International Monetary Theory: Mundell Fleming Redux

by

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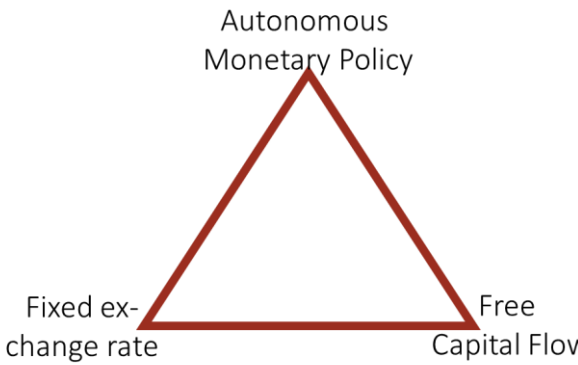
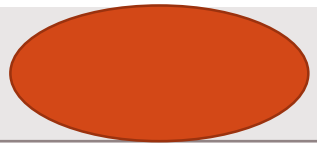
Motivation

- Global currency spillovers
  - "Flight to safety" - Dollar appreciation when risk rises
  - Local currency: good store of value/hedge for idiosyncratic risk
  - Global currency: good hedge for international competitiveness risk
- When to peg to world currency? When to dollarize?
- MoPo space: "Nuanced Mundell-Fleming Trilemma"
  - Local and global money have different risk profile (imperfect substitutes)
    ⇒ increases MoPo space
  - Too high inflation:
    local citizens substitute local currency
    for global currency
    ⇒ limits MoPo space



- Reserve currency management – Irrelevance theorem

Modelling Framework

	Closed economy			Open Economy
Static	Hick's IS-LM			Mundell-Fleming
Dynamic Impulse response	New Keynesian			Obstfeld-Rogoff
Risk & Dynamic financial frictions	Samuelson Diamond	Bewley Aiyagari	I Theory of Money	

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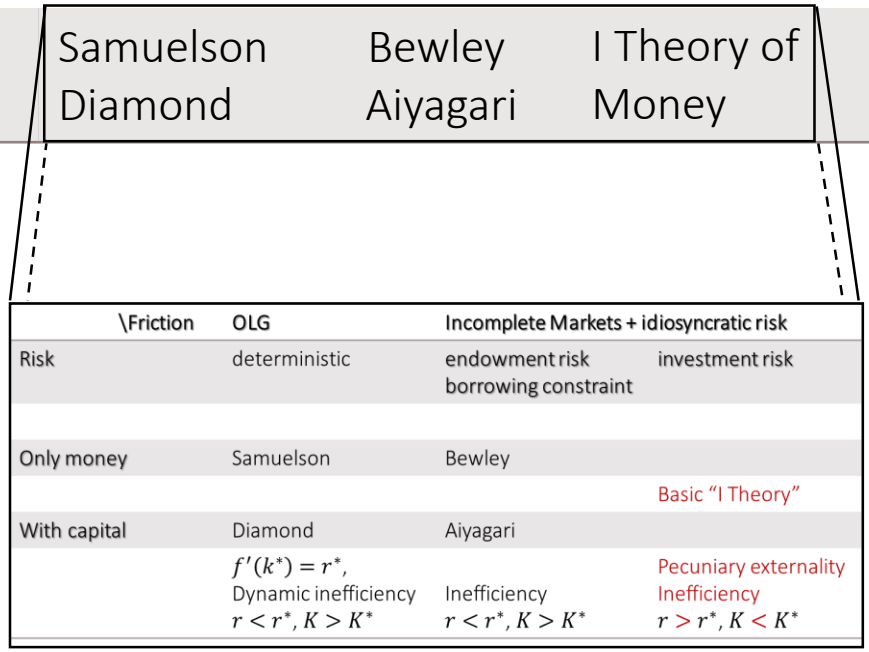

\Friction	OLG	Incomplete Markets + idiosyncratic risk	
Risk	deterministic	endowment risk borrowing constraint	investment risk
Only money	Samuelson	Bewley	
			Basic "I Theory"
With capital	Diamond	Aiyagari	
	$f'(k^*) = r^*$, Dynamic inefficiency $r < r^*, K > K^*$	Inefficiency $r < r^*, K > K^*$	Pecuniary externality Inefficiency $r > r^*, K < K^*$

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Frictions

- Incomplete markets
  - Within country
    - only w.r.t. idiosyncratic risk $d\tilde{Z}_t^i$
    - (other risks can be shared within national economy)
  - Across countries
    - Only global money can be traded

➡ Money is a bubble

Like in Samuelson, Bewley

- Price are fully flexible

International setting

- Small Economy

- Local currency
  - Store of value
  - Hedge against idiosyn-cratic risk
- Consumption basket

Exchange rate

- Large Economy*

- Global currency* $
  - …
  - Hedge for SOE's citizens against "international competitive risk"
- Consumption basket*

International setting

- Small Economy

- Local currency
  - Store of value
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  - Non-tradable local good aK_t
  - tradable good 1 $b_{1,t}K_t$
  - tradable good 2 $b_{2,t}K_t$

Exchange rate

- Large Economy*

- Global currency* $
  - …
  - Hedge for SOE's citizens against "international competitive risk"
- Consumption basket*
  - Non-tradable good* $a^*K_t^*$
  - tradable global good 1 ${b_{1,t}}^*K_t^*$
  - tradable global good 2 ${b_{2,t}}^*K_t^*$

$$\frac{b_{2,t}}{b_{1,t}} < \frac{b_{2,t}^*}{b_{1,t}^*}$$

Intuition

- Purchase good 2 in exchange of good 1 (depends on ToT)
- Hold global money as Net Foreign Asset Position

- Value of money – money is safe asset
  - Local money is store of value with nice hedge against idiosyncratic risk
  - Global money ($) hedges better "export risk" (competitiveness = ToT + productivity)

  - 2 money can coexist (even though both are "bubbles")
    - Different return-risk profile

Overview

- Large country
  - Portfolio choice between
    - Physical capital k_t^*
    - US Dollar, \$ – "bubble in positive net supply"
  - No state variable: due to scale invariance

- Small country
  - Portfolio choice between
    - Physical capital k_t
    - Peso "hedge against idiosyncratic shocks"
    - US Dollar, \$ "hedge against ToT + export productivity shocks"
  - State variable ν_t:
    Accumulation dynamics of foreign asset position (in \$)

