A Model of the International Monetary System

Emmanuel Farhi Matteo Maggiori

Harvard University
NBER & CEPR

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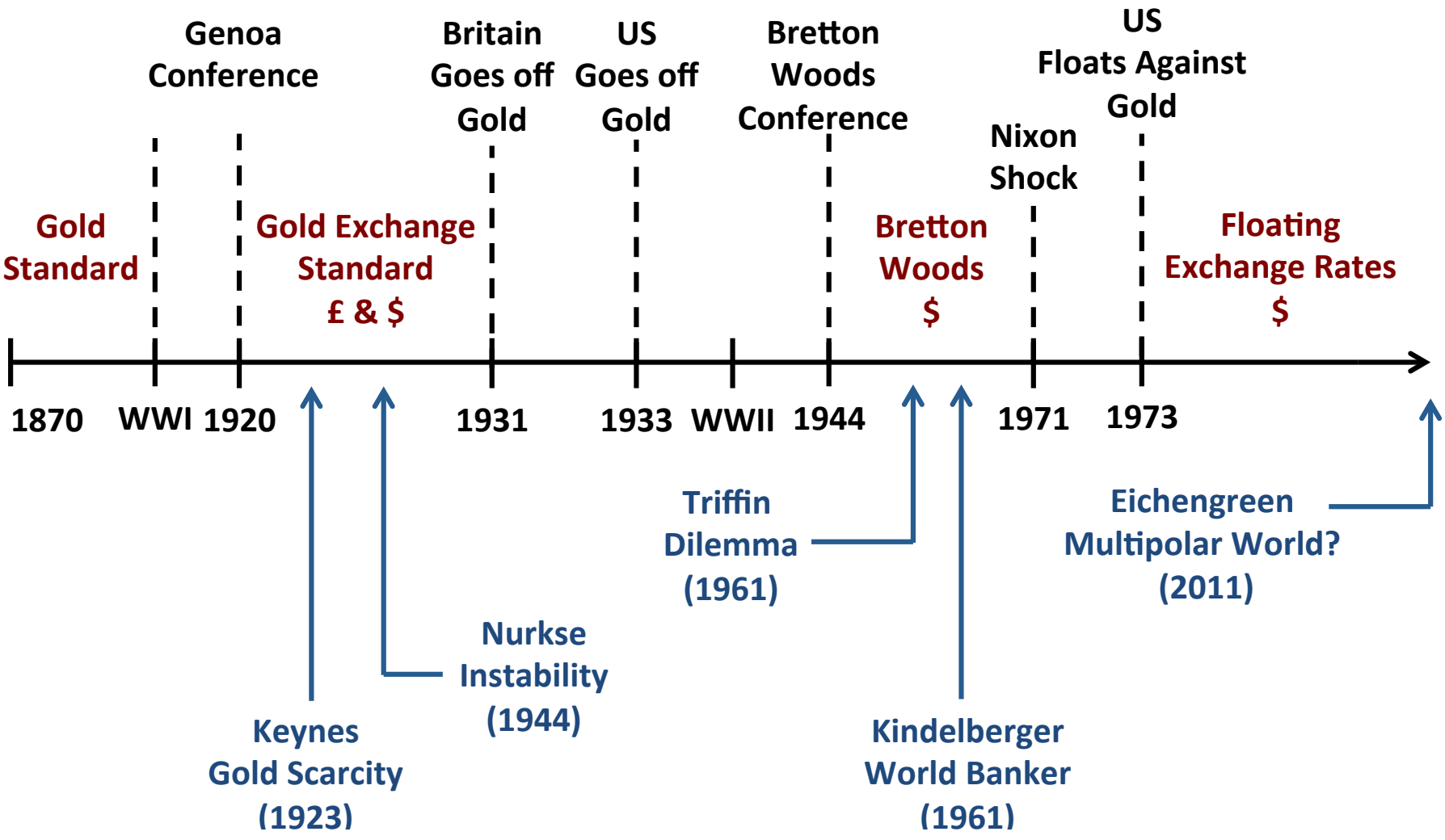
The International Monetary System

- Defining features:
  - Exchange rate regime: fixed, floating, managed
  - Financial architecture: international institutions (WB, IMF), LoLR, risk-sharing agreements (reserve sharing agreements, swap lines)
  - Provision and use of international reserve assets
- Fundamental questions:
  - Hegemonic vs. multipolar system
  - Determinants of reserve status
  - System stability
  - Adequate supply of reserve assets
  - Gold-Exchange standard, floating exchange rates
- Little formal analysis

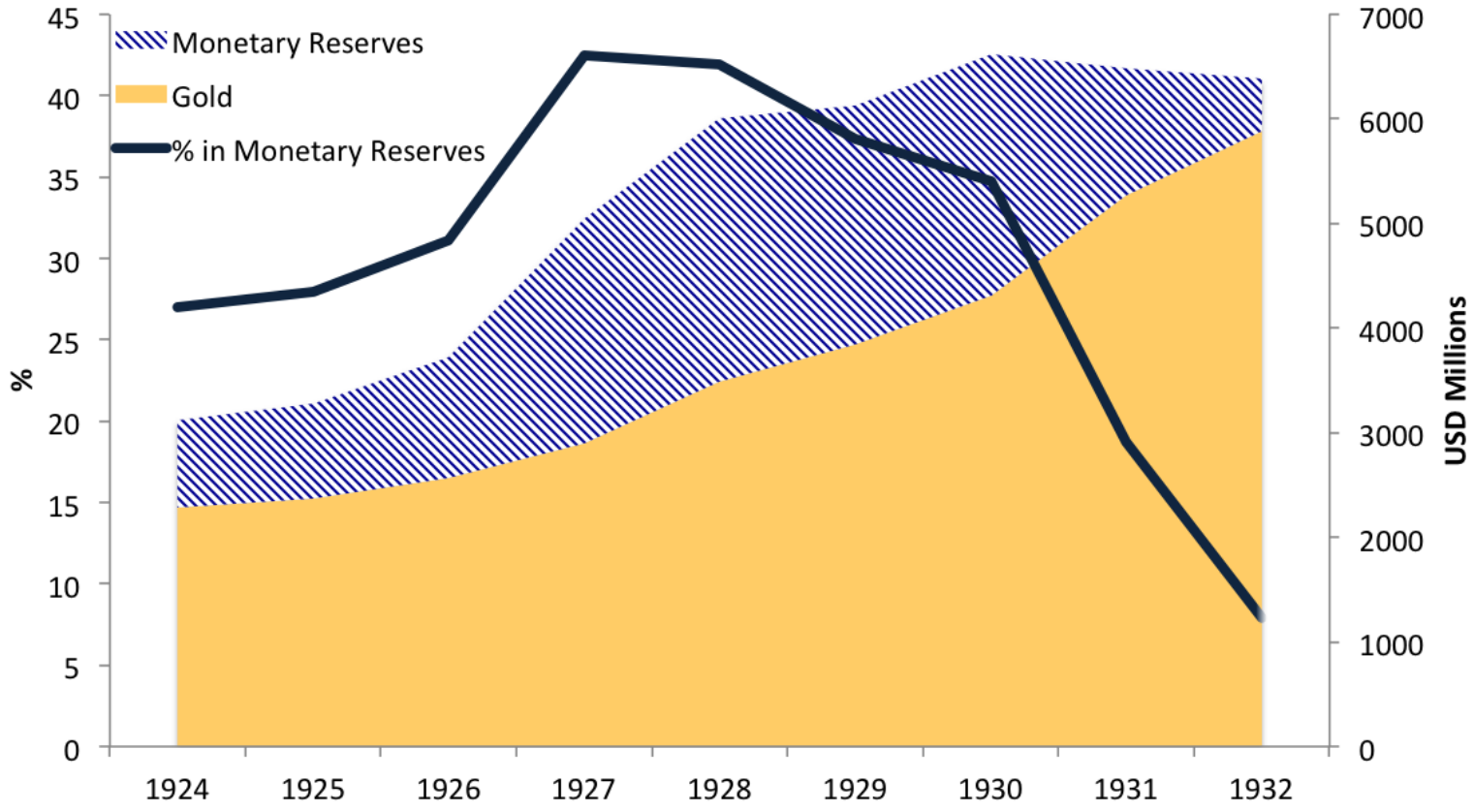
The International Monetary System: History and Thought



Some History and Stylized Facts about the IMS

Fact 1: Emergence of Monetary Assets as Reserves 1920-1935

- After WWI countries return to gold pegs (at pre-war parity)
- Gold supply too low to accommodate demand for reserves
- Most central banks change statute to include monetary assets as reserves: the Gold-Exchange standard



