Liquidity Traps, Capital Flows & Currency Wars: A Model of the Great Recession

Sushant Acharya[1] Julien Bengui[2]

[1]Federal Reserve Bank of New York

[2]Université de Montréal

March 2016

International Research Forum on Monetary Policy

MOTIVATION: POST-2008 GLOBAL ECONOMY

1. Loose monetary policy in advanced economies
   - perception of deficient demand
   - period of binding zero lower bound (ZLB) on interest rate
2. Marked increase in capital flows from advanced to emerging economies
   - appreciation of emerging mkt currencies
3. Some key emerging markets imposed capital controls
   - combat currency appreciation
   - prevent overheating

MOTIVATION: POST-2008 GLOBAL ECONOMY

1. Loose monetary policy in advanced economies
   - perception of deficient demand
   - period of binding zero lower bound (ZLB) on interest rate
2. Marked increase in capital flows from advanced to emerging economies
   - appreciation of emerging mkt currencies
3. Some key emerging markets imposed capital controls
   - combat currency appreciation
   - prevent overheating

MOTIVATION: POST-2008 GLOBAL ECONOMY

1. Loose monetary policy in advanced economies
   - perception of deficient demand
   - period of binding zero lower bound (ZLB) on interest rate

2. Marked increase in capital flows from advanced to emerging economies
   - appreciation of emerging mkt currencies

3. Some key emerging markets imposed capital controls
   - combat currency appreciation
   - prevent overheating

QUESTIONS

In a liquidity trap...

I what role do capital flows play in macro adjustment?

II are free capital flows efficient?

III is capital flow management warranted?

QUESTIONS

In a liquidity trap...

I what role do capital flows play in macro adjustment?

II are free capital flows efficient?

III is capital flow management warranted?

QUESTIONS

In a liquidity trap...

I what role do capital flows play in macro adjustment?

II are free capital flows efficient?

III is capital flow management warranted?

QUESTIONS

In a liquidity trap...

I what role do capital flows play in macro adjustment?

II are free capital flows efficient?

III is capital flow management warranted?

THIS PAPER

Environment

- Multi-country New Keynesian model based on Gali-Monacelli (2005)
- Flexible exchange rates
- Nominal rigidities
- Zero bound on interest rates

Liquidity trap experiment

- Large demand shock pushes part of the world economy to ZLB
- Analysis of global macro adjustment under various capital flow regimes

THIS PAPER

Environment

- Multi-country New Keynesian model based on Gali-Monacelli (2005)
- Flexible exchange rates
- Nominal rigidities
- Zero bound on interest rates

Liquidity trap experiment

- Large demand shock pushes part of the world economy to ZLB
- Analysis of global macro adjustment under various capital flow regimes

RESULTS

I Capital flows foster demand and expenditure reallocation across countries and alleviate demand-driven recession

II Free capital flows are constrained inefficient

- constrained efficiency requires larger flows during and after liquidity trap

III Uncoordinated capital flow management is not warranted

- optimal uncoordinated CFM might hamper rather than foster global adjustment

RESULTS

I Capital flows foster demand and expenditure reallocation across countries and alleviate demand-driven recession

II Free capital flows are constrained inefficient

- constrained efficiency requires larger flows during and after liquidity trap

III Uncoordinated capital flow management is not warranted

- optimal uncoordinated CFM might hamper rather than foster global adjustment

RESULTS

I Capital flows foster demand and expenditure reallocation across countries and alleviate demand-driven recession

II Free capital flows are constrained inefficient

- constrained efficiency requires larger flows during and after liquidity trap

III Uncoordinated capital flow management is not warranted

- optimal uncoordinated CFM might hamper rather than foster global adjustment

RELATED LITERATURE

1. Optimal monetary policy at ZLB
   - closed economy: Krugman (1998), Eggertsson & Woodford (2003), Werning (2012)
   - open economy: Svensson (2001, 2003, 2004), Jeanne (2009), Fujiwara et. al (2013), Haberis & Lipinska (2012), Cook & Devereux (2013), Devereux and Yetman (2014)
2. Capital flow management
   - financial market frictions: Caballero & Krishnamurthy (2001), Korinek (2010, 2013), Bianchi (2011)
   - goods market frictions: Farhi & Werning (2012a, 2014), Costinot et. al (2014), De Paoli & Lipinska (2014), Schmitt-Grohe & Uribe (forthcoming)
3. Open-economy aspect of secular stagnation: Caballero, Farhi & Gourinchas (2015), Eggertsson, Mehrotra, Singh & Summers (2015)

OUTLINE

1. Model
2. Positive analysis: capital flows at the ZLB
3. Normative analysis: efficient capital flows?
4. A case for uncoordinated capital flow management?

