. needs in dollars}}$$

$e_1^B L^*$

Intervention by the Fed (Swap Lines)

Figure Intervention by the Fed and the ECB



Welfare implications

Extension: full/partial repayment

- Allow HH to **recover a fraction** ϕ of L^* if banks collapse
  - EU households (banks' owners) bear with that cost in $t = 1$, if needed
- The dollar now **further appreciates** in the "bad" equilibrium:

$$e_1^B = \frac{\eta^*}{\eta} \longrightarrow e_1^B = \frac{\eta^*}{\eta - \frac{1}{1+\beta}\frac{\theta}{1-\theta}\phi L^*}$$

  - Coming from a more severe impact on EU households' wealth and AD.

Winners and Losers

- Consequences:
  - **Goods:** loss of investment A^* and A (US and EU NT goods in $t = 2$)
  - **Financial:** EU lose banks' profits Π, and US loses L^* (or partially)

1. NT sector: both countries lose, $\downarrow C_2^{*N}$ and $\downarrow C_2^N$ **(Direct effect)**
2. T sector: **US consumes more** and **EU less,** $\uparrow C_t^{*T}$ and $\downarrow C_t^T$ **(General Eq.)**
   - Loss of deposits L^* hurts the US
   - But global crisis $\Rightarrow$ stronger dollar $\uparrow e_t$ and $\uparrow$ capital flows to the US

- **EU always impacted negatively** but **US faces a trade-off**

Fed's trade-off and optimal policy

- **US Welfare losses** from the crisis:

$$U^*_{Good} - U^*_{Bad} = \theta\beta^* \underbrace{\ln\left(\frac{A^* + Y_2^{*N}}{Y_2^{*N}}\right)}_{\text{Loss from} \downarrow \text{NT}} - (1-\theta) \underbrace{\left[\ln\left(\frac{C_{B,1}^{*T}}{C_{G,1}^{*T}}\right) + \beta^* \ln\left(\frac{C_{B,2}^{*T}}{C_{G,2}^{*T}}\right)\right]}_{\text{Gain from} \uparrow \text{T}}$$

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  - T consumption across countries determined by e_t ($\uparrow e_t \longrightarrow \uparrow C_t^{*T}$ and $\downarrow C_t^T$)

$$C_1^{*T} = (Y_1^T + Y_1^{*T})\frac{e_1}{1+e_1}$$

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  - T consumption across countries determined by e_t ($\uparrow e_t \longrightarrow \uparrow {C^*_t}^T$ and $\downarrow C^T_t$)

$$ {C^*_1}^T = (Y^T_1 + {Y^*_1}^T)\frac{e_1}{1+e_1}$$

- **Fed's optimal policy:** if $U^*_{Good} - U^*_{Bad} \begin{cases} > 0 & \longrightarrow \text{Swap Lines} \\ < 0 & \longrightarrow \text{No Swap Lines} \end{cases}$

Fed's trade-off and optimal policy

Proposition 3

The Fed/US ***does not provide the liquidity needed (swap lines)*** *if:*

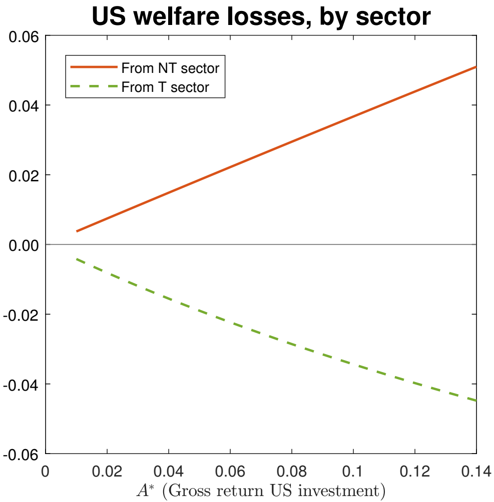
$$\frac{\theta\beta^*}{(1-\theta)(1+\beta^*)}\ln\left(\frac{A^* + Y_2^{*N}}{Y_2^{*N}}\right) < \ln\left(\frac{1+\beta^* + \frac{\theta}{1-\theta}\left(\frac{A^*\beta^*}{A^*+Y_2^{*N}} - L^*\right)}{1+\beta^* - \frac{\theta}{1-\theta}\phi L^*}\right)$$

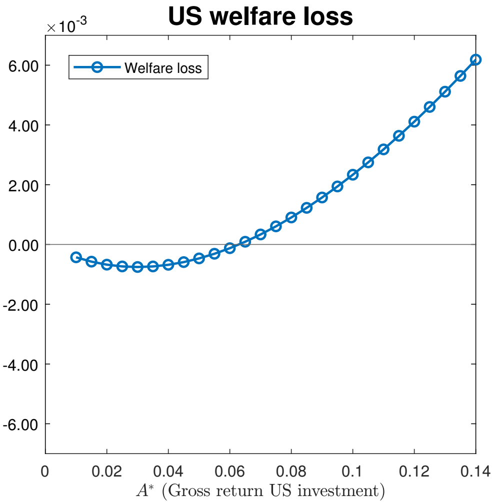
- Deposit recovery ϕ: Higher recovery rate of US deposits $\longrightarrow$ fewer incentives
- Return on US assets A^*: i) $\uparrow$ banks' profits to EU $\longrightarrow$ fewer incentives
  ii) $\uparrow$ NT supply $\longrightarrow$ more incentives

State-space ex.

US Welfare losses as a function of A^*

Under full repayment of L^* ($\phi = 1$)





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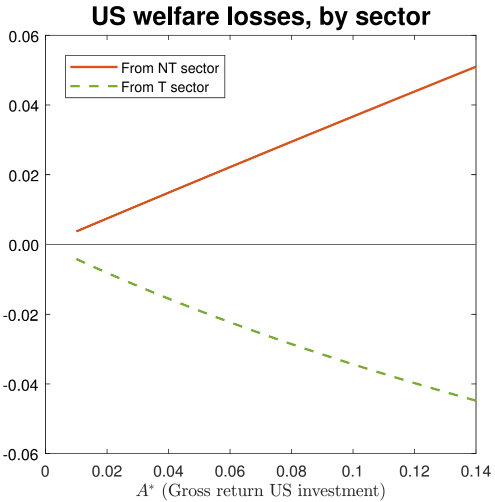
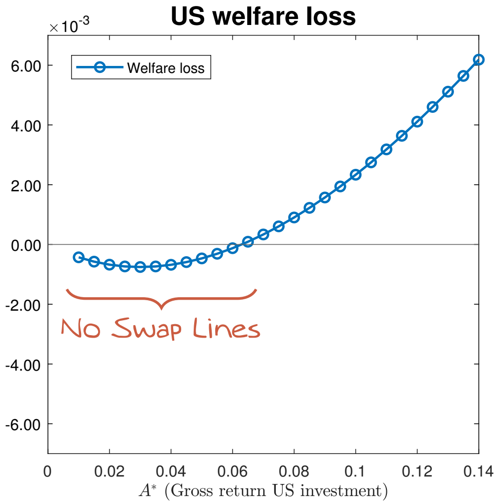