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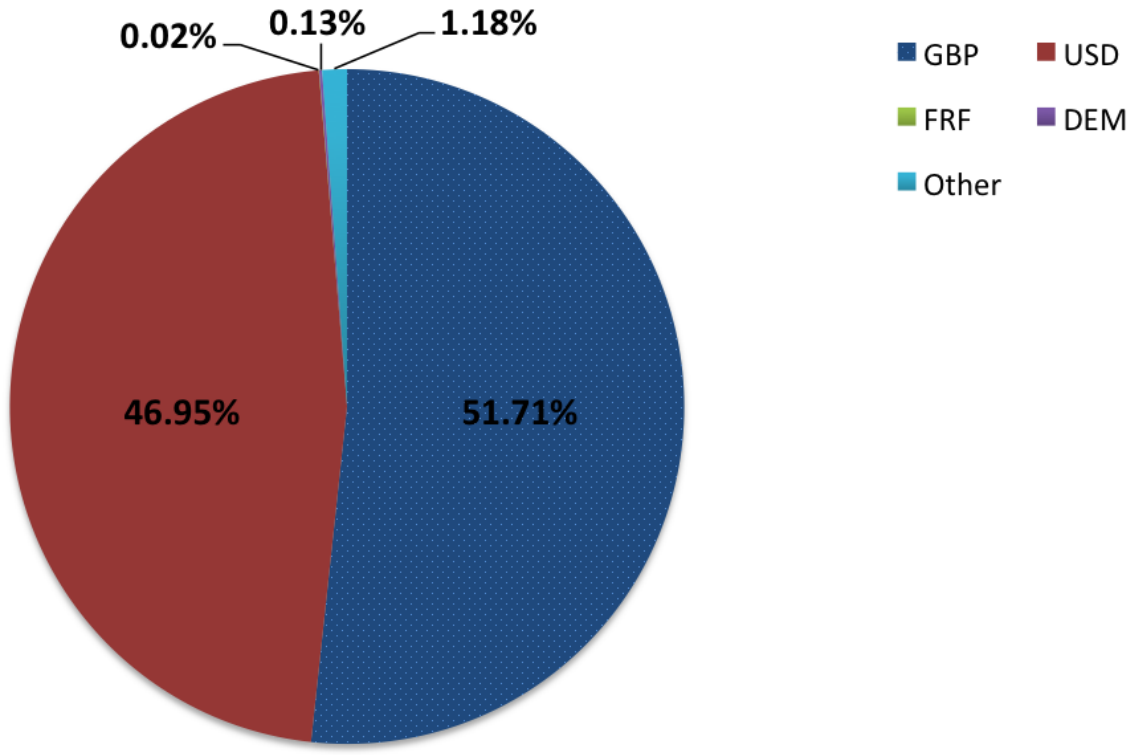


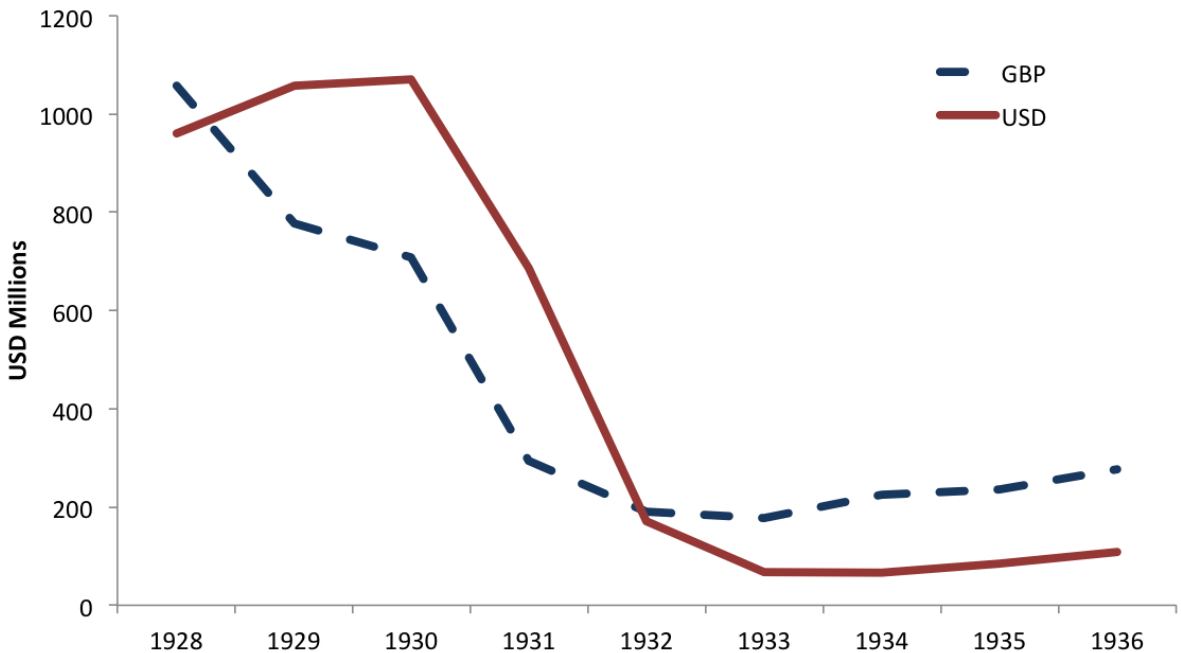
Source: Eichengreen and Flandreau (2009)

- Reserves switch often between pounds and dollars: Nurkse instability

Some History and Stylized Facts about the IMS

Fact 3: The Gold-Exchange standard collapse

- Evidence that Great Depression initially made worse by Gold standard
- In 1931 England depreciates the pound unexpectedly
- Major losses around the world...Banque de France goes "bankrupt"
- Global flight to gold, dollar reserves liquidated, US devalues in 1933



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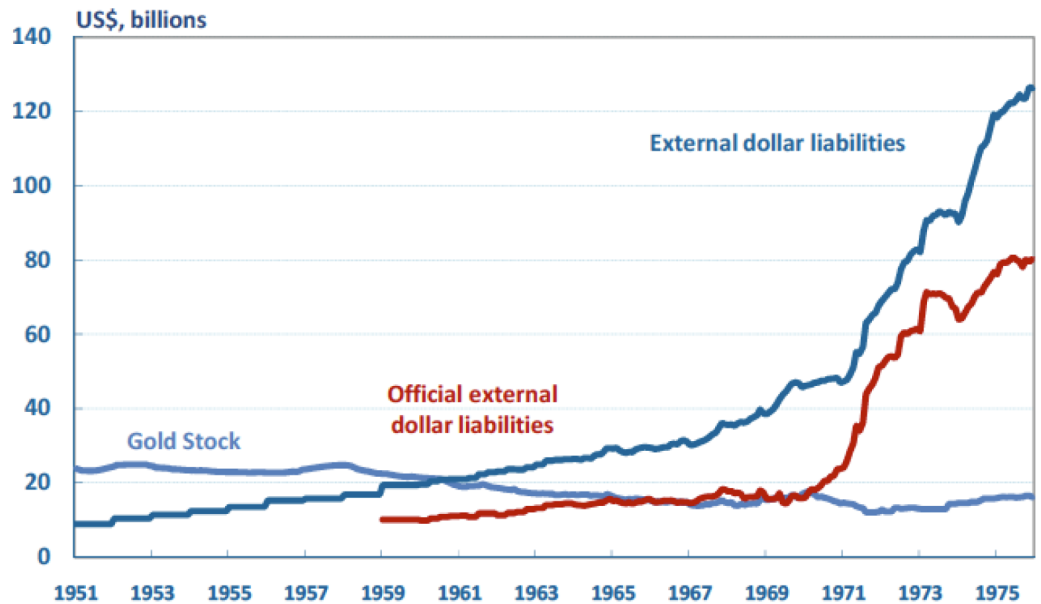
Fact 4: The Bretton Woods collapse in 1973

- Triffin (1961): predicted that the US would face a dilemma between supplying more dollar debt as a reserve asset and maintaining the credibility of the dollar convertibility to gold. Ultimately, the system would be brought down by a confidence crisis. This prediction is known as the Triffin Dilemma
- Nixon Shock: Nixon administration first devalued to $42 an ounce in 1971 and ultimately had to abandon convertibility in 1973