MODEL FEATURES

- Continuous time
- Unit mass of small open economies making up world economy:
  - measure x of North economies
  - measure $1 - x$ of South economies
- Monopolistic competition and nominal rigidities in price setting
- Flexible exchange rates
- No uncertainty

Preferences

$$\int_0^\infty e^{-\int_0^t(\rho+\zeta_{k,h})dh}\left[\log \mathbb{C}_{k,t} - \frac{(N_{k,t})^{1+\phi}}{1+\phi}\right]dt$$

- $\zeta_{k,h}$: preference shock

Budget constraint

$$\dot{a}_{k,t} = i_{k,t}a_{k,t} + W_{k,t}N_{k,t} + T_{k,t} - \mathbb{P}_{k,t}\mathbb{C}_{k,t} + \int_0^1 \left[(i_{j,t}-i_{k,t}) + \frac{\dot{\mathcal{E}}^j_{k,t}}{\mathcal{E}^j_{k,t}} - (\tau_{j,t}-\tau_{k,t})\right]\mathcal{E}^j_{k,t}D^j_{k,t}dj$$

- $a_{k,t} = \int_0^1 \mathcal{E}^j_{k,t}D^j_{k,t}dj$: wealth of country k (in own currency)
- $\tau_{k,t}$: tax on capital inflows into country k

Preferences

$$\int_0^\infty e^{-\int_0^t (\rho+\zeta_{k,h})dh} \left[\log \mathbb{C}_{k,t} - \frac{(N_{k,t})^{1+\phi}}{1+\phi} \right] dt$$

- $\zeta_{k,h}$: preference shock

Budget constraint

$$\dot{a}_{k,t} = i_{k,t} a_{k,t} + W_{k,t} N_{k,t} + T_{k,t} - \mathbb{P}_{k,t} \mathbb{C}_{k,t} + \int_0^1 \left[(i_{j,t} - i_{k,t}) + \frac{\dot{\mathcal{E}}^j_{k,t}}{\mathcal{E}^j_{k,t}} - (\tau_{j,t} - \tau_{k,t}) \right] \mathcal{E}^j_{k,t} D^j_{k,t} dj$$

- $a_{k,t} \equiv \int_0^1 \mathcal{E}^j_{k,t} D^j_{k,t} dj$: wealth of country k (in own currency)
- $\tau_{k,t}$: tax on capital inflows into country k

MODEL: PREFERENCES AND BUDGET SET

Preferences

$$\int_0^\infty e^{-\int_0^t (\rho+\zeta_{k,h})dh} \left[\log \mathbb{C}_{k,t} - \frac{(N_{k,t})^{1+\phi}}{1+\phi}\right] dt$$

- $\zeta_{k,h}$: preference shock

Budget constraint

$$\dot{a}_{k,t} = i_{k,t} a_{k,t} + W_{k,t} N_{k,t} + T_{k,t} - \mathbb{P}_{k,t}\mathbb{C}_{k,t} + \int_0^1 \left[(i_{j,t} - i_{k,t}) + \frac{\dot{\mathcal{E}}^j_{k,t}}{\mathcal{E}^j_{k,t}} - (\tau_{j,t} - \tau_{k,t})\right] \mathcal{E}^j_{k,t} D^j_{k,t} dj$$

- $a_{k,t} \equiv \int_0^1 \mathcal{E}^j_{k,t} D^j_{k,t} dj$: wealth of country k (in own currency)
- $\tau_{k,t}$: tax on capital inflows into country k

MODEL: NESTED CES GOODS STRUCTURE

Consumption basket

$$\mathbb{C}_k \equiv \left(C_k^H\right)^{1-\alpha}\left(C_k^F\right)^{\alpha}$$

- $1-\alpha$: degree of home-bias
- home goods

$$C_k^H \equiv \left[\int_0^1 C_k^H(\ell)^{\frac{\epsilon-1}{\epsilon}} d\ell\right]^{\frac{\epsilon}{\epsilon-1}}$$

- foreign goods

$$C_k^F \equiv \exp\left(\int_0^1 \log C_k^j dj\right)$$

▸ Price indices

Continuum of monopolistically competitive firms

- differentiated varieties within each country
- production function:

$$Y_k(\ell) = AN_k(\ell)$$

- aggregate output defined as

$$Y_k \equiv \left[\int_0^1 Y_k(\ell)^{\frac{\epsilon-1}{\epsilon}} d\ell\right]^{\frac{\epsilon}{\epsilon-1}}$$