Large country

$$E\left[\int_0^\infty e^{-\rho t}\log c_t^*\,dt\right]$$

- Consumption Cobb-Douglas preferences
  (over 1 non-tradable one 2 tradable goods)

$$\left(c_{0,t}^*\right)^{(1-\alpha)}\left(\left(c_{1,t}^*\right)^{\beta}\left(c_{2,t}^*\right)^{(1-\beta)}\right)^{\alpha}$$

- Investment rate ι^* in terms of non-tradable local good
- Evolution of physical capital stock

$$\frac{dk_t^*}{k_t^*}=(\Phi(\iota^*)-\delta)dt$$

- Output shocks *per unit of capital* a^*, $b_{1,t}^*$, or $b_{2,t}^*$
  - Determines relative prices
  - … has to be indifferent

Ito-processes

- Idiosyncratic *real* cash flow shocks $\tilde{\sigma}k_t^*d\tilde{Z}_t^{i*}$
- Net worth dynamics:

$$\frac{dn_t^*}{n_t^*}=\theta_t^*r^{M*}dt+(1-\theta_t)r^{K*}dt-\frac{c_t^*}{n_t^*}dt+\tilde{\sigma}\frac{k_t^*}{n_t^*}d\tilde{Z}_t^{i*}+\frac{\tau_t^*}{n_t^*}dt$$

- Value of output of all goods produced $a^*K_t^*$

Numeraire is non-tradable local good

Non-tradeable to consumption basket

- Tradeable, non-tradeable good 1 and 2
  - a^* units of non-tradeable good buy
    - $b^*_{1,t}$ of tradeable good, or
    - $(a^*)^{1-\alpha}\left(b^*_{1,t}\right)^{\alpha\beta}\left(b^*_{2,t}\right)^{\alpha(1-\beta)}$ units of the "aggregate good" (consumption basket).
  - Hence, production of consumption basket is

$$(a^* - \iota^*_t)(b^*_t)^{\alpha} K^*_t, \text{ with } b^*_t = \frac{\left(b^*_{1,t}\right)^{\beta}\left(b^*_{2,t}\right)^{1-\beta}}{a^*}$$

Numeraire is consumption basked in large country

Return on global money ($)

- In terms of non-tradable local good (as numeraire)
  (which is used for investment rate ι_t^*)

$$r^* dt = (\Phi(\iota^*) - \delta)dt \qquad \text{is risk free}$$

- Change of numeraire
  In terms of tradable basket (change of numeraire)

$$r_t^G \equiv r^* dt + \frac{db_t^*}{b_t^*}$$

  - Where price of non-tradable good in terms of tradable basket

$$b_t^* = \frac{\left(b_{1,t}^*\right)^{\beta}\left(b_{2,t}^*\right)^{1-\beta}}{a^*}$$

  - *Special case:* $\left(b_{1,t}^*\right)^{\beta}\left(b_{2,t}^*\right)^{1-\beta}$ and hence b_t^* is constant

Solving

1. Postulate
   - Price processes $dp_t^*/p_t^* = \mu_t^{p*}dt + \sigma^{p*}dZ_t^*, \quad dq_t^*/q_t^* = \cdots$
   - Portfolio processes $d\theta_t^*/\theta_t^*$

2. Derive return processes
   - $dr^{K*} = (\Phi(\iota^*) - \delta)dt + \frac{a^* - \iota^*}{q}dt + \frac{\tilde{\sigma}}{q}d\tilde{Z}_t$
   - $dr^{M*} = (\Phi(\iota^*) - \delta)dt - (\mu^{M*} - \mu^{Mi*})dt$

money supply growth rate that is NOT distributed via interest payment
Set $\mu^{Mi*} = 0$

3. Optimality conditions & Market clearing conditions

4. Solve "undetermined coefficients" $(\mu^x(s_t), \sigma^x(s_t))$
   - Solving ODE with boundary conditions
   - For large country: simply solve for constants

Solving

1. Postulate
   - Price processes p_t^*, q_t^*
   - Portfolio processes θ_t^*

   Simply constants for large country

2. Derive return processes
   - $dr^{K*} = (\Phi(\iota^*) - \delta)dt + \frac{a^* - \iota^*}{q}dt + \frac{\tilde{\sigma}}{q}d\tilde{Z}_t$
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Optimality (=) & market clearing (=)

- Investment rate, ι^*
  - Tobin's q: $\Phi'(\iota^*) = \frac{1}{q^*}$ (static problem)
    - For $\Phi(\iota^*) = \frac{1}{\kappa}\log(\kappa\iota^* + 1) \Rightarrow \kappa\iota^* = q^* - 1$
- Portfolio choice, θ^*
  - $E[dr^{K*} - dr^{M*}]/dt = Cov[dr^{K*} - dr^{M*}, \underbrace{\frac{dn_t^*}{n_t^*}}_{dr^{M*}+(1-\theta^*)(dr^{K*}-dr^{M*})}] = (1-\theta^*)(\tilde{\sigma}^*/q)^2$

$$1 - \theta^* = \frac{E[dr^{K*} - dr^{M*}]/dt}{(\tilde{\sigma}^*/q^*)^2} = \frac{(a^* - \iota^*)/q^* + \mu^{M*}}{(\tilde{\sigma}^*/q^*)^2} = \frac{q^*}{q^* + p^*}$$

Capital market clearing

  - Dividend yield on capital must be ρ
- Consumption

Output market clearing

  - Demand $\rho N_t^* = \rho(q^* + p^*)K_t^* = (a^* - \iota^*)K_t^*$ Supply

$$q^* = \underbrace{\left(\frac{q^*}{q^* + p^*}\right)}_{=1-\theta^*}(a^* - \iota^*)/\rho$$

Equilibrium

Moneyless equilibrium		Money equilibrium
$p_0^* = 0$		$p^* = \frac{\tilde{\sigma}^*(1+\kappa\rho)}{\sqrt{\rho+\hat{\mu}^{M*}}} - (1+\kappa a^*)$
$q_0^* = \frac{\tilde{\sigma}^*}{\sqrt{\rho+\hat{\mu}^{M*}}}$	$>$	$q^* = (1+\kappa a^*) - \frac{\kappa\rho\tilde{\sigma}^*}{\sqrt{\rho+\hat{\mu}^{M*}}}$

where $\hat{\mu}^{M*} = \underbrace{(1-\theta^*)}_{portfolio\ share} \mu^{M*}$ (monotone transformation)