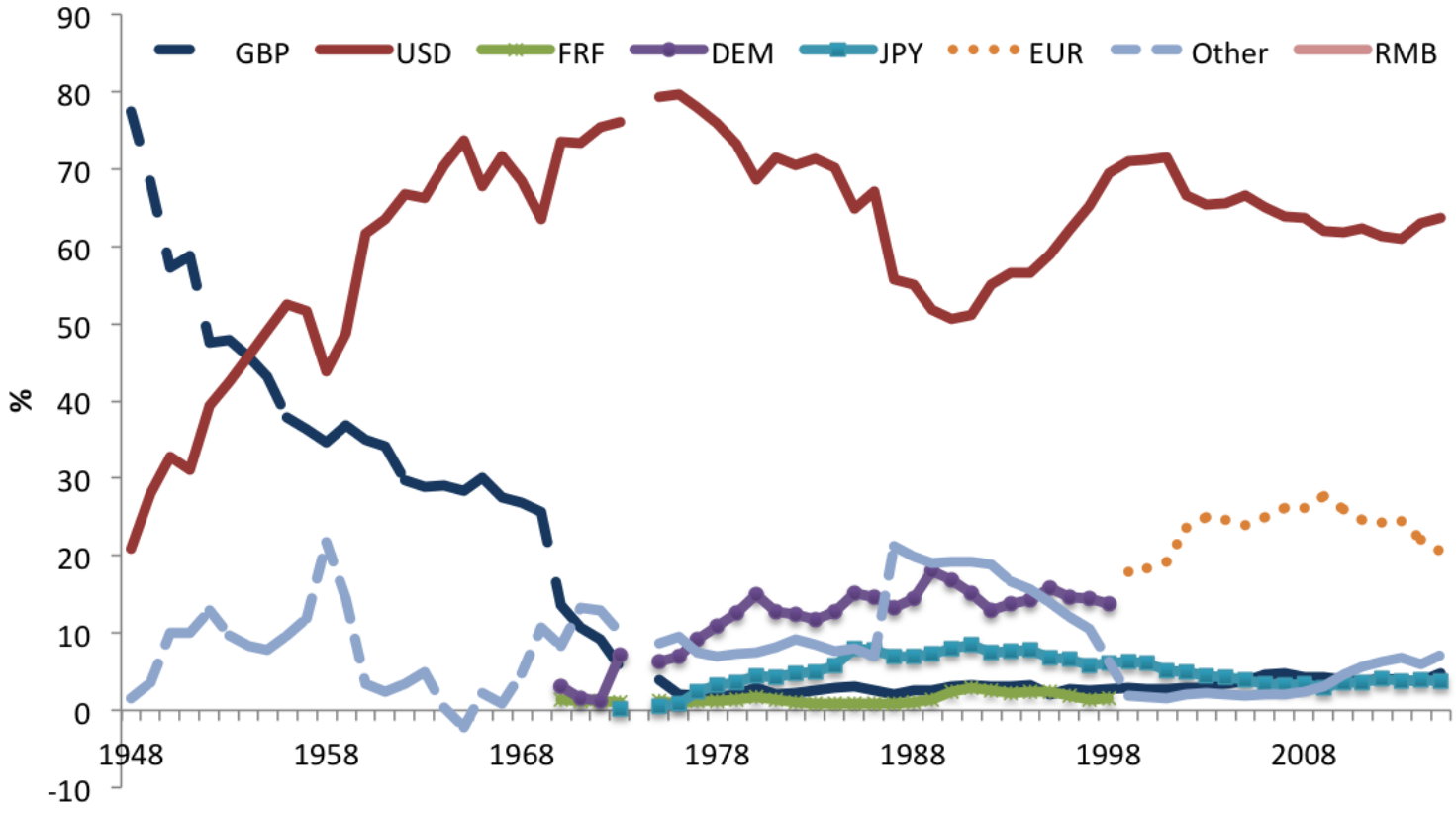


Source: Bordo (2017)

Some History and Stylized Facts about the IMS

Fact 5: Dollar reserves in a floating exchange rate system (1973-2016)

- USD remains the dominant reserve currency with a share of 60-80%



Source: Eichengreen, Chitu, Mehl (2014)

- Triffin logic remains?

Previous Literature

- **Monetary History:** Nurkse (1944), Triffin (1961), Eichengreen (2011), Eichengreen-Flandreau(2009), Chitu-Eichengreen-Mehl(2014), Frieden (2015)

- **Early Literature:** Keynes (1923,1941,46), Kenen (1960), Aliber (1964,1967), Machlup (1965), Hagemann (1969), Officer-Willett (1969), Cooper (1987)

- **Modern Literature:** Caballero-Farhi-Gourinchas (2008,15), Gourinchas-Rey (2007a,b), Mendoza-Quadrini-Rioss-Rul (2009), Farhi-Gourinchas-Rey (2011), Gourinchas-Govillot-Rey (2011), Maggiori (2012), He-Krishnamurthy -Milbrandt (2015)

- **Currency Competition Litterature**: Friedman (1960), Hayek (1976), Klein (1975), Tullock (1975), Taub (1990), Kiyotaki-Matsuyama-Matsui (1993), Trejos-Wright (2001), Marimon-Nicolini-Teles (2012)

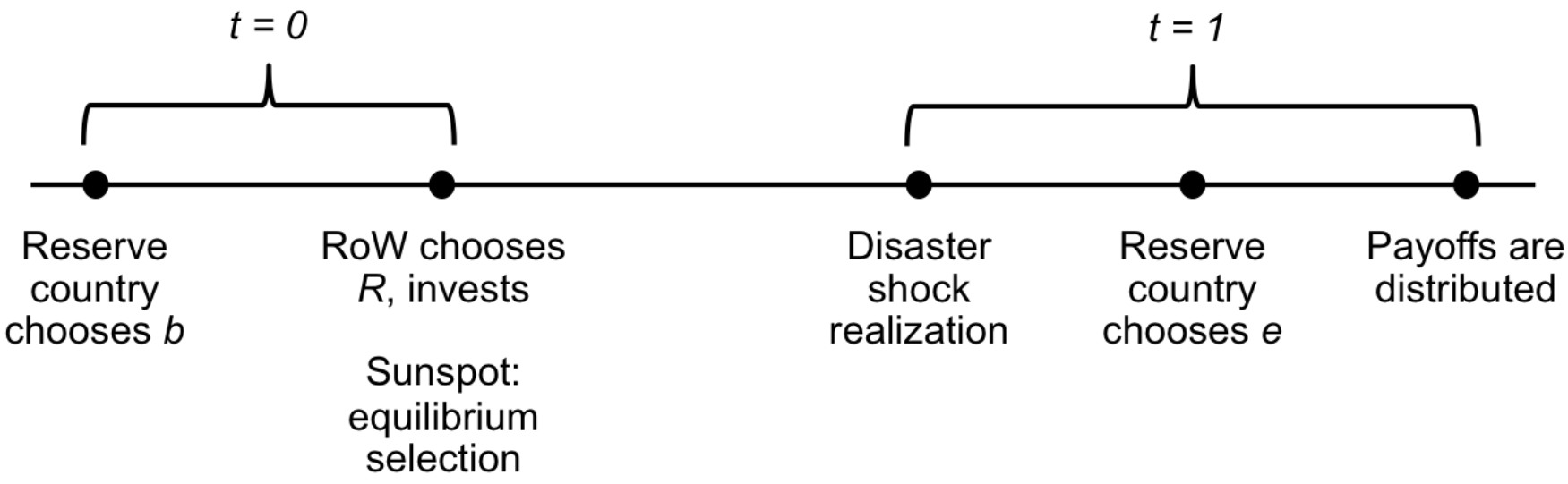
- **Sovereign Debt Litterature**: Calvo (1988), Cole-Kehoe (2000),Lizarazo (2010), Arellano-Bai (2014), Aguiar-Chatterjee-Cole-Stangebye (2016), Azzimonti-Quadrini (2016)

The Hegemon Model

- Two periods: $t = 0, 1$. Two countries: Reserve country and RoW
- World risky asset with variance σ^2 in perfectly elastic supply:
  - $R_H^r > 1$ if no disaster, probability $(1 - \lambda)$
  - $R_L^r < 1$ if disaster, probability λ
- Reserve country:
  - Monopolistic supplier of a nominal bond that pays R in Reserve currency
  - At $t = 1$, if disaster occurred, chooses whether to depreciate by $e_L < 1$
  - Risk neutral with time preference $\delta^{-1} = E[R^r]$
- RoW:
  - Risk averse: mean-variance preferences over $t = 1$ consumption
  - Receives endowment w^* at $t = 0$ and invests in risky and safe assets

Limited Commitment Problem and Timing

- Limited exchange-rate commitment and Calvo (1988) timing:
  - $t = 0^-$: Reserve country decides how much debt b to issue
  - $t = 0^+$: sunspot realized, Row investors choose portfolio, R determined
  - $t = 1$: shocks realized, Reserve country chooses whether to depreciate



Decision to Devalue at time t=1 in a Disaster

Depreciate iff:

$$\underbrace{bR(1-e_L)}_{\text{fiscal benefit of depreciation}} > \underbrace{\tau(1-e_L)}_{\text{cost of depreciation}}$$

- Fiscal burden rule: devalue iff $bR > \tau$
- Direct cost
- Reduced form for (later) infinite-horizon commitment problem