Conclusions

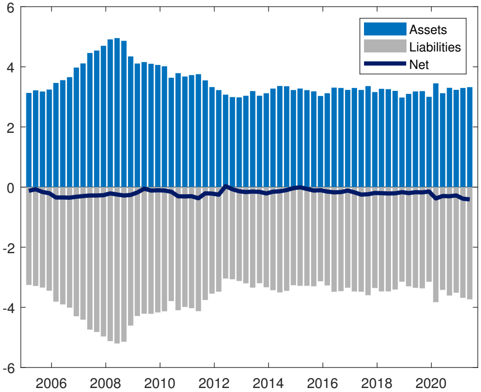
Conclusions

- **Self-fulfilling expectations** about the exchange rate can trigger **global financial crises**
- **Foreign CBs can do little** to eliminate the bad equilibrium (e.g. € weaker during a crisis)
- **Fed** can provide $ liquidity, but **has fewer incentives compared to a "World" social planner**
  - US HH lose their deposits, and productive investment of global banks...
  - ...but they benefit from a stronger dollar and cheaper sources of funding

Thank you!

More data

Back



Dollar Assets and Liabilities of EU banks,
($ trillions)

More data

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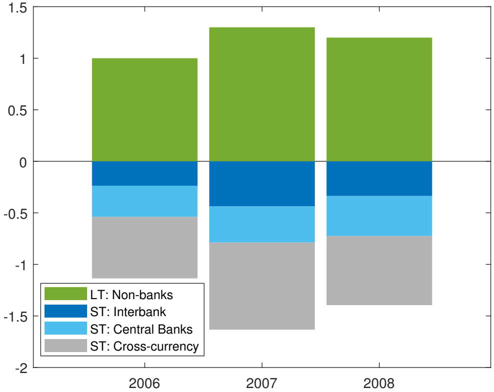

Net dollar positions of EU banks,
by counterparty ($ trillions)

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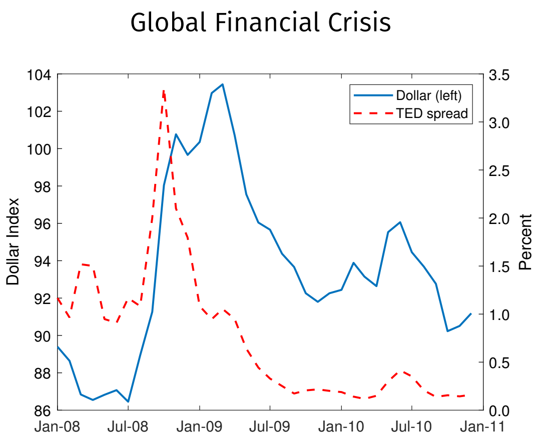
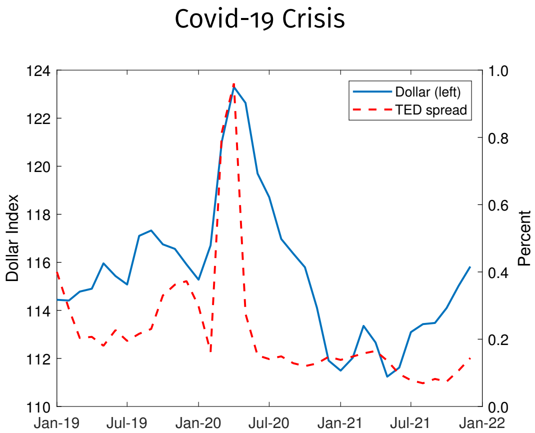


Note: TED spread: 3-month LIBOR – 3-month T-bill rate.

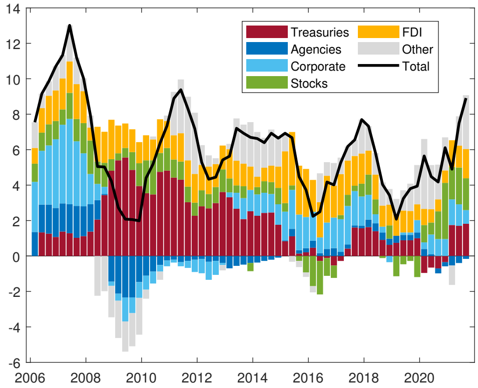


Note: An increase in the TED spread shows that interbank lenders demand a higher interest rate.

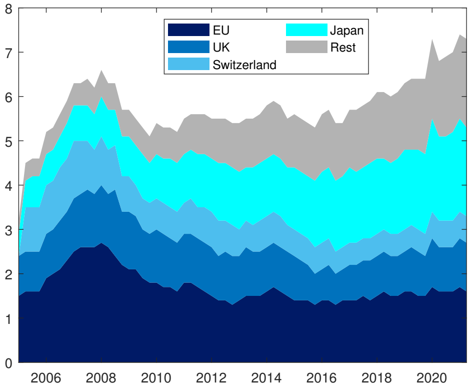
EUR/USD cross-curr.

More data ◂ Back

- Non-US global banks have a large footprint in dollar banking.

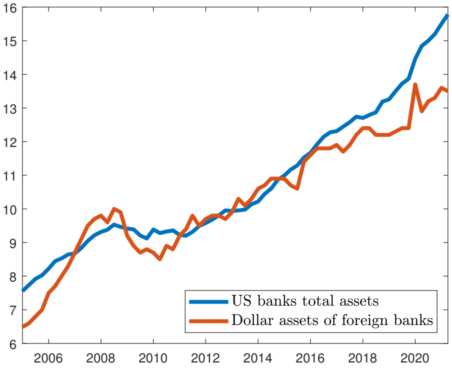


Purchases of US assets by foreigners (% of GDP)

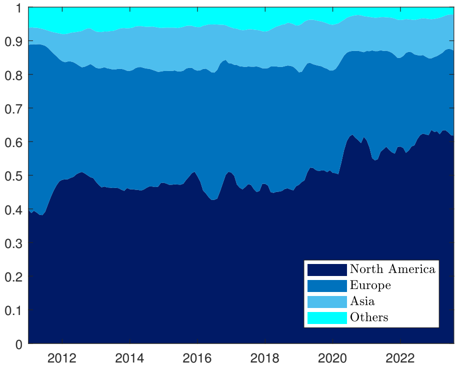


Foreign claims on US counterparties ($ trillions)

More data ◂ Back



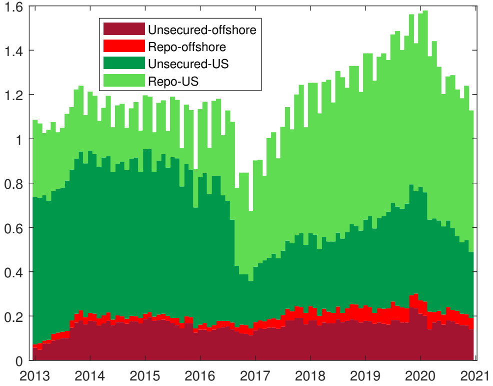
Dollar cross-border claims of non-US banks and US banks' total assets ($ trillions)



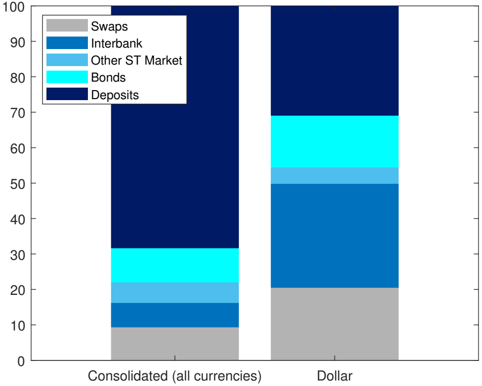
US Prime Money Market Funds composition (share of total)

More data ◂ Back

- Dollar funding of non-US global banks is short-term and fragile.