- Numeraire is local good

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Optimal Monetary Policy

- Money growth μ affects inflation in two ways

$$\pi = \mu^{M*} - \underbrace{(\Phi\left(\iota^*\left(\mu^{M*} - \mu^{M,i*}\right)\right) - \delta)}_{g}$$

boosts growth like in Tobin (1965)

- MoPo can correct pecuniary externality
  - Citizens take real interest rate as given when choosing their portfolio between money & physical capital
  - Money exists for $\tilde{\sigma}^* > \sqrt{\rho}$
  - Money growth > 0 is optimal for $\tilde{\sigma}^* > 2\sqrt{\rho}$ (for $\kappa = 0$)
  - MoPo improves insurance provided by "safe asset"
    - Constrained optimal!
    - Incentive compatible
- Money is neither neutral nor super-neutral (no price stickiness)

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  - State variable ν_t:
    Accumulation dynamics of foreign asset position (in \$)

$$\mu_t^x = \mu^x(\nu_t), \qquad \sigma_t^x = \sigma^x(\nu_t)$$

Small country

- Small country cannot produce tradable good 2
- tradable basket can be traded for global good 1 at rate

$$b_t := \underbrace{b_{1,t}}_{\text{Productivity}} \underbrace{\left(b^*_{2,t}/b^*_{1,t}\right)^{1-\beta}}_{\text{Terms of Trade}} = \frac{b_{1,t}}{b^*_{1,t}}\left(\left(b^*_{1,t}\right)^{\beta}\left(b^*_{2,t}\right)^{1-\beta}\right)$$

- Short-cut thinking:
  one unit of capital produces b_t units of tradable basket
  (while actually it produces only good 1 at rate b_1 and trades some of them for tradable good 2)

$$\frac{db_t}{b_t} = \mu^b dt + \sigma^b dZ_t$$

since all $b_{1,t}$, $b^*_{2,t}$, $b^*_{1,t}$ are (correlated) geometric Brownian.

Ito product rule: $d(X_t Y_t) = dX_t Y_t + X_t dY_t + \sigma_X \sigma_Y dt$

- Return on global money can be written as

$$dr^G_t = \mu^G dt + \sigma^G dZ_t + \sigma^{G,*} dZ^*_t$$

Part of b^*_t which is orthogonal to b_t

Small country

- Same preferences:
  - $E\left[\int_0^\infty e^{-\rho t} \log c_t \, dt\right]$
  - $\left(c_{0,t}\right)^{(1-\alpha)} \left(c_{1,t}^{\beta} c_{2,t}^{(1-\beta)}\right)^{\alpha}$
- $\hat{\alpha}_t K_t$ devoted to produce tradable good 1
  - Can be traded for tradable basket since small county can't produce tradable good 2 itself
- $\xi_t b_t K_t$ consumption of tradable goods basket
- $(\hat{\alpha}_t - \xi_t) b_t K_t$ trade-imbalance (net export)
- $G_t > 0$ Net foreign asset position (only global money) (in tradable goods basket)

$$\frac{dG_t}{G_t} = dr_t^G + \frac{(\hat{\alpha}_t - \xi_t) b_t K_t}{G_t} dt$$

State variable

- Equilibrium is a map

Histories of shocks $\{Z_\tau, Z_\tau^*, 0 \le \tau \le t\}$ ⟶ prices q_t, p_t, allocation $\hat{\alpha}_t, \iota_t, \xi_t$ & portfolio $(1-\theta_t-\zeta_t, \theta_t, \zeta_t)$

net foreign asset position to tradable production potential

$$\nu_t = \frac{G_t}{b_t K_t}$$

- Evolution

$$\frac{d\nu_t}{\nu_t} = dr_t^G + \frac{\hat{\alpha}_t - \xi_t}{\nu_t}\,dt - \frac{db_t}{b_t} - (\Phi(\iota_t) - \delta)\,dt + \sigma^b(\sigma^b - \sigma^G)\,dt =$$

$$\frac{\hat{\alpha}_t - \xi_t}{\nu_t}\,dt + \underbrace{(\mu^G - \mu^b + \sigma^b(\sigma^b - \sigma^G) + \delta)}_{M}\,dt - \Phi(\iota_t)\,dt + (\sigma^G - \sigma^b)\,dZ_t + \sigma^{G,*}\,dZ_t^*.$$

Portfolio choice & Asset pricing

- Portfolio share (processes)
  - Local money $\frac{d\theta_t}{\theta_t} = \mu_t^{\theta} dt + \sigma_t^{\theta} dZ_t + \sigma_t^{\theta,*} dZ_t^*$
  - Global money $\frac{d\zeta_t}{\zeta_t} = \mu_t^{\zeta} dt + \sigma_t^{\zeta} dZ_t + \sigma_t^{\zeta,*} dZ_t^*$

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  - Global money $\frac{d\zeta_t}{\zeta_t} = \mu_t^{\zeta} dt + \sigma_t^{\zeta} dZ_t + \sigma_t^{\zeta,*} dZ_t^*$
- Returns expressed with country net worth N_t as numeraire
  - Return on individual net worth $dr_t^n = \rho dt + \underbrace{(1 - \theta_t - \zeta_t)}_{\tilde{\sigma}^n} \tilde{\sigma}(q_t)$
  - Return on local money $dr_t^{ML} = \frac{d\theta_t}{\theta_t}$ Money worth θ net worths
  - Return on global money ($) $dr_t^{MG} = \frac{\xi_t - \hat{\alpha}_t}{\nu_t} dt + \frac{d\zeta_t}{\zeta_t}$ Assuming no seignorage

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  - Return on global money ($) $dr_t^{MG} = \frac{\xi_t - \hat{\alpha}_t}{\nu_t} dt + \frac{d\zeta_t}{\zeta_t}$
- Asset pricing equation (due to log utility)

E[net worth – money return]

$$E[dr_t^n - dr_t^{ML}] = Cov[dr_t^n - dr_t^{ML}, dr_t^n] \Rightarrow \rho - \mu_t^\theta = (\tilde{\sigma}^n)^2$$

$$E[dr_t^n - dr_t^{MG}] = Cov[dr_t^n - dr_t^{MG}, dr_t^n] \Rightarrow \rho - \frac{\xi_t - \hat{\alpha}_t}{\nu_t} - \mu_t^\zeta = (\tilde{\sigma}^n)^2$$