Demand for Safe Assets

- If bond expected to be safe, finitely elastic demand:

$$R - E[R^r] = -2\gamma\sigma^2(w^* - b)$$

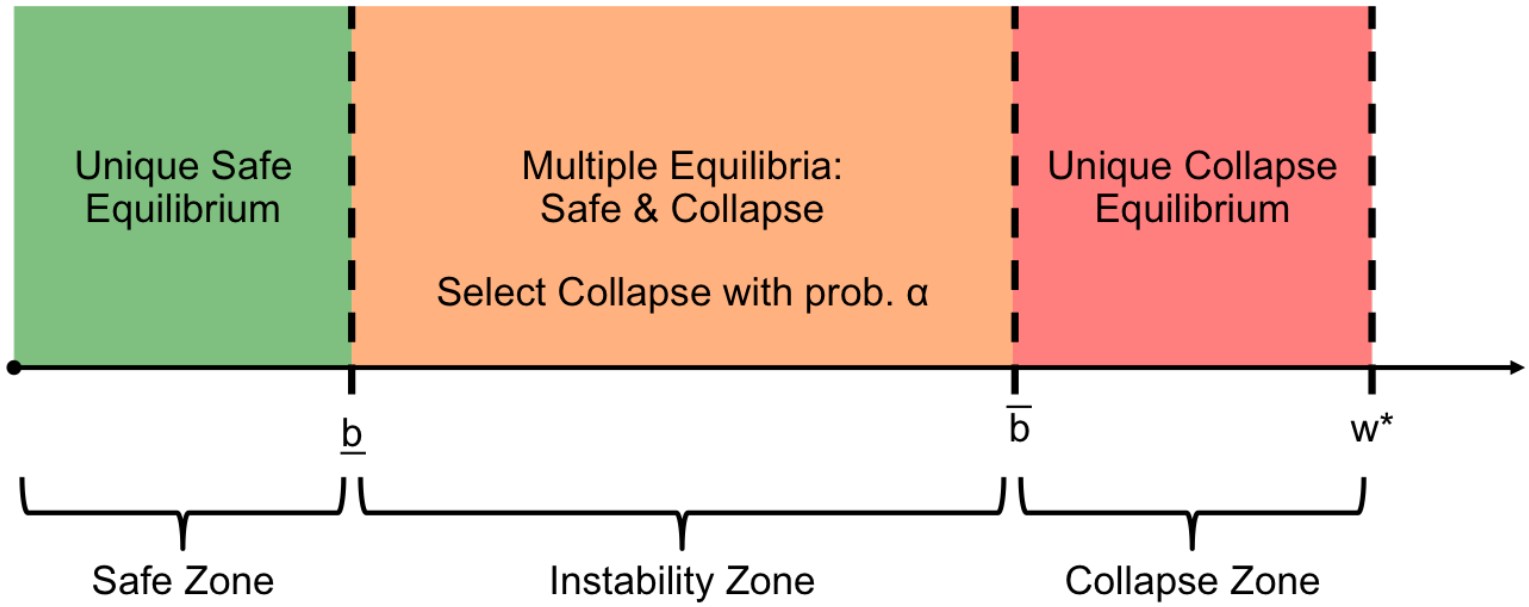
- If bond expected to be risky, infinitely elastic demand:

$$RE^r[e] - E[R^r] = 0 \quad \text{and} \quad 0 \leq b \leq w^*$$

- In paper: liquidity benefits, network effects, private issuance

Assumption: risky bond and risky asset are perfect substitutes $e_L = \frac{R^r_L}{R^r_H}$

The Three Regions of the International Monetary System



Issuance

- Issuance problem of the Hegemon

$$\max_{b}(1-\alpha(b))b(E[R^r]-R^s(b))-\alpha(b)\lambda\tau(1-e_L)$$

where

$$R^s(b)=E[R^r]-2\gamma\sigma^2(w^*-b)$$

- Solve first under full commitment
- Solve then under limited commitment

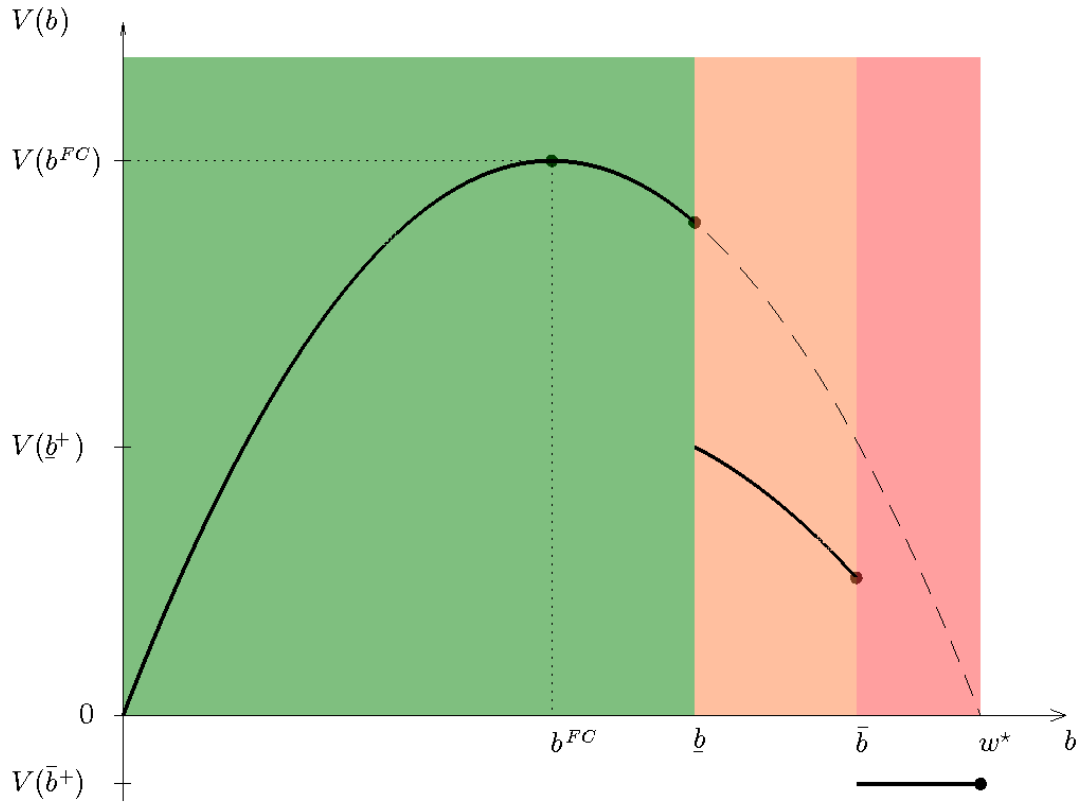
Equilibrium under Full Commitment

- Monopolist optimal supply: $E[R^r] - R^s(b) - b\underbrace{R^{s\prime}(b)}_{2\gamma\sigma^2} = 0$

- Monopoly rent (Exorbitant Privilege) by influencing price of risk:

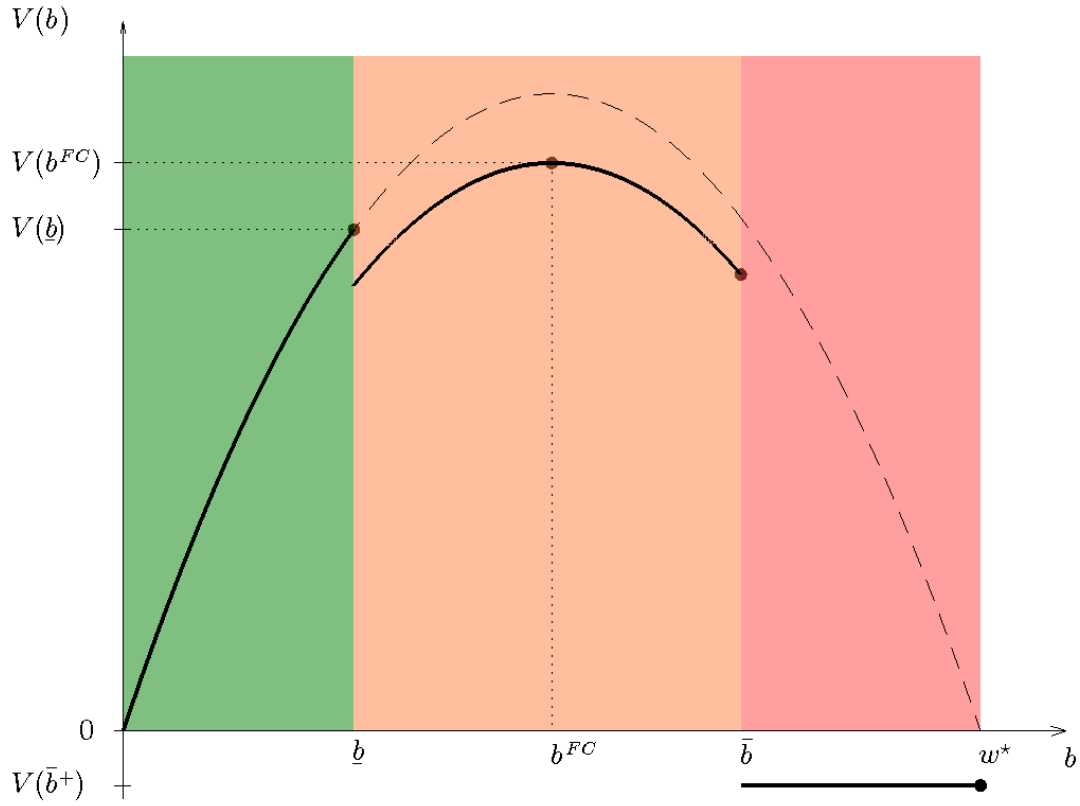
$$\underbrace{b^{FC}}_{\frac{1}{2}w^*}\underbrace{(E[R^r] - R^{s,FC})}_{\gamma\sigma^2 w^*} = \frac{1}{2}\gamma\sigma^2 w^{*2}$$