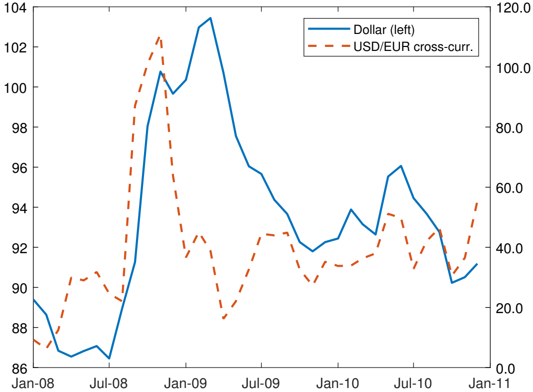


Money Market Funds funding ($ trillions)



Funding Structure of non-US global banks, 2017 (%)

More data
◂ Back



Dollar index and Cross-currency basis

US prime money funds' assets, mid-2008 ◂ Back

Fund	Non-US banks (%)	EU banks (%)	Net assets ($ bill.)
Fidelity Cash Reserves	63	51	128
JPMorgan Prime Money Market	67	62	120
Vanguar Prime Money Market	33	24	106
BlackRock Liquidity Temp	51	47	68
Reserve Primary	43	37	65
Schwab Value Advantage	54	40	61
GS FS Prime Obligations	0	0	56
Dreyfus Inst Cash Advantage	62	51	49
Fidelity Inst Money Market	61	54	47
Morgan Stanley Inst Liq Prime	37	37	34
Dreyfus Cash Management	70	56	33
AIM STIT Liquid Assets	57	45	32
Barclays Inst Money Market	24	19	31
Merrill Lynch Premier Inst Portf.	60	51	26
Fidelity Inst MM: Prime	56	47	21
Total	50	42	878

SOURCE. Baba et al. (2009) .

Swap Lines

Back

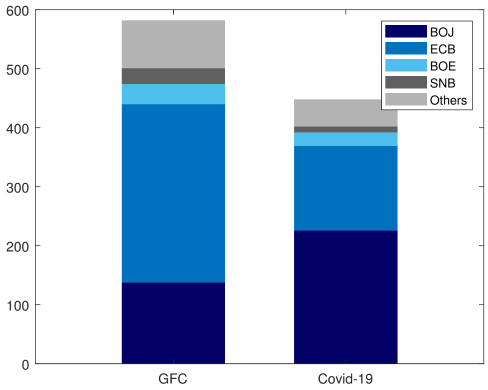
"The Swap Lines are designed to improve liquidity conditions in dollar funding markets in the US and abroad [...] during times of stress. They have helped to ease strains in financial markets and mitigate their effects on economic conditions." (Federal Open Market Committee)

Central banks + Add to myFT

Central banks announce dollar liquidity measures to ease banking crisis

Turmoil prompts authorities to launch daily operations to access dollar funding via standing swap lines

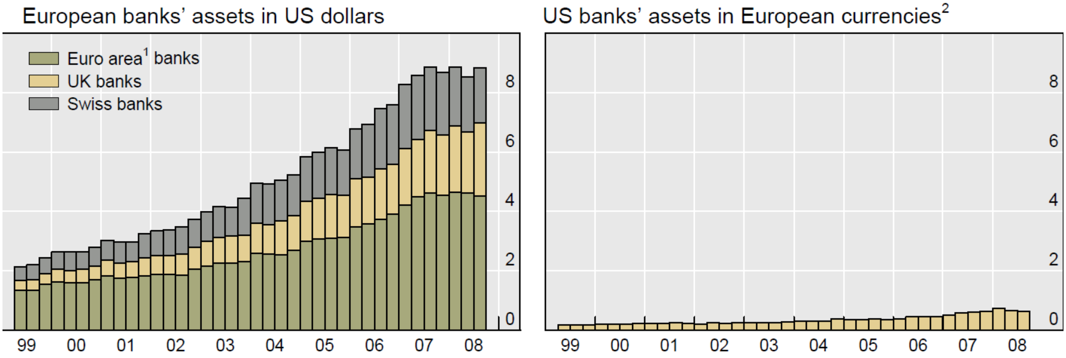
Colby Smith in Washington and **Martin Arnold** in Frankfurt MARCH 19 2023 193



Outstanding Swap Lines usage (US$ billions)

Why Swap Lines now? Back

Asymmetry in international banking

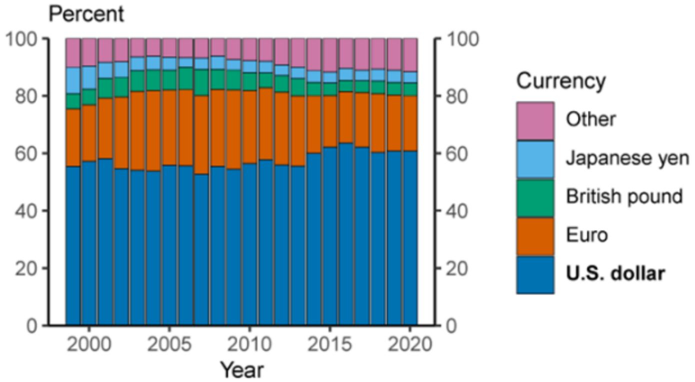


[1] Includes Austria, Belgium, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. [2] Euro, pound sterling and Swiss franc. Pound sterling covers only US banks' UK offices; Swiss franc covers only US banks' Swiss offices.