Price of risk × risk

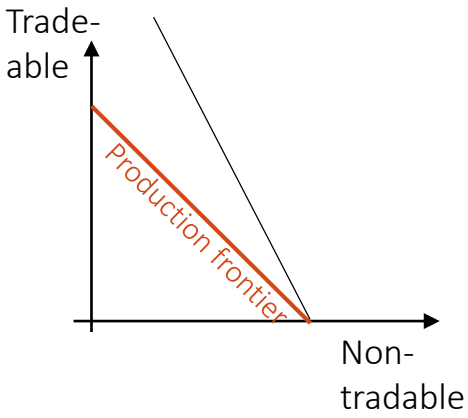
Consumption & Investment

- Consumption Demand $\rho \underbrace{\frac{G_t}{\zeta_t}}_{\text{wealth in trad.basket}} = \frac{\xi_t b_t K_t}{\alpha}$ Supply (incl. net exports)
  - Cobb-Douglas ⇒constant consumption expenditure shares

Consumption of tradables → $\frac{\xi_t b_t K_t}{\alpha} P_t^g = \frac{[(1-\hat{\alpha}_t)a-\iota_t]}{1-\alpha} P_t^l$ ← Output of non-tradable

- Production allocation

$$\frac{b_t P_t^g}{a P_t^l} = \frac{(1-\hat{\alpha}_t)a-\iota_t}{1-\alpha}\frac{\zeta_t}{a\rho\nu} \begin{cases} = 1 & \text{if } \hat{\alpha}_t \in (0,1), \\ \geq 1 & \text{if } \hat{\alpha} = 1 \end{cases}$$



- Investment rate ι_t
  - Depends on q_t

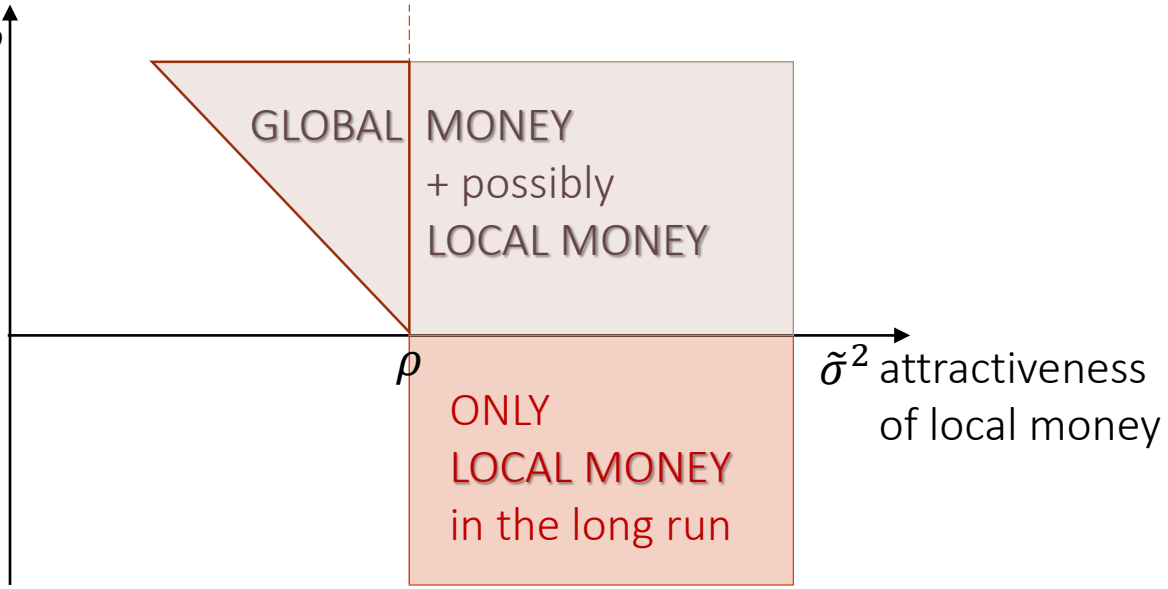
$$q_t K_t = (1-\zeta_t-\theta_t)\frac{G_t}{\zeta_t}\frac{P_t^g}{P_t^l} \quad \Rightarrow \quad q_t = a\nu_t \frac{1-\zeta_t-\theta_t}{\zeta_t} \underbrace{\frac{(1-\hat{\alpha}_t)a-\iota(q_t)}{1-\alpha}\frac{\zeta_t}{a\rho\nu_t}}_{1 \text{ if } \hat{\alpha}_t \in (0,1)}$$

(Co-)Existence of Money

- Proposition 1:
  - If $\tilde{\sigma}^2 > \rho$ and $\mathrm{M} \leq \Phi(\iota_{\nu=0})$, then local money has value and $\nu = 0$ (no NFAP) is absorbing state
  - Otherwise, if $\tilde{\sigma}^2 - \rho + \mathrm{M} - \Phi(\iota_{\nu=0}) > 0$, then global money has value for citizens in small country (and local money may or may not have value)