Equilibrium with Limited Commitment: Low Demand



- If b^{FC} in Safe Zone, issue b^{FC}
  - RoW savings are sufficiently low: $\downarrow w^*$
  - Commitment technology is sufficiently good: $\uparrow \tau$

Equilibrium with Limited Commitment: High Demand

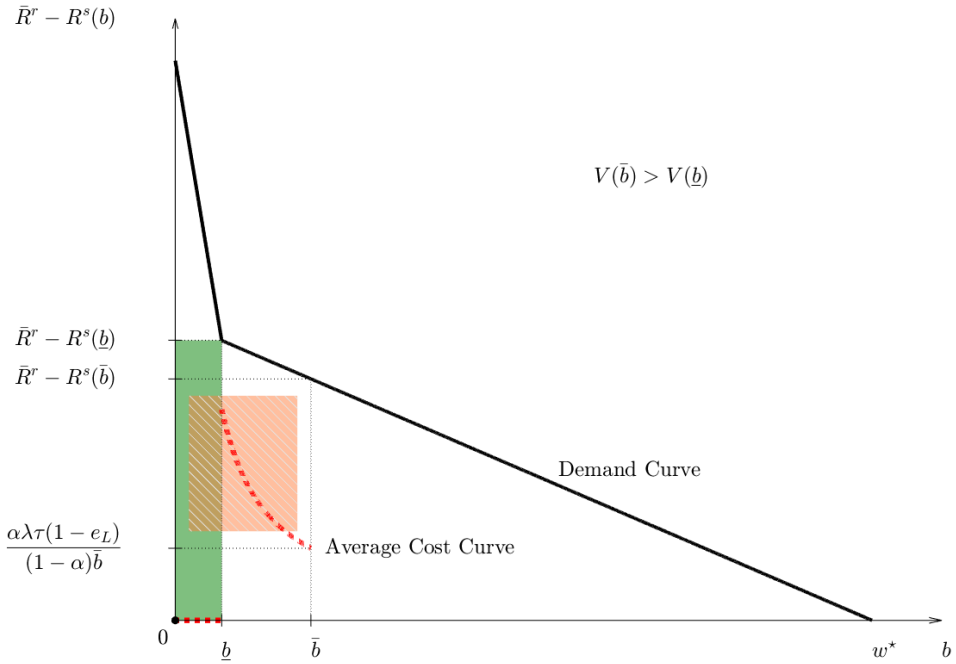


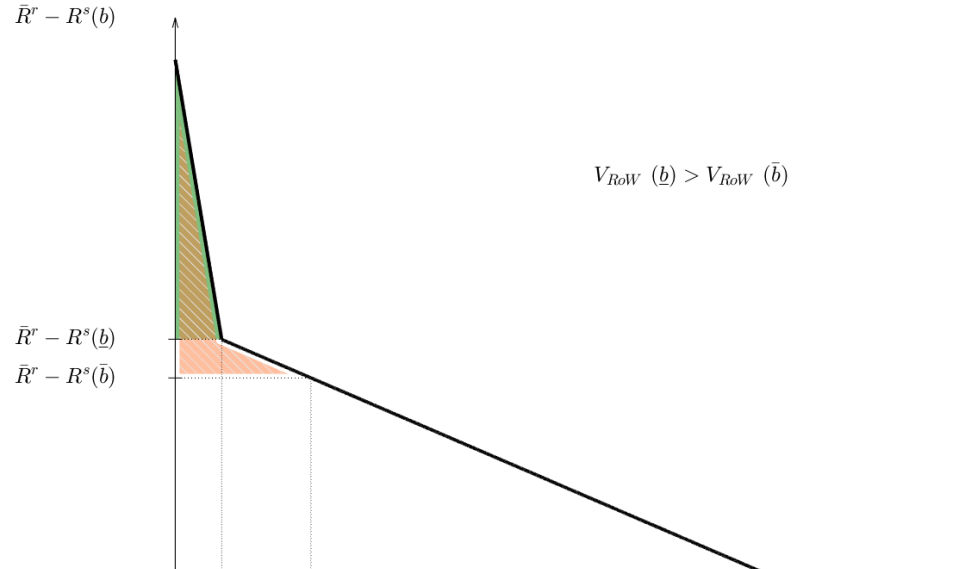
- If b^{FC} in Instability zone, **Triffin dilemma**:
  - Issue $\underline{b} \Rightarrow$ safe
  - Issue $b^{FC} \Rightarrow$ risk of collapse
- Bridge with **World Banker** view: banking is fragile

The Triffin Dilemma: Social vs. Private

- Within zones, too little issuance: monopolist does not internalize marginal increase in consumer surplus from marginal sale
- Across zones, countervailing force: monopolist does not internalize risk of destroying infra-marginal consumer surplus
- Depends on shape of demand curve $R^s(b)$:
  - Linear $\Rightarrow$ under-issuance
  - Sufficiently concave $\Rightarrow$ over-issuance
- Analogy with classic Spence (1975) analysis of quality under monopoly

The Triffin Dilemma: Welfare Analysis





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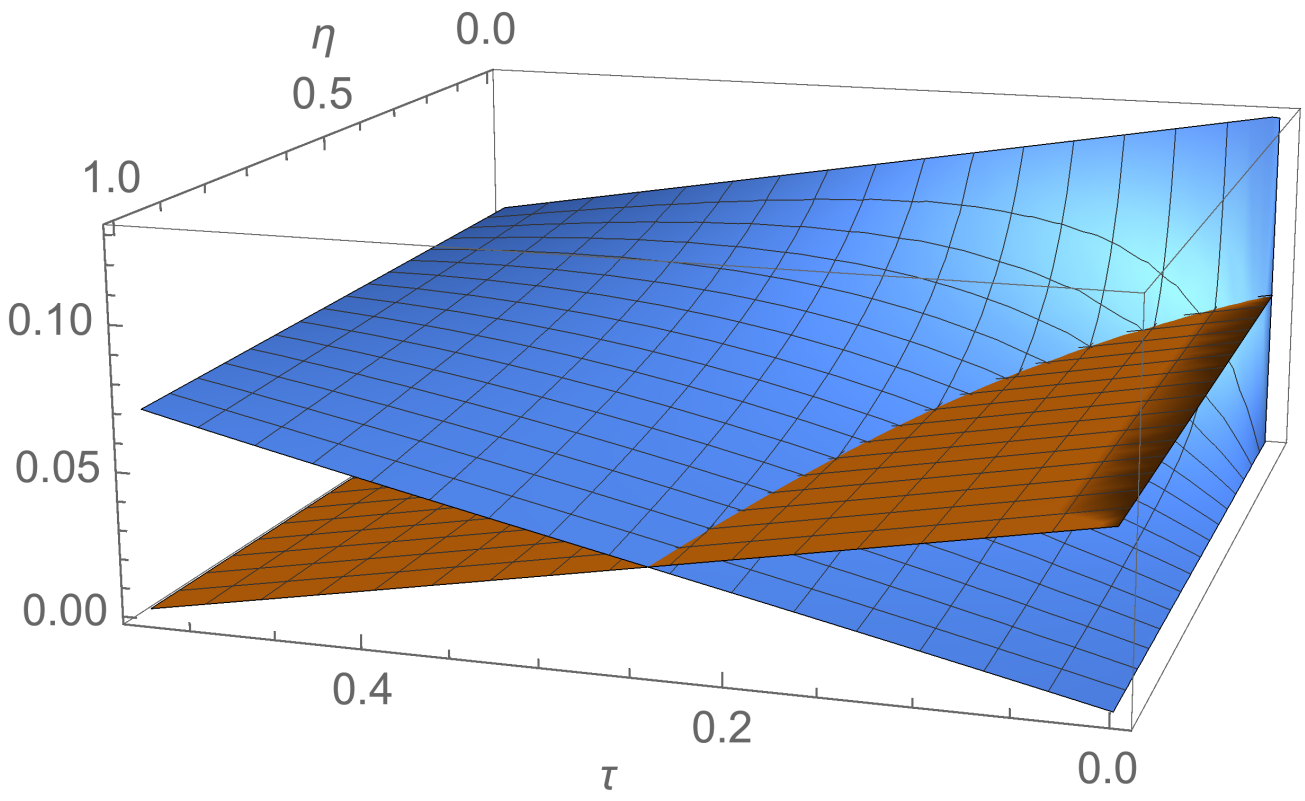


- Varying level of commitment (τ) and convexity of demand curve (η)
- Surfaces are the threshold crisis probabilities that make the Hegemon (α^*_m) and the RoW (α^*_{row}) indifferent between safe or risky issuance.