Sources: BIS consolidated statistics (immediate borrower basis); BIS locational statistics by nationality. Graph 1

Share of international banking claims

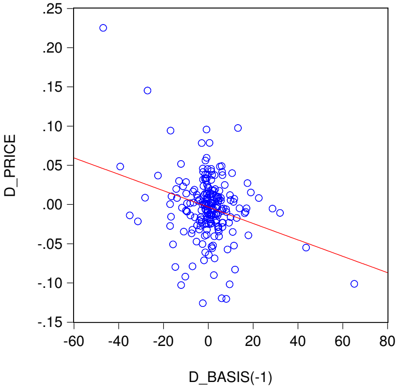
Back



Relative price of US/EU Banks

Back

(a) Linear relation in first differences (2005-2020)



(b) Dynamics around the GFC

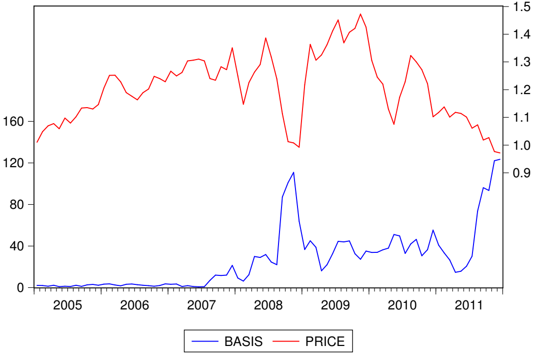
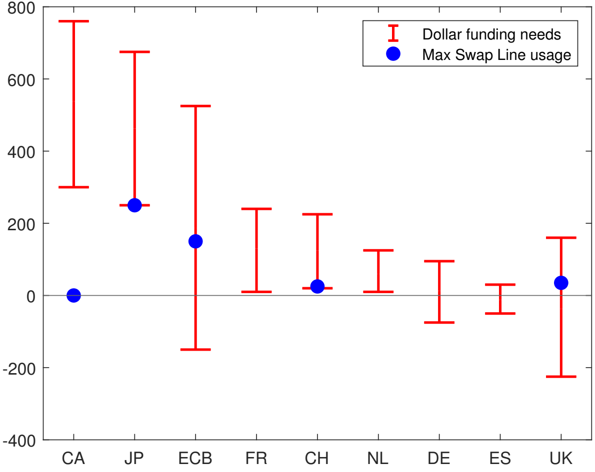


Figure Relative price of US/EU Banks and UIP deviations

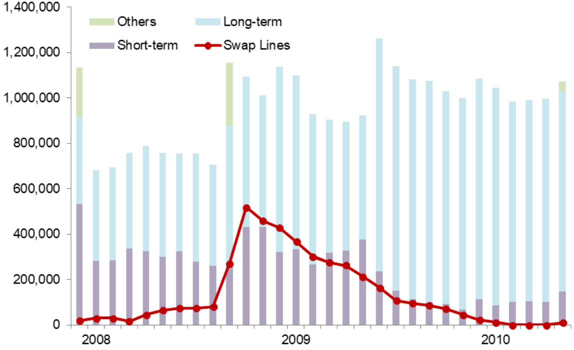
Who used the Swap Lines? Back



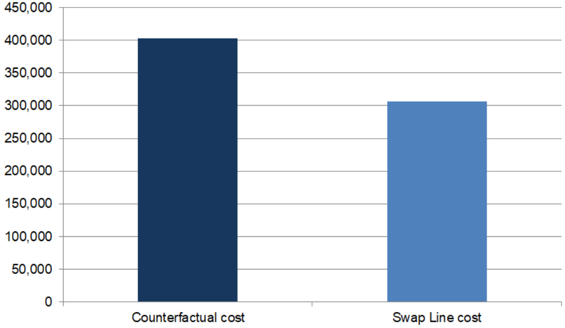
Short-term funding needs and swap lines in 2020, by banking system (USD bn)

Is this relevant in magnitude? Back

(a) Liquidity injections by the ECB outstanding, USD millions



(b) Interest payments of the ECB on Dollar loans in 2008-2009, USD millions



- Swap Lines equivalent to 40% of the ECB euro liquidity injection at the peak of the GFC.
- Over 2008-2009, the ECB/EU-Banks would have had to spend an additional $100 billion.

Related work Back

- **Self-fulfilling crises.** Calvo (1988), Schmitt-Grohé & Uribe (2016), Obstfeld (1996), Cole & Kehoe (2000), Céspedes et al. (2017), Aguiar et al. (2017), Farhi & Maggiori (2018), Bocola & Lorenzoni (2020).
- **Role of the US and the dollar** in the international monetary system. Farhi & Maggiori (2018), Maggiori (2017), Gourinchas, Rey, & Govillot (2018), Kekre and Lenel (2021), Cesa-Bianchi & Eguren-Martin (2021), Obstfeld & Zhou (2022).
- **Empirical work on Swap Lines:** effective in easing strains in dollar funding markets. Baba & Packer (2009), Aizenman & Pasricha (2010), Moessner & Allen (2013), Aizenman et al. (2021), Bahaj & Reis (2020), Goldberg & Ravazzolo (2022), Ferrara et al. (2022).
- **Theoretical work on Swap Lines.** Bahaj & Reis (2022), Eguren-Martin (2020), Marin (2022), Cesa-Bianchi et al. (2022)

EU Households ◂ Back

- Similar preferences,

$$\max_{C_t} \mathcal{U} = \ln(C_1) + \beta \mathbb{E} \ln(C_2)$$

- Endowments Y_t^T and Y_t^N, preexisting positions L, Banks' profits Π

- Bonds: 1) B in EU NT with banks

$$L + Y_1^N + p_1 Y_1^T = p_1 C_1^T + C_1^N + B$$

$$R\, B + \Pi + Y_2^N + p_2 Y_2^T = p_2 C_2^T + C_2^N$$

EU Households ◂ Back

- Similar preferences,

$$\max_{C_t} \mathcal{U} = \ln(C_1) + \beta \mathbb{E} \ln(C_2)$$

- Endowments Y_t^T and Y_t^N, preexisting positions L, Banks' profits Π

- Bonds: 1) B in EU NT with banks 2) $\widetilde{B}$ in US NT with US HH

$$L + Y_1^N + p_1 Y_1^T = p_1 C_1^T + C_1^N + B + e_1 \widetilde{B}$$

$$e_2 R^* \widetilde{B} + R\, B + \Pi + Y_2^N + p_2 Y_2^T = p_2 C_2^T + C_2^N$$

EU Households ◂ Back

- Similar preferences,

$$\max_{C_t} \mathcal{U} = \ln(C_1) + \beta \mathbb{E} \ln(C_2) - \zeta(\widetilde{B})$$

- Endowments Y_t^T and Y_t^N, preexisting positions L, Banks' profits Π

- Bonds: 1) B in EU NT with banks 2) $\widetilde{B}$ in US NT with US HH

$$L + Y_1^N + p_1 Y_1^T = p_1 C_1^T + C_1^N + B + e_1 \widetilde{B}$$

$$e_2 R^* \widetilde{B} + R\, B + \Pi + Y_2^N + p_2 Y_2^T = p_2 C_2^T + C_2^N$$

- Trading bonds in foreign currency entails a small non-pecuniary cost:

$$\zeta(\widetilde{B}) = \begin{cases} \chi & \text{if } \widetilde{B} \neq 0 \\ 0 & \text{otherwise} \end{cases}, \qquad \chi > 0$$

Optimality conditions

- EU FOCs:

$$\text{Euler:} \qquad p_{t+1}C^T_{t+1} = \beta R_t p_t C^T_t$$

$$\text{NT demand:} \qquad C^N_t = \frac{\theta}{1-\theta} p_t C^T_t$$

- US FOCs:

$$\text{Euler:} \qquad p^*_{t+1}C^{*T}_{t+1} = \beta^* R^*_t p^*_t C^{*T}_t$$

$$\text{NT demand:} \qquad C^{*N}_t = \frac{\theta^*}{1-\theta^*} p^*_t C^{*T}_t$$

Multiple equilibria

Back

When can they arise?

