A Model of the International Monetary System

Emmanuel Farhi       Matteo Maggiori

Harvard University   NBER & CEPR

January 23, 2020
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
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
Some History and Stylized Facts about the IMS

**Fact 2:** Co-issuance of reserves in 1920-1931

- British pound dominant reserve currency, but US dollar is also used

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

Source: Eichengreen and Flandreau (2009)
Some History and Stylized Facts about the IMS

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


The Hegemon Model

- Two periods: $t = 0, 1$. Two countries: Reserve country and RoW
- World risky asset with variance $\sigma^2$ in perfectly elastic supply:
  - $R_H^r > 1$ if no disaster, probability $(1 - \lambda)$
  - $R_L^r < 1$ if disaster, probability $\lambda$
- 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:

$$bR(1 - e_L) > \tau(1 - e_L)$$

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

- If bond expected to be risky, infinitely elastic demand:
  \[ RE'[e] - E[R'] = 0 \quad \text{and} \quad 0 \leq b \leq w^* \]

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

Assumption: risky bond and risky asset are perfect substitutes \( e_L = \frac{R_L}{R_H} \)
The Three Regions of the International Monetary System

- **Unique Safe Equilibrium**
- **Multiple Equilibria: Safe & Collapse**
  - Select Collapse with prob. \( \alpha \)
- **Unique Collapse Equilibrium**

- **Safe Zone**
- **Instability Zone**
- **Collapse Zone**

The diagram illustrates the three regions of the international monetary system, categorizing them into unique safe equilibrium, multiple equilibria (safe and collapse), and unique collapse equilibrium. The transitions are marked by thresholds labeled as \( b \), \( \overline{b} \), and \( w^* \).
Issuance

- Issuance problem of the Hegemon

\[
\max_b (1 - \alpha(b)) b (E[R'] - R^s(b)) - \alpha(b) \lambda \tau (1 - e_L)
\]

where

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

- Solve first under full commitment
- Solve then under limited commitment
Equilibrium under Full Commitment

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

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

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

\[ V(\bar{h}) > V(\bar{b}) \]

\[ V_{\text{IMF}}(\bar{h}) > V_{\text{IMF}}(\bar{b}) \]
The Triffin Dilemma: Welfare Analysis

• Varying level of commitment ($\tau$) and convexity of demand curve ($\eta$)

• Surfaces are the threshold crisis probabilities that make the Hegemon ($\alpha^*_m$) and the RoW ($\alpha^*_row$) 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 $n$

$$b_n^{FC} = \frac{n}{n+1}w^*$$

$$R_{n}^{s,FC} = E[R'] - \frac{2}{n+1}\gamma\sigma^2 w^*$$

• Same equilibrium under limited commitment for $n$ sufficiently high

• First best obtains in perfect competition limit $n \rightarrow \infty$

• 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 $\alpha_{\tilde{1}} = 1$
  
  - Instability from coordination problems among substitutable reserve assets
More in Paper

• Reserve currencies as funding currencies with private issuance

• Infinite horizon:
  • $\tau$ 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:** \( R = R^r_H \) for any \( b \) in all future periods if in current period the Reserve country devalues if facing \( R < R^r_H \)
The Hegemon Model: Infinite Horizon

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

\[
\frac{b}{E[R^r] - 1} \geq \frac{bR(1 - e_L)}{E[R^r] - 1}
\]

Present Value of Rents

One-off devaluation gain

• Take \(\alpha = 0\) for simplicity

• \(\approx\) endogenous \(\tau\)
• **Full Commitment:** under full commitment optimal issuance is

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

\(b^{FC}\) 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 $B = (b, \tilde{b})^T$:

$$E[C^*_1] - \gamma \text{Var}(C^*_1) + (B^T \omega + B^T \Omega B) \mathbf{1}_{\{E^+[e] = 1\}}$$

- 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 $\mu$ 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 $\eta$ 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:
  \[ R_s^i(b_i; b_{-i}) = \bar{R}^r - 2\gamma\sigma^2(w^* - (b_i + b_{-i})) - \omega_1 - 2\Omega_{11}(b_i + b_{-i}) - (\Omega_{12} + \Omega_{21})b_i \]
- Difference in equilibrium issuance:
  \[ b_1 - b_2 = \frac{\bar{R}^r \left( \frac{1}{\phi_1} - \frac{1}{\phi_2} \right)}{2(\gamma\sigma^2 - \Omega_{11} - \Omega_{12} - \Omega_{21})} \]
- Endogenous amplification of small differences generates a Hegemon
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 $b > b$
  - 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 $b$ and issuing in the instability region, if the other issuer is issuing $b$
  - Assume two countries have small difference in their fiscal capacity:
    $$\eta_H > \eta > \eta_L \quad \eta_H - \eta_L < \epsilon$$
  - 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 $\tau$, 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 utility now $C_t + \nu_t(C_{NT,t})$

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

- Further benefit from devaluation at $t = 1$ if output below potential:
  $$\nu_1(C_{NT,t}(e_L)) - \nu_1(C_{NT,t}(1))$$

- Isomorphic to reduction in $\tau$:
  $$\bar{\tau} = \tau - \frac{\nu_1(C_{NT,t}(e_L)) - \nu_1(C_{NT,t}(1))}{1 - e_L} < \tau$$
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
Some History and Stylized Facts about the IMS

Fact 1: shortage of reserve assets in 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
Some History and Stylized Facts about the IMS

Fact 2: Co-issuance of reserves in 1920-1931

- British pound dominant reserve currency, but US dollar is also used

![Pie chart showing foreign currency holdings in 1929](image)

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
Some History and Stylized Facts about the IMS

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
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: 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:

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

s.t. \( C_0 + s = w + b \)

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

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

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

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

• 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, $\alpha$ 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