Benefits of Multipolar System: Competition

- Multipolar world with n identical countries-issuers of reserve currencies
- Issuers compete à la Cournot issuing $b_{i,n}$
- Equilibrium under full commitment all n

$$\begin{aligned} b_n^{FC} &= \frac{n}{n+1} w^* \\ R_n^{s,FC} &= E[R^r] - \frac{2}{n+1} \gamma \sigma^2 w^* \end{aligned}$$

- Same equilibrium under limited commitment for n sufficiently high
- First best obtains in perfect competition limit $n \to \infty$
- Benefits of multipolar systems (**Eichengreen**): low rents and stable
- Biggest benefits from first few entrants

Costs of Multipolar System: Nurkse Instability

Nurkse (1944): multipolar systems are unstable because investor sentiment swings among candidates for reserve status

- **Equilibrium Selection 1:** if one country alone, then coordinate on safe. If two countries, one has most favorable expectations $\alpha_i = 0$ and the other the most unfavorable expectations $\alpha_{-i} = 1$
  - Asymmetric equilibrium (switches over time, in paper)
- **Equilibrium Selection 2:** if one country alone, then coordinate on safe. If two countries, one at random has most favorable expectations $\alpha_{\tilde{i}} = 0$ and the other the most unfavorable expectations $\alpha_{-\tilde{i}} = 1$
  - Instability from coordination problems among substitutable reserve assets

More in Paper

- Reserve currencies as funding currencies with private issuance
- Infinite horizon:
  - τ as loss of franchise value of reserve status
  - Competition reduces franchise value
- Endogenous emergence of a Hegemon
  - Characteristics of Hegemon: fiscal capacity, reputation, goods pricing
  - Amplification of differences: liquidity and network effects
  - Natural monopoly from costly reputation building
- LoLR and risk-sharing arrangements
- Exchange rate regimes: sticky prices, gold exchange standard, floats and ZLB

The Infinite Horizon Model

- Actions' timing in all periods are identical to 1-period model
- Disaster risk i.i.d.
- RoW modeled as 1-period OLG
  - The Young invest endowment w^*
  - The Old consume proceeds of their earlier investment
- Reserve countries: 1-period nominal debt and devaluation $\{1, e_L\}$
- Strategies depend on devaluation (not issuance) history
- **Trigger Strategy Equilibrium:** $R = R_H^r$ for any b in all future periods if in current period the Reserve country devalues if facing $R < R_H^r$

The Hegemon Model: Infinite Horizon

- In each period, the Reserve country chooses not to devalue iff:

$$\underbrace{b\frac{E[R^r]-R}{E[R^r]-1}}_{\text{Present Value of Rents}} \geq \underbrace{bR(1-e_L)}_{\text{One-off devaluation gain}}$$

- Take $\alpha = 0$ for simplicity
- $\approx$ endogenous τ

The Hegemon Model: Infinite Horizon, Equilibrium Issuance

- **Full Commitment:** under full commitment optimal issuance is

$$\max_b b \frac{E[R^r] - R^s(b)}{E[R^r] - 1}$$

  b^{FC} and R^{FC} are identical to the 1-period model

- **Limited Commitment:** equilibrium issuance is $\min(b^{FC}, \bar{b})$

Competition in the Infinite Horizon Model

- By analogy with 1-period model, best responses:

$$b_{i,n} = \min(b_{i,n}^{FC}(b_{n-1}), \bar{b}_n)$$

- Loss of commitment from competition through decreased rents

- So severe that total issuance independent of n:

$$\bar{b}_n = \frac{\bar{b}_1}{n}$$

- Connected to, but different from Marimon, Nicolini, Teles (2012)

Nurkse Instability in the Infinite Horizon Model

- Assume IMS stable under Hegemon ($\alpha = 0$) with issuance $\bar{b}_{1,\alpha=0}$
- Consider IMS under duopoly
- **Equilibrium Selection:** one country safe, other not, random
- Individual issuance $\bar{b}_{1,\alpha=0.5} < \bar{b}_{1,\alpha=0}$
- IMS unstable and effective issuance of reserves falls
- Analogy with argument in banking literature of financial destabilization through competition via erosion of franchise value

Liquidity and Network Effects

- Capture liquidity/networks with “safe assets in utility function" (Stein 2012) with $B = (b, \tilde{b})^T$:

$$E[C_1^*] - \gamma Var(C_1^*) + (B^T \omega + B^T \Omega B)\mathbf{1}_{\{E^+[e]=1\}}$$

- Demand function isomorphic to basic model

$$R^s(b) = \bar{R}^r - 2\hat{\gamma}\sigma^2(\hat{w}^* - b)$$

where $\hat{\gamma} \equiv \gamma - \frac{2\Omega_{11}+\Omega_{12}+\Omega_{21}}{2\sigma^2}$ and $\hat{w}^* \equiv w^* \frac{\gamma}{\hat{\gamma}} + \frac{\omega_1}{2\hat{\gamma}\sigma^2}$.

Private Issuance

- Mass μ of private issuers within the Hegemon country who can each issue one unit of debt denominated in reserve currency
- Each issuer can issue at a cost η distributed uniform over $[0, \xi]$
- Total issuance

$$b^T = b + \frac{\mu}{\xi}(\bar{R}^r - R^s(b^T))$$

- Demand curve isomorphic to basic model

$$\hat{R}^s(b) = \bar{R}^r - 2\hat{\gamma}\sigma^2(w^* - b)$$

where $\hat{\gamma} \equiv \frac{\gamma}{1+\frac{\mu}{\xi}2\gamma\sigma^2}$

LoLR and Risk-Sharing Arrangements

- IMF facilities, reserve-sharing agreements, swap lines
- See paper
- Idiosyncratic shocks in each RoW country
- Precautionary savings increases demand for reserves assets
- Risk-sharing arrangements for idiosyncratic risk reduce demand for reserve assets
- Reduces probability of Collapse, stimulates economy if Gold Exchange Standard or ZLB

Emergence of a Hegemon: Fiscal Capacity and Networks

- Full commitment for simplicity
- Repaying bR costs $bR\phi$ with $\phi > 1$ (marginal cost of public funds)
- Duopoly $i \in \{1, 2\}$ with $\phi_1 < \phi_2$
- Network/liquidity externality:

$$R_i^s(b_i; b_{-i}) = \bar{R}^r - 2\gamma\sigma^2(w^* - (b_i + b_{-i})) - \omega_1 - 2\Omega_{11}(b_i + b_{-i}) - (\Omega_{12} + \Omega_{21})b_i$$

- Difference in equilibrium issuance:

$$b_1 - b_2 = \frac{\bar{R}^r(\frac{1}{\phi_1} - \frac{1}{\phi_2})}{2(\gamma\sigma^2 - \Omega_{11} - \Omega_{12} - \Omega_{21})}$$

- Endogenous amplification of small differences generates a Hegemon

Emergence of a Hegemon: IMS Meets IPS

- Complementarity between reserve and goods' pricing currency
  - More prices rigid in given currency...
  - ...lower real impact of devaluation on repayment...
  - ...lower incentives to devalue...
  - ...competitive advantage for reserve currency ($\approx \tau \uparrow$, $e_L \downarrow$)
- Extreme example: all prices sticky in dollars $\rightarrow$ full commitment for US
- Prevalence of USD goods pricing in world trade (Gopinath (2015))

Emergence of a Hegemon: Natural Monopoly

- Ex-ante investment $K(\tau)$ at date $t = 0^-$
- Entry cost to benefit from share of oligopoly rents
- Large fixed cost, small variable cost
- Natural monopoly: only one or a few entrants

Emergence of a Hegemon: Fiscal Capacity and Coordination

- Fiscal capacity:
  - Repaying bR costs $bR\phi$ with $\phi > 1$ to issuer conditional on $b > \underline{b}$
  - Idea: convexity in distortionary effect of taxation and public debt
- Under limited commitment:
  - We set the probability of collapse such that each issuer is indifferent between issuing $\underline{b}$ and issuing in the instability region, if the other issuer is issuing $\underline{b}$
  - Assume two countries have small difference in their fiscal capacity:

$$\eta_H > \eta > \eta_L \qquad \eta_H - \eta_L < \epsilon$$

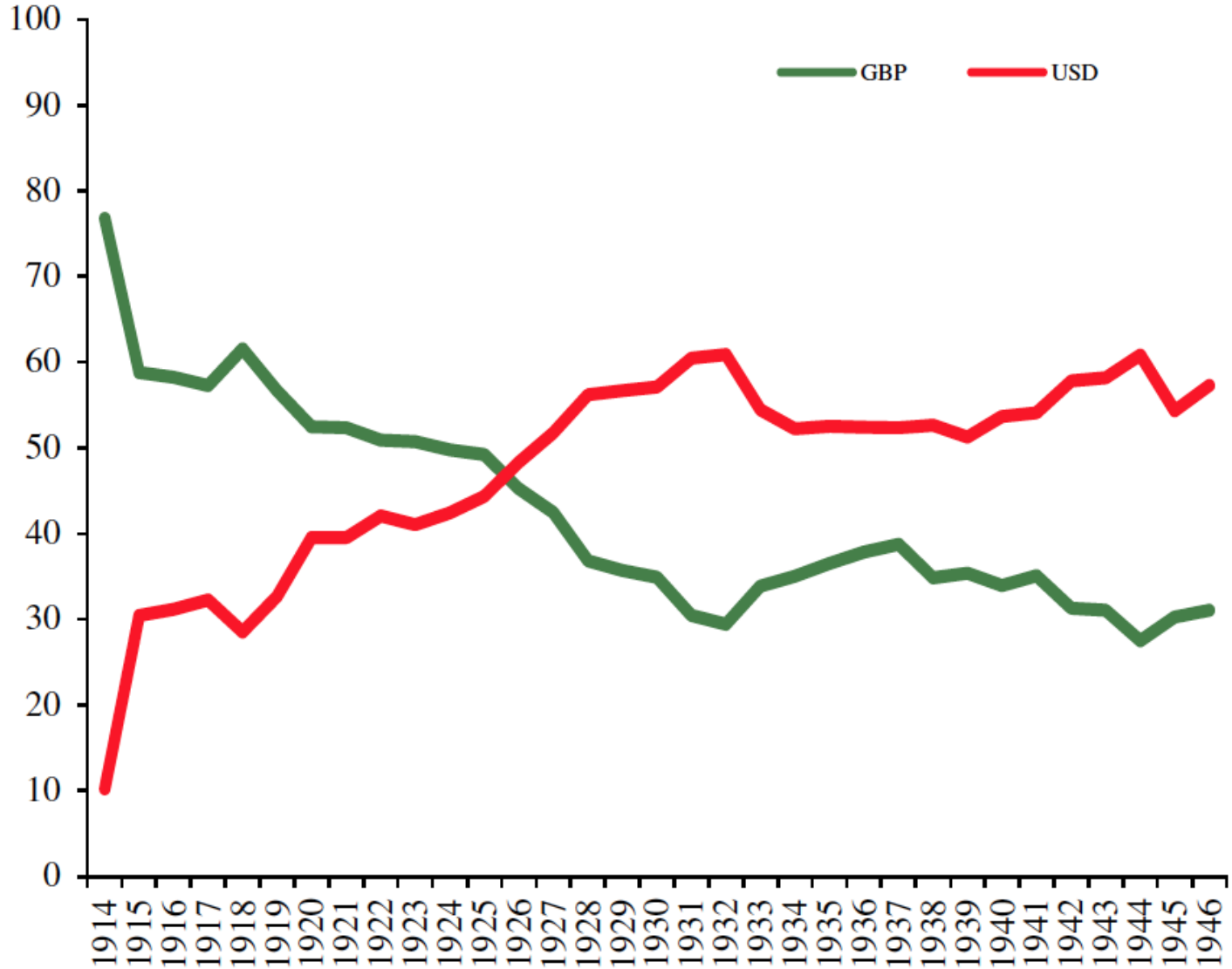
  - Unique asymmetric equilibrium with $b_L >> b_H$
  - Endogenous amplification of small differences generates a Hegemon

Reserve and Funding Currencies: Third Party Issuance

- Consider small borrower in RoW
- Choice between funding in: home risky currency, foreign risky currency, or reserve currency
- Most models of original sin are about issuing in generic foreign currency
- Our model provides a trade-off from issuing in reserve currency
  - Low yields for dollar denominated debt: capture part of monopoly rents, Exorbitant Privilege
  - Unattractive state-contingent properties: real dollar debt value higher in disaster because of dollar appreciation
- Reserve currency is both saving and funding vehicle
- Third party issuance improves outcomes: doesn't deteriorate Reserve country commitment

Reserve and Funding Currencies: Evidence

Third country issuance in USD and Pound in % of foreign currency debt



Source: Chitu, Eichengreen, Mehl (2014)

Gold-Exchange Standard

- Production, sticky wages: investable wealth $w^{*e} + \bar{w}^* \ell^*$
- Gold as a safe asset:
  - Pays "dividend" D for sure tomorrow, infinitesimal supply
  - Price of gold $p_G = \frac{D}{R^s}$
- Gold Exchange Standard: p_G constant $\iff$ R^s constant
- Equilibrium output determination:

$$R^s = E[R^r] - 2\gamma\sigma^2(w^{*e} + \bar{w}^* \ell^* - b)$$

- Adjustment to expansion in world demand for gold/reserves ($\uparrow w^{*e}$):
  - Expansion in monetary reserve assets ($\uparrow b$)
  - Global recession ($\downarrow \ell^*$)
  - Abandonment of the gold standard ($\downarrow R^s$, $\uparrow p_G$)

Optimal Issuance Under the Gold-Exchange Standard

- Hegemon faces perfectly elastic demand curve
- May increase incentives to issue in the Instability region
- Issuance capped at $\bar{b}_G$: might not be able to achieve full employment
- With expenditure switching effects (e.g. non-tradable goods) ex-post benefit of Hegemon unilateral break of gold peg, further reduces ex-ante credibility (isomorphic to reduction in τ, see paper)

Expenditure Switching Effects

- With expenditure switching effects (e.g. non-tradable goods) ex-post benefit of Hegemon unilateral break of gold peg, further reduces ex-ante credibility

- Level of exchange rate $\mathcal{E}_t$ with $\mathcal{E}_0 = 1$ and $e = \frac{\mathcal{E}_1}{\mathcal{E}_0}$

- Hegemon utiity now $C_t + v_t(C_{NT,t})$

- $v'(C_{NT,t}) = \frac{\bar{w}}{\bar{w}^*}\mathcal{E}_t$ or $C_{NT,t}(\mathcal{E}_t) = v_t'^{-1}(\frac{\bar{w}}{\bar{w}^*}\mathcal{E}_t)$

- Further benefit from devaluation at $t = 1$ if output below potential:

$$v_1(C_{NT,t}(e_L)) - v_1(C_{NT,t}(1))$$

- Isomorphic to reduction in τ:

$$\bar{\tau} = \tau - \frac{v_1(C_{NT,t}(e_L)) - v_1(C_{NT,t}(1))}{1 - e_L} < \tau$$

Modern Analog of Keynes Gold Recession: Floats at ZLB

- More flexible than gold-exchange standard as long as $R^s \geq 1$
- Similar economics at ZLB ($R^s = 1$)
- **Intuition:** common element across pegs to gold and ZLB is the "impossibility" to let the interest rate on reserve assets fall sufficiently

Conclusions

- A *Model* of the International Monetary System
- A basic model to organize thoughts on important topic
  - Triffin dilemma as a commitment problem
  - Social vs. private welfare: under or over issuance
  - IMS and world recessions under Gold-Exchange Standard and ZLB
  - Hegemon vs. Multipolar world: competition, rents, Nurkse's instability, failure of Hayek's competition in issuance

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Fact 1: shortage of reserve assets in 1920-1935

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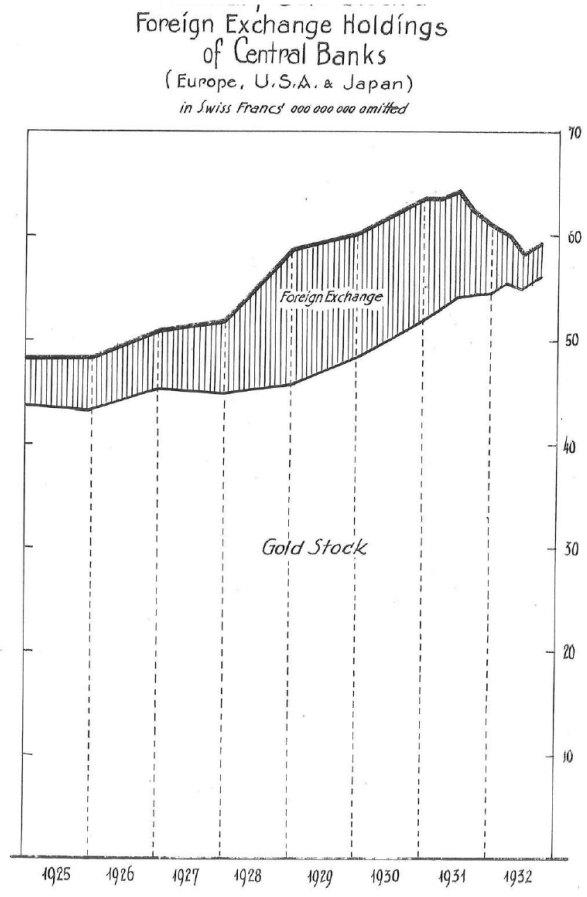
- Most central banks change statute to include monetary assets as reserves: the Gold-Exchange standard