Figure Unique Equilibrium (Good)

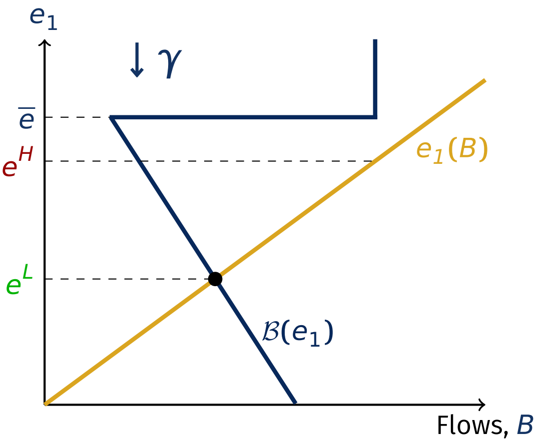
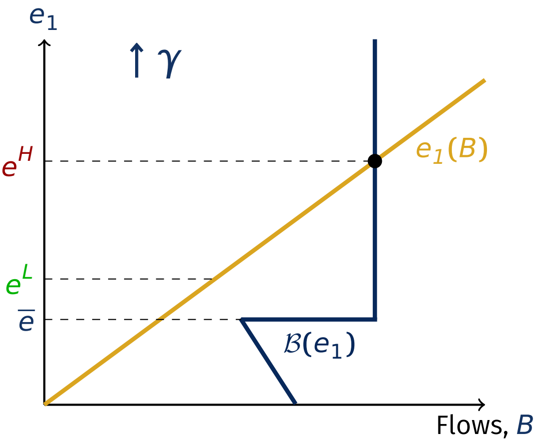


Figure Unique Equilibrium (Bad)



Equilibrium depends on fundamentals

Back

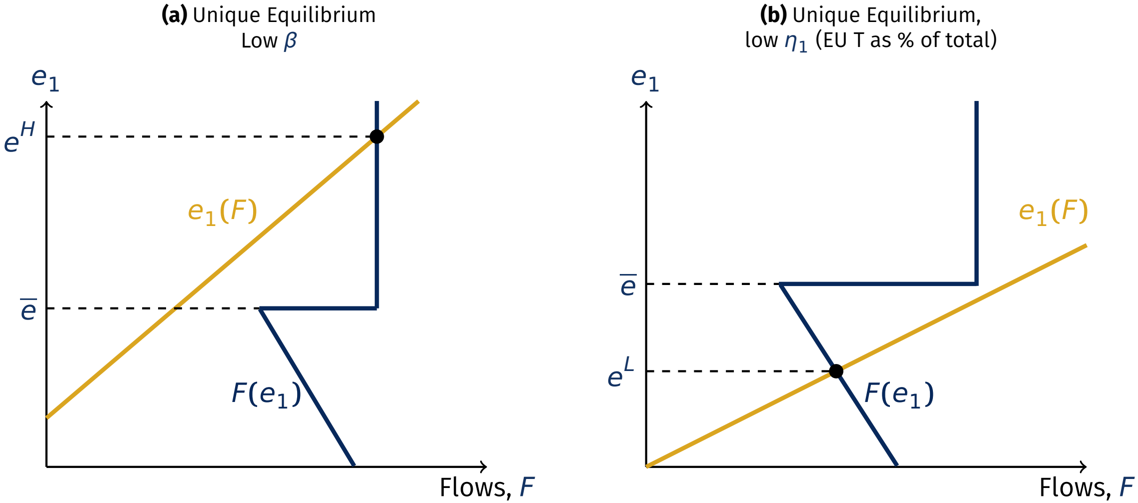


Figure Exchange rate and Capital Flows

Multiple equilibria
Back

When can they arise?

- Bad eq:

$$e_1^H = \frac{1-\eta}{\eta}$$

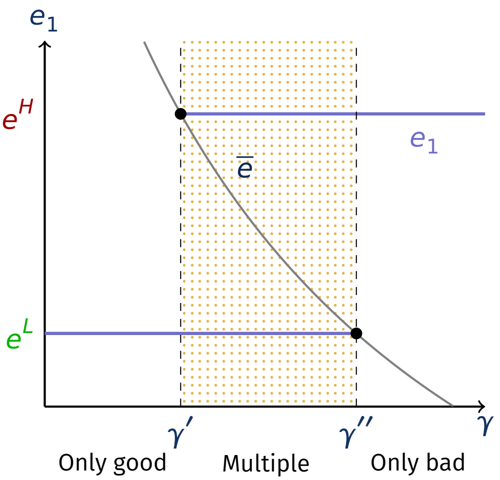
- Good eq:

$$e_1^L = \frac{1-\eta}{\eta + \frac{\theta}{1-\theta}\frac{1}{1+\beta}\left(\frac{1}{R^*}A^* - L^*\right)}$$

- Threshold:

$$\bar{e} \equiv \frac{A/R}{(1+\gamma)L^* - A^*/R^*}$$

Figure Equilibrium exchange rate and financial constraint γ



Multiple equilibria

Back

When can they arise?

- Bad eq:

$$e_1^B = \frac{Y_1^N(1+\beta)\eta^*}{Y_1^{*N}(1+\beta^*)\eta}$$

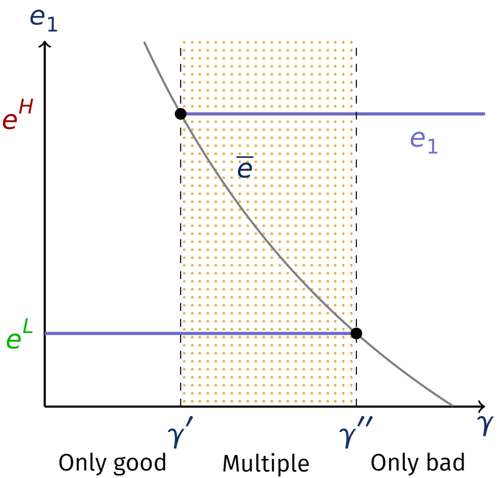
- Good eq:

$$e_1^G = \frac{Y_1^N(1+\beta)\eta^*}{Y_1^{*N}(1+\beta^*)\eta + \frac{\theta}{1-\theta}(A^*/R^* - L^*)}$$

- Threshold:

$$\bar{e} \equiv \frac{A/R}{(1+\gamma)L^* - A^*/R^*}$$

Figure Equilibrium exchange rate and financial constraint γ



Multiple Equilibria

Back

Proposition 1

***Multiple equilibria** are possible if*

$$\underbrace{\frac{\eta^*}{\eta + \frac{1}{1+\beta}\frac{\theta}{1-\theta}(\frac{A^*}{R^*} - L^*)}}_{\text{Good, } e^G} < \underbrace{\frac{A/R}{(1+\gamma)L^* - \frac{A^*}{R^*}}}_{\bar{e}} < \underbrace{\frac{\eta^*}{\eta}}_{\text{Bad, } e^B}$$

- A **crisis is more likely** (multiple eq. or only bad eq.) when:
  - Initial $ debt is high ($\uparrow L^*$)
  - financial markets are tight ($\uparrow \gamma$)
  - return on assets is low ($\downarrow A, A^*$)...