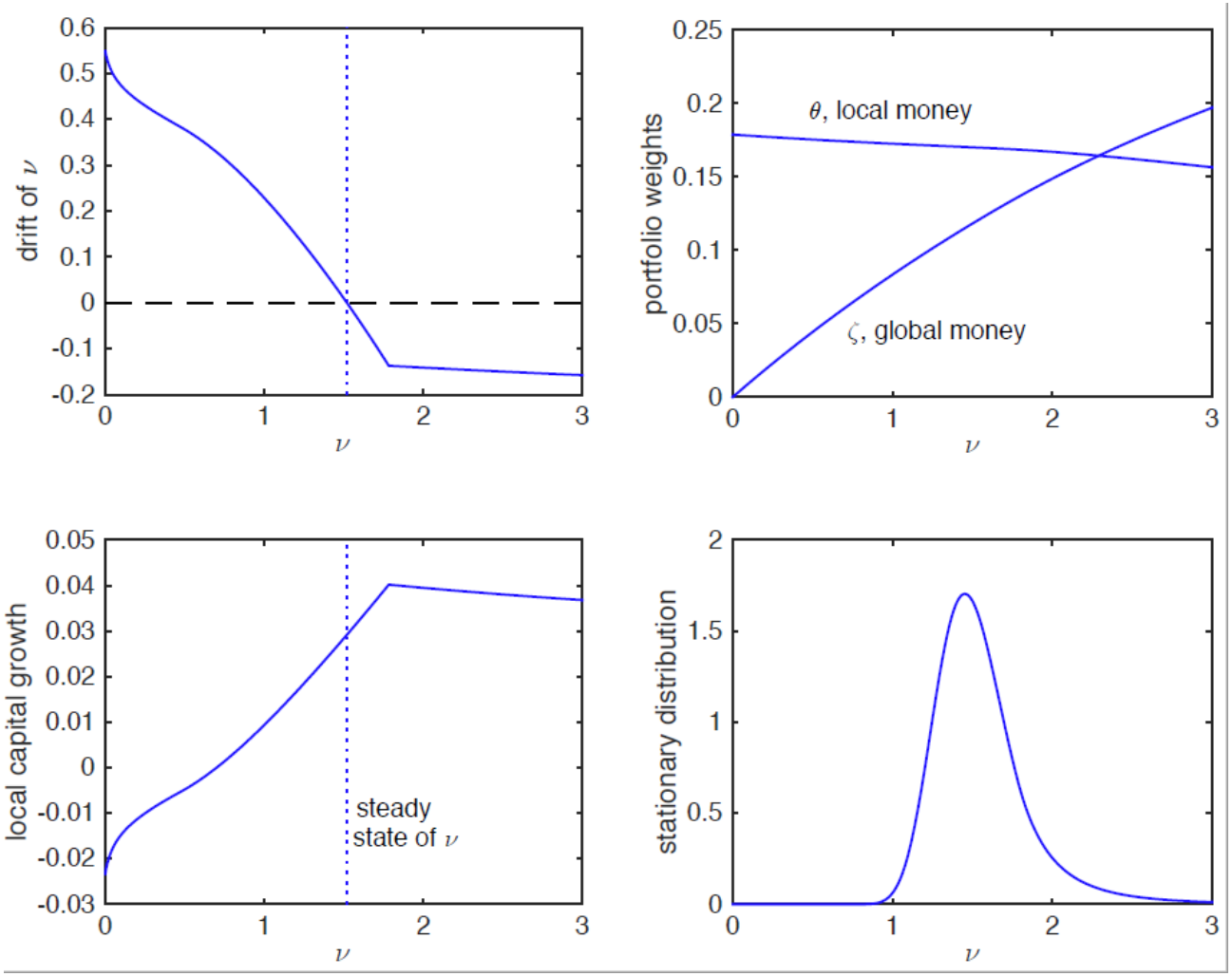
for ι at $\nu = 0$

$\mathrm{M} - \Phi(\iota) =$
$\mu^G - \mu^b + (\sigma^b - \sigma^G)\sigma^b$
$-\Phi(\iota) + \delta$
attractiveness of global money



Numerical Example

- $\rho = 5\%, \tilde{\sigma} = .3, \alpha = .2, \mu^b = 1\%, \sigma^b = .15, \mu^G = 2.2\%, a = .13,$
  $\delta = 2\%, \sigma^G = \sigma^{G,*} = 0, \kappa = 2 \quad \Rightarrow M = .0545, \sigma^\nu = .15$



Exchange rate dynamics - UIP

$$i_t^* - i_t = E_t[\Delta\mathcal{E}] + \psi_t$$

$$\psi_t = \underbrace{-\sigma^\theta}_{>0}\underbrace{(\sigma^\zeta - \sigma^\theta)}_{>0}$$

(risk premium in terms of Peso)

- For $i_t = i_t^* \ (= 0)$
  - foreign currency is expected to appreciate relative to local currency (whenever it is held in positive quantity).
    - Local currency is a hedge, it appreciates relative to net worth when ν drops.
    - Global currency is risky, so to be held in positive amount it must earn a risk premium
- UIP violation, ψ_t, depends whether money is "printed"
  - to pay interest μ^{Mi}
    - No real changes (portfolio choice is not affected)
    - Higher inflation $\pi = \mu^{Mi} - (\phi(\iota) - \delta)$,
    - $E_t[\Delta\mathcal{E}] = \mu^{Mi}$ (dollar appreciates)
  - to generate seignorage (redistributed $\propto$ wealth share) $(\mu^M - \mu^{Mi})$
    - Affects portfolio choice, q, investment rate ι, growth rate risk premium ψ_t

Flight to safety (into dollar)

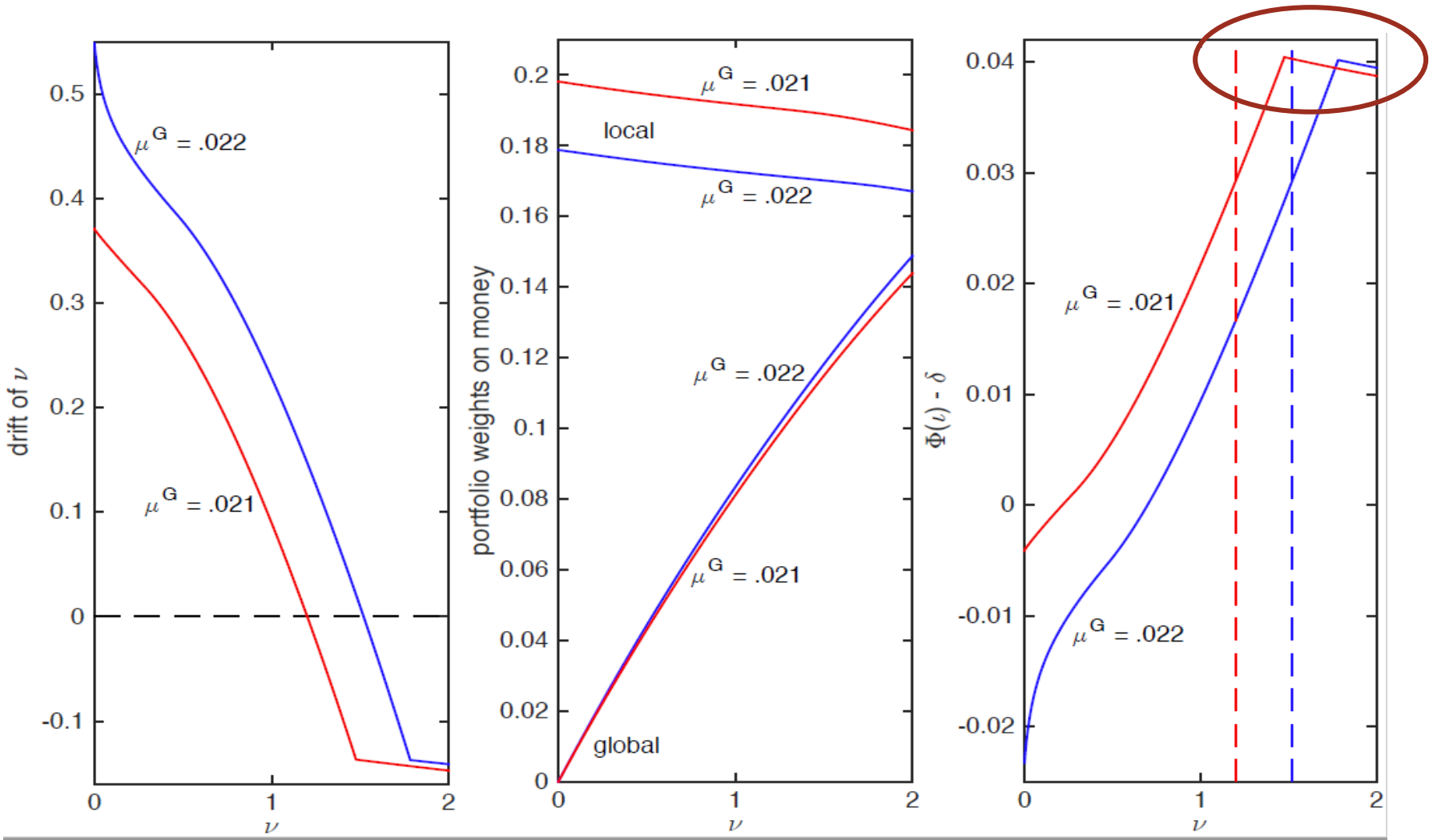
- Unanticipated increase in σ^b
  - E.g. ToT becomes more volatile