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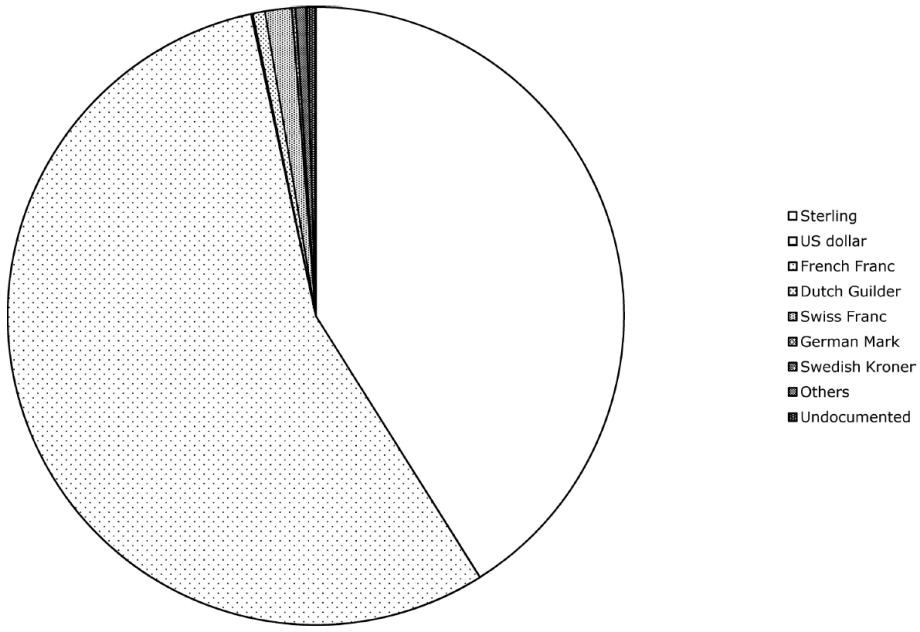

Figure 2. *Aggregate foreign currency holdings in 1929: a snapshot (16 countries)*

Source: Eichengreen and Flandreau (2009)

- Reserves switch often between pounds and dollars: Nurkse instability

Some History and Stylized Facts about the IMS

Fact 3: The Gold-Exchange standard collapse

- Great depression initially made worse by Gold standard: the Keynes gold recession
- England is the main supplier of the reserve asset, but is hit by the global depression shock
- In 1931 England depreciates the pound unexpectedly
- Depreciation of the pound induces major losses around the world: e.g. the Banque de France goes bankrupt
- Global flight to gold, dollar reserves are liquidated. US devalues in 1933

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Fact 4: The Bretton Woods collapse in 1973

- USD is the dominant reserve asset in the Bretton Woods system established in 1944
- USD is pegged to gold at $35 an ounce
- Triffin (1961): predicted that the US would face a dilemma between supplying more dollar debt as a reserve asset and maintaining the credibility of the dollar convertibility to gold. Ultimately, the system would be brought down by a confidence crisis. This prediction is known as the Triffin Dilemma
- Nixon Shock: Nixon administration first devalued to $42 an ounce in 1971 and ultimately had to abandon convertibility in 1973

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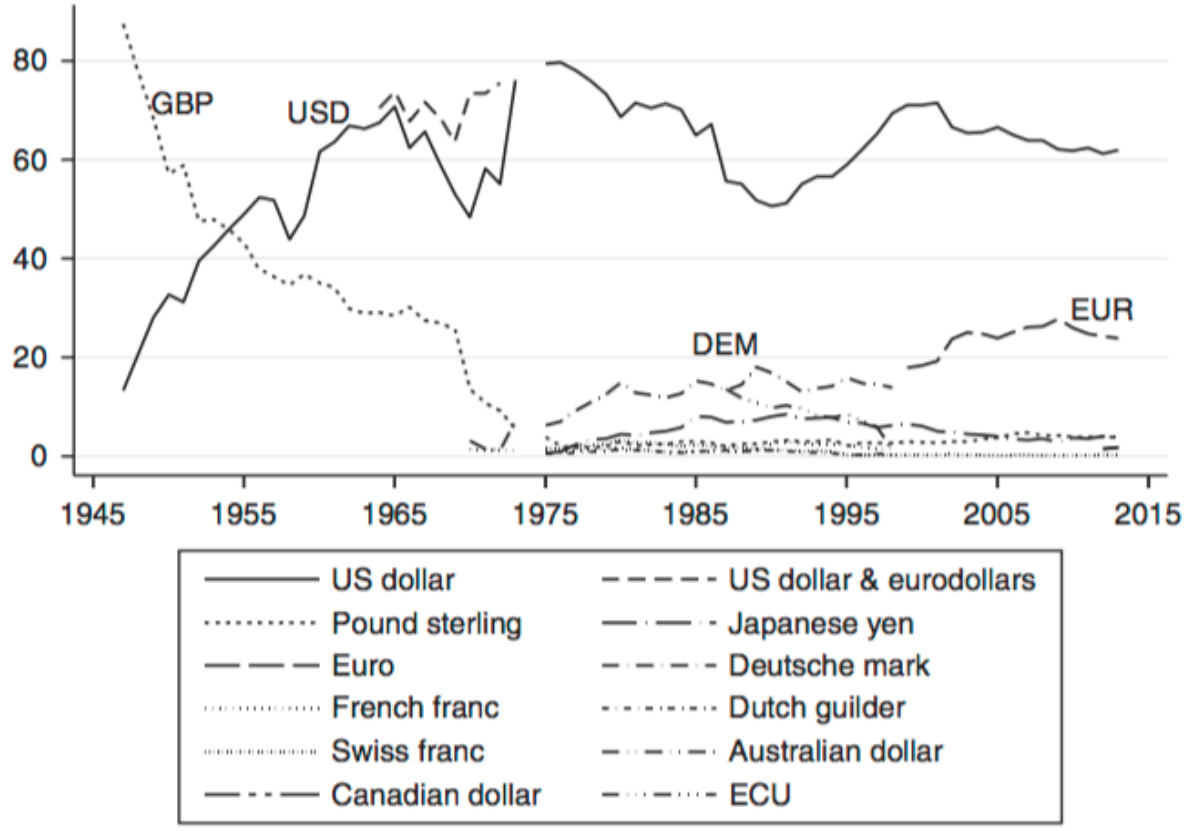

Source: Eichengreen, Chitu, Mehl (2014)

- Triffin logic remains: fiscal not just balance of payments problem

The World Banker View

- **Kindleberger** in 1966 expresses a *minority view* and argues, against Triffin, that the US position is that of a banker with liquid-safe liabilities and risky-illiquid assets. He argues that the IMS under the US hegemon is stable, since the liabilities are backed by the assets.

- **Gourinchas and Rey** brought this view to prominence documenting its empirical importance in the current period of global imbalances (1996-present)

- Our model merges the world banker view with the Triffin instability: banking is a profitable but fragile activity subject to self-fulfilling runs and panics
- Panics harder to resolve than for private banks, no natural LoLR for a Hegemon

Endogenizing Issuance: Problem of Reserve Country

- Monopolist Reserve country maximizes:

$$\max_{b,s} \quad E^{-}[C_0 + \delta C_1 - \tau(1-e)]$$

$$\text{s.t. } C_0 + s = w + b$$

$$\text{s.t. } C_1 = sR^r - bR(b)e$$

Since $\delta^{-1} = E[R^r]$, problem reduces to maximizing expected revenue:

$$\max_{b} \quad bE^{-}[R^r - R(b)e] - \lambda\alpha(b)\tau(1-e_L)$$

- Differences with Calvo and SOE Sovereign Default Models:
  - Issuer affects (and internalizes) both quantity and price of risk

Optimal Issuance under Full Commitment

- Under full commitment Reserve country will issue reserve asset, since it generates positive expected revenue

$$\max_b \quad bE[R^r - R(b)e] - \lambda\alpha(b)\tau(1 - e_L)$$

- Since $\alpha(b) = 0$, simplifies to:

$$\max_b \quad b(E[R^r] - R(b))$$

- Standard optimization leads to:

$$E[R^r] - R(b) - bR'(b) = 0$$

- Monopolist issuer internalizes the effect of supply of the reserve asset on interest rate (can also write as a standard Lerner formula)

Optimal Issuance with Limited Commitment

Without commitment:

- $\alpha(b) = 0$ in Safe Zone, α in Instability zone, 1 in Collapse zone

Proposition Three possible levels of equilibrium debt issuance $\{b^{FC}, \underline{b}, \bar{b}\}$:

- Low demand for safe assets ($b^{FC} \leq \underline{b}$): equilibrium issuance is b^{FC} and equilibrium is unique. Equivalent to full commitment
- Intermediate demand for safe assets ($\bar{b} \geq b^{FC} > \underline{b}$): equilibrium issuance is either $\underline{b}$ or b^{FC}, whichever generates higher expected revenues for the Reserve country
  - $\underline{b} \Rightarrow$ unique safe equilibrium
  - $b^{FC} \Rightarrow$ both the safe and the collapse equilibria
- High demand for safe assets ($b^{FC} > \bar{b}$): equilibrium issuance is either $\bar{b}$ or $\underline{b}$, whichever generates higher expected revenues for the Reserve country
  - $\underline{b} \Rightarrow$ unique safe equilibrium
  - $\bar{b} \Rightarrow$ both the safe and the collapse equilibria