Numerical ex.

Numerical example

Back

Parameter values

Variable	Description	Value	Notes
θ, θ^*	NT preference	0.9	G&M (2015)
β, β^*	Discount factors	0.985	G&M (2015)
η_t	EU % T endowm.	[0.47,0.5]	Data
γ	Financial friction	0.64	Multiple Eq.

FOR THIS EXAMPLE: $A^* = .05$, $L^* = .03$, $A = .07$, $L = .04$, $Y_1^N = 2.58$, $Y_1^{*N} = 2.55$, $Y_2^N = Y_2^{*N} = 2.5$.

Targeted variables

Variable	Description	Target	Model
$\frac{e^B - e^G}{e^G}$	ER depreciation	12.5%	12.5%
	\$ shortage (%)	15%	15%
R^*	US interest rate	1.013	1.013
R	EU interest rate	1.015	1.015

Untargeted variables

Variable	Description	Data	Model
$\frac{A^*}{A^*+Y_2^{*N}}$	US output loss	2.2%	2.0%
$\frac{A}{A+Y_2^N}$	EU output loss	1.8%	2.9%

Comparative Statics

Back

Drop in A^* (USD assets) or increase in L^* (USD liabilities)

Figure State of the economy

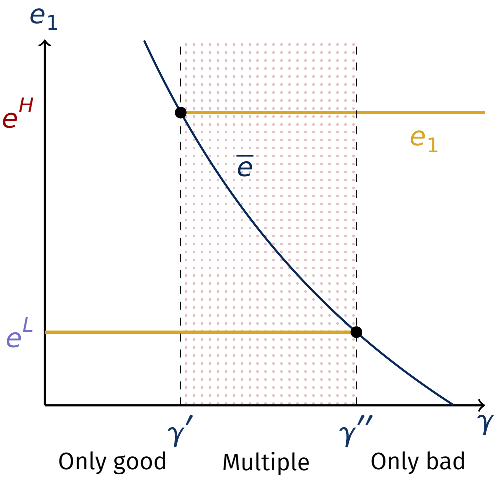
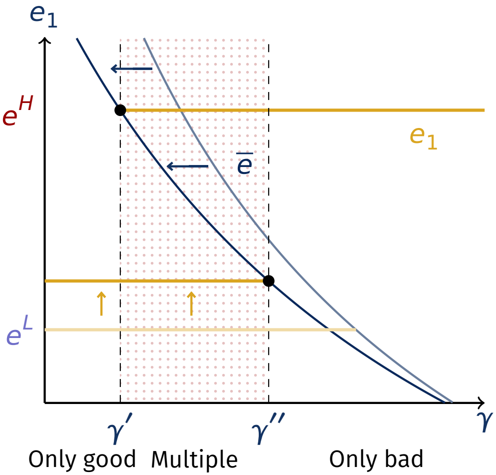
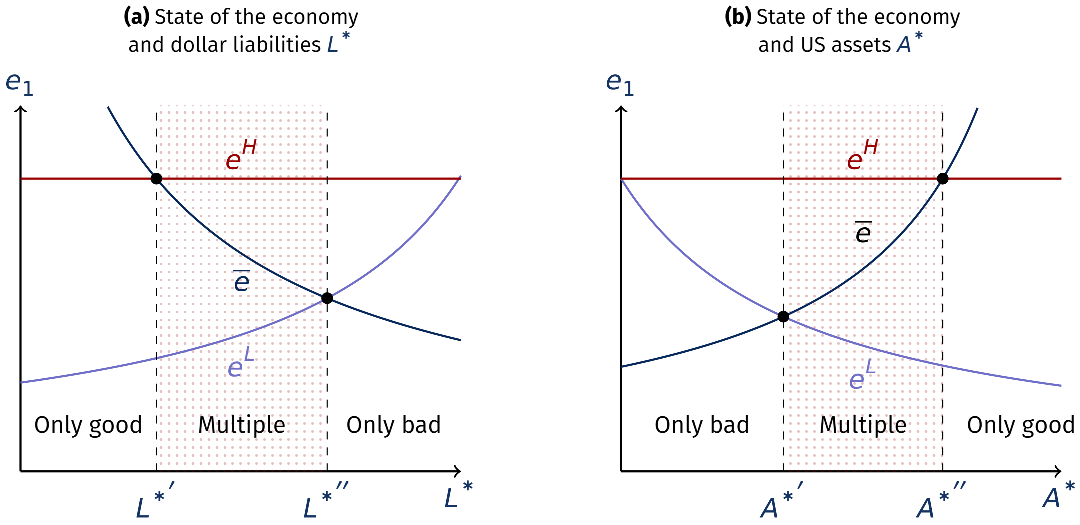


Figure State of the economy after drop in A^* or increase in L^*



Comparative Statics



Lending of Last Resort - ECB

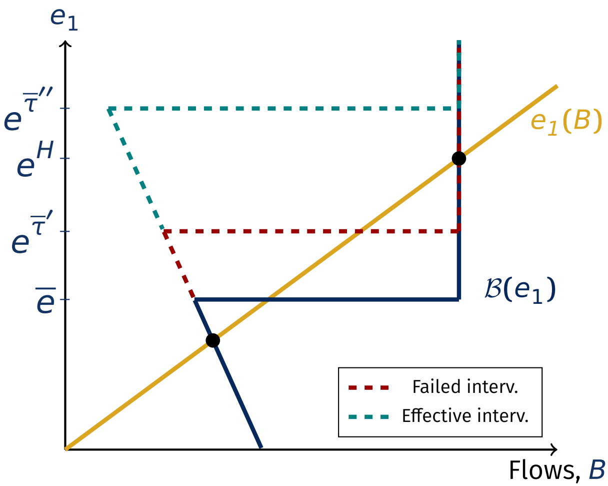
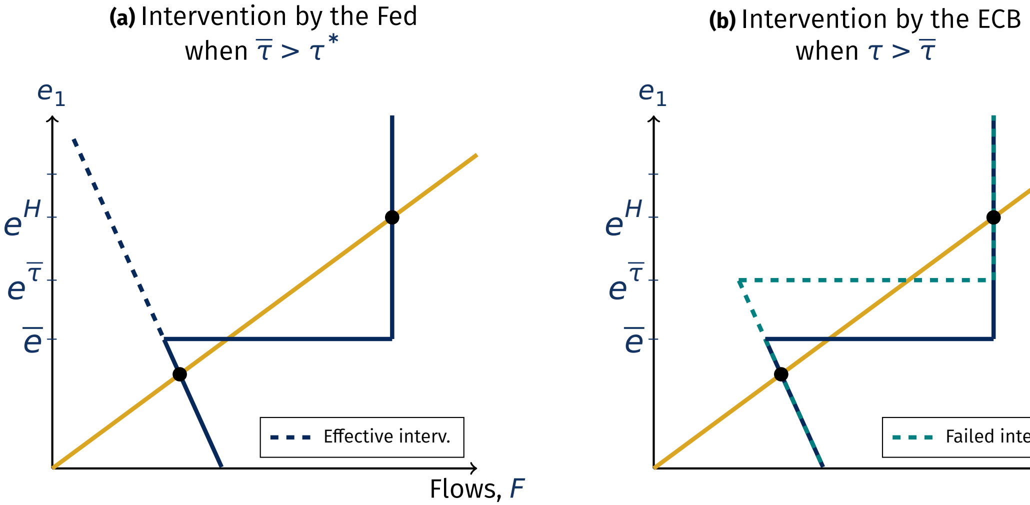