- Portfolio share held in dollars increases
  ➡ Dollar valuation is higher
- (increase in volatility of ν)

- Transition
  - Start with current (dollar holding) G
  - Recalculate new state variable ν_t
  - Our full dynamics also includes transition dynamics

Spillover from lower μ^G

- Higher money supply growth μ^{M*} in large country
- Lower growth $\Phi(\iota^*) - \delta$ in large country
- Loss of competitive edge in global tradable basket

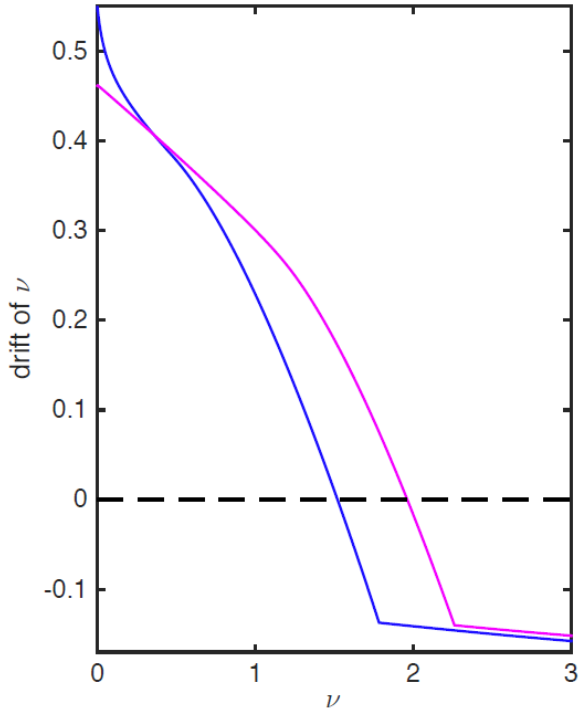


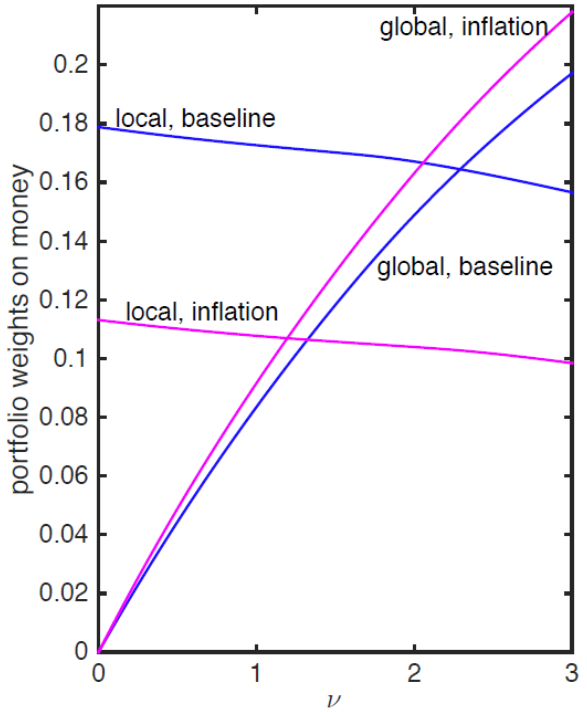
Higher Peso inflation π_t

- seniorage $\left(\mu^M - \mu^{Mi}\right)$ is distributed $\propto$ capital holding
- Store of value is less attractive
  - Pricing equation now

$$\rho + \pi_t - \mu^\theta = (\tilde{\sigma}^N)^2$$

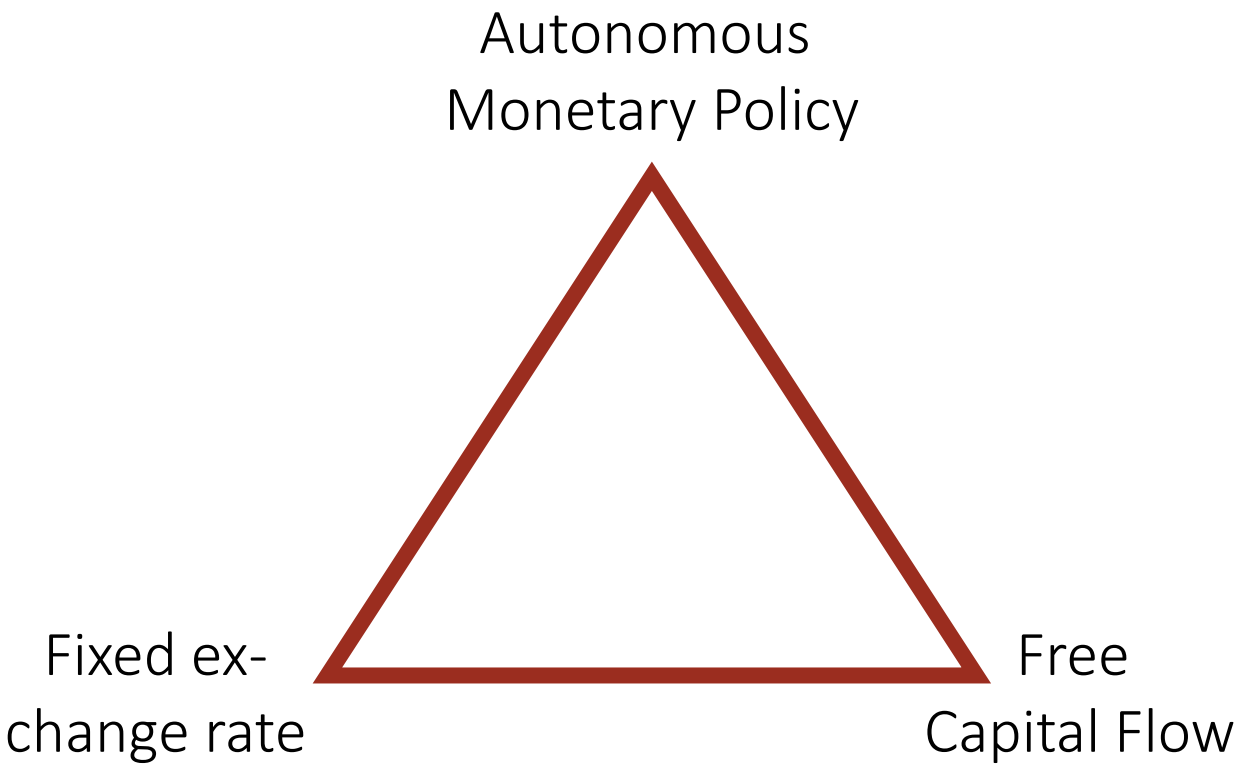
- higher investment $\iota_t \Rightarrow$ boosts growth, but higher idio risk





Mundell-Fleming Trilemma

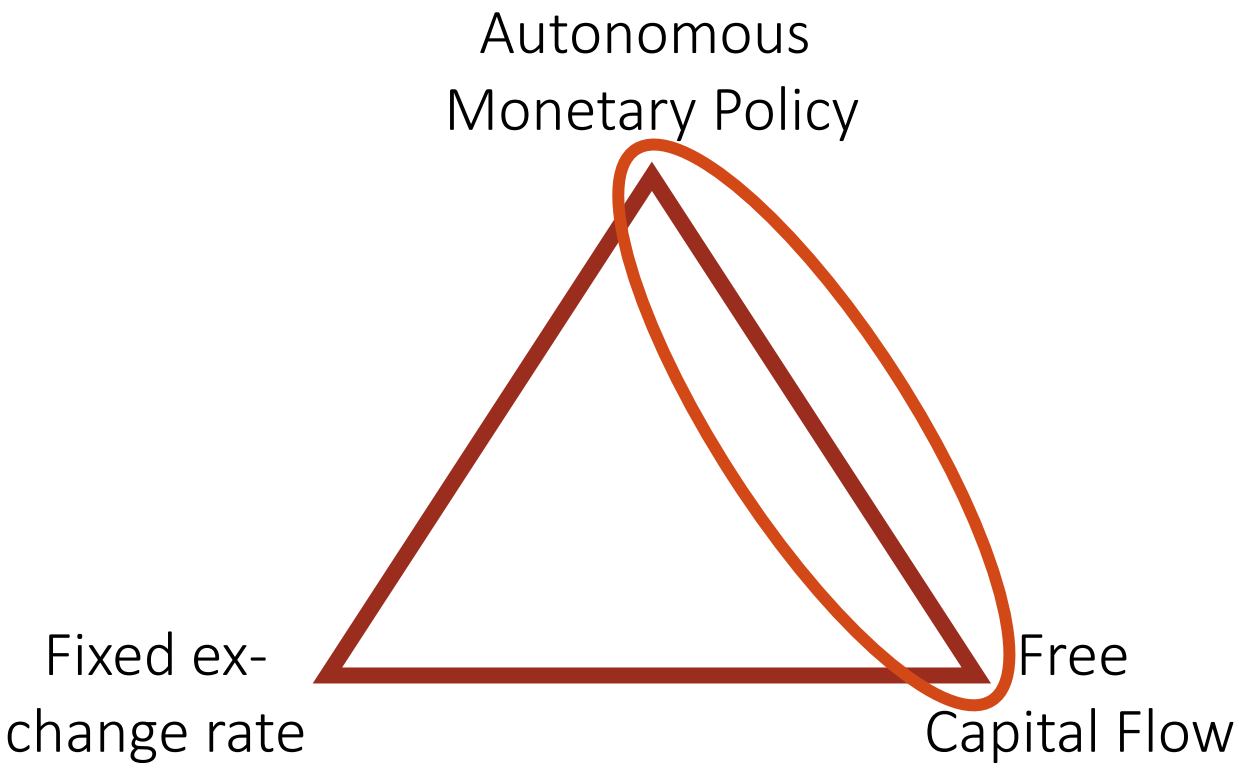
- Trilemma: Can only pick a 2 desiderata out of 3 –1 side



- "Dilemma": Pick only 1

Mundell-Fleming Trilemma

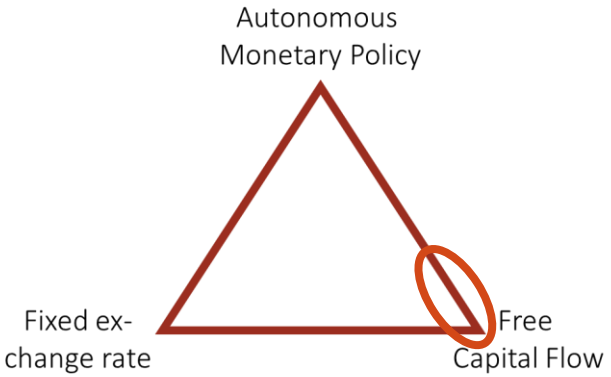
- Trilemma: Can only pick a 2 desiderata out of 3 –1 side