Figure Interventions with $\overline{\tau}' < \overline{\tau}''$

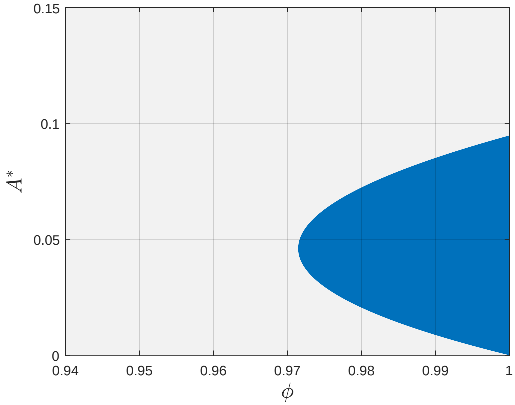
Fed Swap Lines if $\tau > \overline{\tau} > \tau^*$



Incentives for the Fed to intervene

Back

US welfare losses from a collapse
(Pairs of A^* and ϕ)



Note: Gray = Losses. Blue = Gains (Fed does not intervene)

Extensions

Nominal version (w/ monetary policy)

- EU consumption basket now includes **real money balances**, M_t/P_t

$$C_t \equiv \left[(C_t^N)^\theta (C_t^T)^\phi (M_t/P_t)^\omega\right]$$

M_t is the amount of money held by the HH, and P_t is the nominal price level.

- Budget constraint

$$\sum_{t=1}^{2} R^{-t}(p_t^N Y_t^N + p_t^T Y_t^T + M_t^S) = \sum_{t=1}^{2} R^{-t}(p_t^N C_t^N + p_t^T C_t^T + M_t)$$

M_t^S is the seigniorage rebated lump sum by the government. Equal to M_t in equilibrium.

Nominal version (w/ monetary policy)

- Static optimization (US)

$$\frac{M_t^*}{\omega} \equiv m_t^* = p_t^{*N} C_t^{*N} \frac{1}{\theta} = p_t^{*T} C_t^{*T} \frac{1}{\phi}$$

- **Euler equation**: interest rate R_t^* now depends on **current and future money supply**

$$\mathbb{E}(m_{t+1}^*) = m_t^* \beta R_t^*$$

- **US MP tightening** in t pushes the global economy closer to the **bad equilibrium**:
  $\downarrow m_t^* \Rightarrow \uparrow R^* \Rightarrow \downarrow \overline{e}$

$$\downarrow \overline{e} = \frac{A/R}{(1+\gamma)L^* - A^* / \uparrow R^*}$$

Assets in T goods Back

- Banks profits

$$\Pi = e_2 A^* + a + p_2 T - e_2 R^* B^* - RB$$

- From market clearing of tradables

$$p_2 = \frac{1}{Y_2^T + T + Y_2^{*T}} \frac{1-\theta}{\theta} (C_2^N + e_2 C_2^{*N})$$

- Also using UIP $e_2 R^* = e_1 R$, we get

$$e_1 \left[\frac{A^*}{R^*} + \frac{T(A^* + Y_2^{*N})}{R^*(Y_2^T + T + Y_2^{*T})} \frac{1-\theta}{\theta} \right] + \frac{a}{R} + \frac{T(A + Y_2^N)}{R(Y_2^T + T + Y_2^{*T})} \frac{1-\theta}{\theta} > (1+\gamma) e_1 L^*$$

Transferring T goods ◂ Back

- Consider an intervention by the ECB taxing T endowment. It succeeds if

$$
\begin{aligned}
\tau p_1 Y_1^T &> e_1^B L^* \\
\tau \eta_1 \tfrac{1-\theta}{\theta}(Y_1^N + e_1 Y_1^{*N}) &> e_1^B L^* \\
\frac{\tau Y_1^N \eta_1 \frac{1-\theta}{\theta}}{L^* - \tau \eta_1 \frac{1-\theta}{\theta} Y_1^{*N}} &> e_1^B
\end{aligned}
$$

- Whereas from the standard intervention, for the same τ, the condition is

$$
\frac{\tau Y_1^N}{L^*} > e_1^B
$$

- If the endowment of T by EU is low (η_1) or households value NT a lot (high θ), transferring tradables goods might actually be less efficient.

Three-period model

Three-period model

- Banks can **transform 1 unit of EU and US NT goods** in period $t=0$ into r and r^* units in $t=2$, respectively:

$$K \longrightarrow rK \qquad K^* \longrightarrow r^* K^*$$

- Finance investments with short-term **dollar and euro bonds**, D_1 and D_1^*, paying

$$\mathcal{R}_0 \text{ and } \mathcal{R}_0^* = \begin{cases} R_0 \text{ and } R_0^* & \text{with prob. } (1-\rho) \\ 0 \text{ and } 0 & \text{with prob. } \rho \end{cases}$$

- Endogeneizing banks' assets and liabilities:

$$rK \equiv A \quad , \quad r^* K^* \equiv A^* \qquad\qquad R_0 D_1 \equiv L \quad , \quad R_0^* D_1^* \equiv L^*$$

Agents and decisions

- **Banks** face two decisions, both in $t = 0$:
  - How much to invest in K^* and in K.
  - Funding mix between D_1^* and D_1
- **Households** decide if they provide funding in $t = 0$ and in $t = 1$:
  - In $t = 0$: will the bank be able to roll-over the debt next period?
  - In $t = 1$: will the bank divert the funds I give it today?
- **Sunspot variable** S is realized at the beginning of $t = 1$ and **coordinates expectations**
  - $S = 0$ with prob. ρ : pessimistic expectations, banks unable to roll-over debt.
  - $S = 1$ with prob. $(1 - \rho)$: optimistic expectations, banks are able to roll-over debt.