- "Dilemma": Pick only 1

Floating Exchange Rate

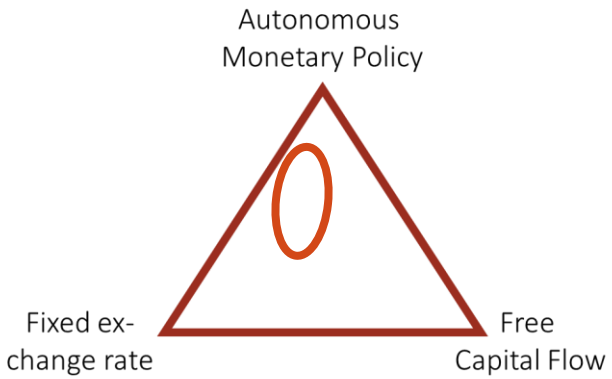
- With floating exchange rate & open capital account
  Still range of Monetary policy, since local and global money are imperfect substitutes
  - Inflation boosts growth,
    but only possible up to a limit $\bar{\pi}(\mu^G)$.
    Beyond $\bar{\pi}(\mu^G)$ monetary policy has little bite
    - Global money becomes too attractive
  - Range is higher with higher inflation
    in large country (global money)
    - Large country's MoPo determines
      range for small country



- Policy range is larger
  if local money is backed by taxes
  ($\bar{\pi}$ depends on distribution of seignorage)

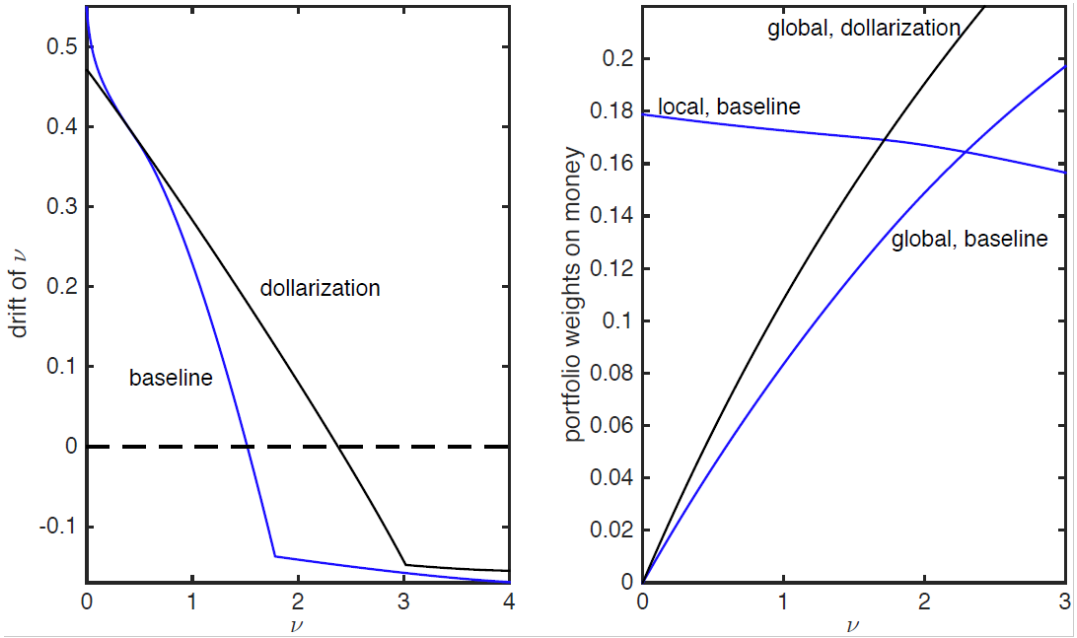
Closed capital account

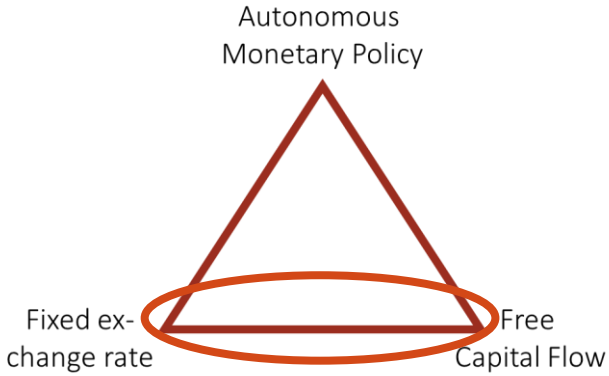
- Range of Monetary policy is much larger, up $\bar{\bar{\pi}} = \tilde{\sigma}^2 - \rho \approx 4\%$
  (physical capital is risky store of value)
- Total money holding is larger with closed capital account
  - Global money would be a better hedge for “export risk”



Fixed exchange rate regimes & no MoPo

- Dollarization = (fully backed) Currency Board





- Exchange rate peg
  - Requires strong fiscal backing
    (since no backing through holding of global reserves)
    - After a string of adverse shocks, government must tax and use to proceeds to remove some of the local currency in circulation

Foreign Currency Reserves

- Irrelevance Theorem:
  - If central bank holds global money (reserves)
  - Citizens in small country will hold accordingly less

- Remark:
  - If central banks holds more $-reserves than citizens would like to hold, then agents borrow foreign currency from abroad.
  - If local money is worthless (without foreign reserves), then the value of local money with reserves only derives from the latter (currency board)
  - With fiscal backing of the local money, complicates analysis

Optimal Monetary Policy

- LARGE COUNTRY
  MoPo can correct pecuniary externality
  - Citizens take real interest rate as given
    when choosing their portfolio between money & physical capital
  - Money exists for $\tilde{\sigma}^* > \sqrt{\rho}$
  - Inflation is optimal for $\tilde{\sigma}^* > 2\sqrt{\rho}$ (For $\kappa = 0$, no adjustment costs)

  - MoPo improves insurance provided by "safe asset"
    - Constrained optimal!
    - Incentive compatible

- SMALL COUNTRY
  - Additional savings decision due open capital account

- Generally, optimal monetary policy depends on control social planner has

Conclusion

- Endogenous value of money (safe asset) in 2 countries
  - Local currency: better hedge for idiosyncratic risk (non-tradable consumption)
  - Global currency: hedge against ToT + export productivity shocks
- Spillover effects from US monetary policy
- Flight to safety
- When to peg? When to dollarize?
- "Nuanced Mundell-Fleming Trilemma"
  - Local and global money have different risk profile (imperfect substitutes)
    ⇒ increases MoPo space
  - Too high Peso inflation:
    local citizens substitute local currency for global currency
    ⇒ limits MoPo space
- Central Bank's foreign reserves holding: Irrelevance Result
- Optimal Monetary Policy
  - Idiosyncratic risk – correct pecuniary externality (real interest rate)
  - International savings