Banks

- Maximize expected profits given ρ, using discount factor M:

$$\text{Max} \quad \mathbb{E}_0(M \cdot \Pi) = (1-\rho) \cdot M^N \cdot \Pi^N + \rho \cdot 0$$

$$\text{where} \quad \Pi^N = e_2 r^* K^* + rK - e_2 R_1^* D_2^* - R_1 D_2$$

subject to

$$\text{(Initial investment)} \qquad e_0 K^* + K = e_0 D_1^* + D_1$$

$$\text{(Roll-over needs)} \qquad e_1 D_2^* + D_2 \geq e_1 R_0^* D_1^* + R_0 D_1$$

$$\text{(IC constraints)} \qquad \mathbb{E}_0(M_1 \cdot \Pi) \geq \gamma \cdot \mathbb{E}_0(e_1 D_2^* + D_2) \quad \text{in } t = 0$$

- **IC constraint binds in $t = 0$:** otherwise, perfect competition leads to zero profits, and banks would not be able to raise funds.

EU Households

- Same preferences as before.
- Trade **euro bonds** with global banks. Budget constraint

$$
\begin{aligned}
Y_0^N + p_0 Y_0^T &= p_0 C_0^T + C_0^N + D_1 \\
Y_1^N + p_1 Y_1^T + \mathcal{R}_0 D_1 &= C_1^N + p_1 C_1^T + D_2 \\
\Pi + Y_2^N + p_2 Y_2^T + R_1 D_2 &= C_2^N + p_2 C_2^T
\end{aligned}
$$

- Interest rate on D_1

$$
\mathcal{R}_0 = \begin{cases} R_0 & \text{with prob. } (1-\rho) \\ 0 & \text{with prob. } \rho \end{cases}
$$

First Order Conditions

- When banks operate, UIP holds

$$\frac{\mathbb{E}(e_{t+1})}{e_t} = \frac{R_t}{R_t^*} \quad \text{for } t = 0, 1$$

- Optimal choice of K and K^* requires that

$$\frac{\mathbb{E}(e_2)}{e_0} = \frac{r}{r^*}$$

- Households' Euler in $t = 0$:

$$R_0 = \frac{1}{1-\rho} \frac{C_1^N}{\beta C_0^N} \qquad R_0^* = \frac{1}{1-\rho} \frac{C_1^{*N}}{\beta^* C_0^{*N}}$$

Optimal Exposure

Optimal investment and exchange rate

- Assume that the financial constraint is binding in $t = 0$. **Optimal investment** in K and K^* (equivalent with (*))

$$K = \frac{r\beta^2 Y_0^N - \frac{1+\gamma}{1-\rho} Y_2^N}{r\left(\beta^2 + \frac{1+\gamma}{1-\rho}\right)}$$

- $\frac{\partial K}{\partial \rho} < 0$: ρ affects the cost of funding and also the expected profits.
- Symmetric countries for simplicity. **Exchange rate** in $t = 0$ is given by

$$e_0^N = \frac{1}{1 + \gamma K^* \frac{2}{\frac{1}{1-\rho} + \beta + \beta^2}}$$

- $\frac{\partial e_0}{\partial \rho} > 0$: Invest. and profits Π are lower, thus $\downarrow$ EU Agg. Demand $\Rightarrow e_t \uparrow$.

Imbalances

- Since the constraint binds in $t = 0$, banks positions are such that the ER matches $\overline{e}$:

$$e_1^N = \overline{e}$$

- Is there any ρ that leads to

$$e_1^N \leq \overline{e} \equiv \frac{rK/R_1 - R_0 D_1 (1+\gamma)}{(1+\gamma)R_0^* B_1^* - r^* K^* / R_1^*} < e_1^C \quad ?$$

- Yes, since e_1^N and $\overline{e}$ are increasing in ρ, and e_1^C is constant.
- **But what determines ρ?**: Define ρ as

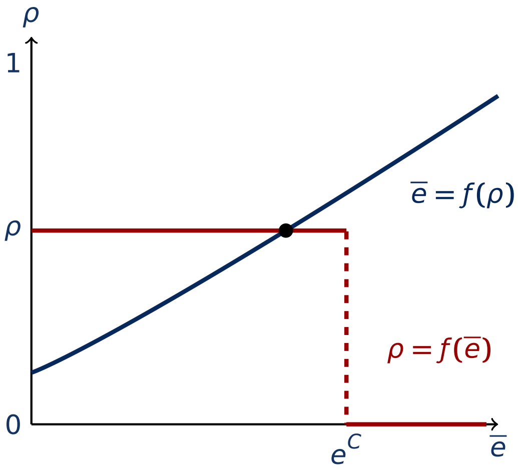
$$\rho = \begin{cases} (0, 1] & \text{if } \overline{e} < e_1^C \\ 0 & \text{if } e_1^C < \overline{e} \end{cases}$$

State of the economy

- Start with $\rho = 0$: banks face very little restrictions $\longrightarrow$ take more debt to invest more.
  - Debt in $ increases: it's cheaper.
  - Banks' profit maximization when $\rho = 0$ implies that $e_1^N = \overline{e}$ is low.
  - But when $e_1^N \leq \overline{e} < e_1^C$, a bank collapse is possible. Thus $\rho = 0 \Rightarrow\Leftarrow$
- Start with $\rho \sim 1$: banks face tight restrictions $\longrightarrow$ take limited debt and invest less.
  - As main source of funding, debt in $ decreases largely.
  - Banks' profit maximization when $\rho \sim 1$ leads to smaller imbalances, and so $\overline{e}$ is high.
  - But when $e_1^C < \overline{e}$, a bank collapse is not possible. Thus $\rho \sim 1 \Rightarrow\Leftarrow$

Bank runs and imbalances

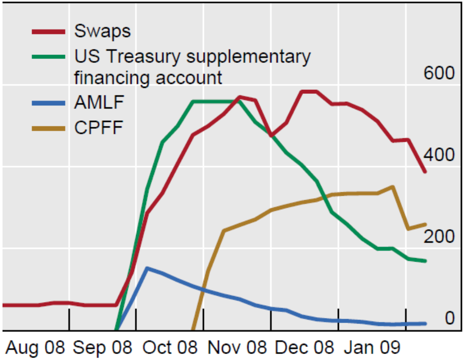
Figure Probability of a bank run and exchange rate that collapses



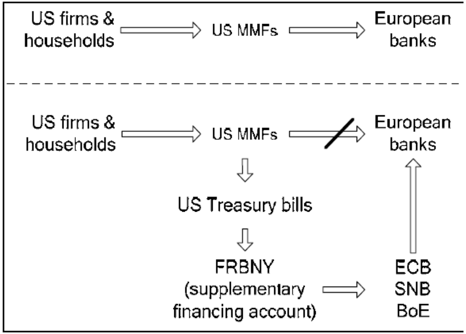
Fed liquidity and official reintermediation

Back

Federal Reserve liquidity operations[1]



Official reintermediation of US dollar credit to non-US banks



[1] Outstanding amounts, in billions of US dollars; Wednesday observations.

Source. Baba, McCauley and Ramaswamy (2009)