Fully rigid prices + Law of one price

$\Rightarrow$ fixed PPI in own currency (but flexible exchange rates $\rightarrow$ CPI not fixed)

$\Rightarrow$ terms of trade & real exchange rate related to nominal exchange rate

Continuum of monopolistically competitive firms

- differentiated varieties within each country
- production function:

$$Y_k(\ell) = AN_k(\ell)$$

- aggregate output defined as

$$Y_k \equiv \left[\int_0^1 Y_k(\ell)^{\frac{\epsilon-1}{\epsilon}} d\ell \right]^{\frac{\epsilon}{\epsilon-1}}$$

Fully rigid prices + Law of one price

$\Rightarrow$ fixed PPI in own currency (but flexible exchange rates $\rightarrow$ CPI not fixed)

$\Rightarrow$ terms of trade & real exchange rate related to nominal exchange rate

MODEL: KEY EQUILIBRIUM CONDITION & EXPERIMENT

- Backus-Smith condition

$$\mathbb{C}_{k,t} = \Theta^n_{k,t}\mathbb{C}_{n,t}\mathcal{Q}^n_{k,t} \qquad \text{with} \qquad \frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} = (\zeta_{n,t} - \zeta_{k,t}) - (\tau_{n,t} - \tau_{k,t})$$

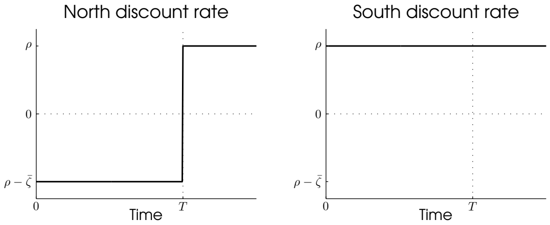
- Liquidity trap experiment

MODEL: KEY EQUILIBRIUM CONDITION & EXPERIMENT

- Backus-Smith condition

$$\mathbb{C}_{k,t} = \Theta^n_{k,t}\mathbb{C}_{n,t}\mathcal{Q}^n_{k,t} \qquad \text{with} \qquad \frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} = (\zeta_{n,t} - \zeta_{k,t}) - (\tau_{n,t} - \tau_{k,t})$$

- Liquidity trap experiment



OPTIMAL MONETARY POLICY

- Monetary authority in country k solves

$$\max_{\{i_{k,t}\}} \int_0^\infty e^{-(\rho+\zeta_{k,h})dh} \left[(1-\alpha) \log Y_{k,t} - \frac{1}{1+\phi} \left(\frac{Y_{k,t}}{A} \right)^{1+\phi} \right] dt$$

subject to:

$$\begin{aligned} \frac{\dot{Y}_{k,t}}{Y_{k,t}} &= i_{k,t} - (\rho + \zeta_{k,t}) - \frac{\alpha x}{\Lambda_{k,t}} \frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} - \frac{\alpha (1-x) \Theta^n_{s,t}}{\Lambda_{k,t}} \frac{\dot{\Theta}^s_{k,t}}{\Theta^s_{k,t}} \\ i_{k,t} &\geq 0. \end{aligned}$$

for $\Lambda_{k,t} \equiv (1-\alpha) \Theta^n_{k,t} + \alpha x + \alpha (1-x) \Theta^n_{s,t}$

Optimal monetary policy

- if ZLB slacks, target $Y_{k,t} = \overline{Y} \equiv A (1-\alpha)^{\frac{1}{1+\phi}}$ by appropriately choosing $i_{k,t}$.
- if ZLB binds, delay exit to $\widehat{T}_k > T$.

- Optimal delay: keep $i_{k,t}$ at zero past liquidity trap to center output around target level $\overline{Y}$ (Eggertson-Woodford(2003), Werning (2012))

OPTIMAL MONETARY POLICY

- Monetary authority in country k solves

$$\max_{\{i_{k,t}\}} \int_0^\infty e^{-(\rho+\zeta_{k,h})dh} \left[(1-\alpha) \log Y_{k,t} - \frac{1}{1+\phi} \left(\frac{Y_{k,t}}{A} \right)^{1+\phi} \right] dt$$

subject to:

$$\begin{aligned} \frac{\dot{Y}_{k,t}}{Y_{k,t}} &= i_{k,t} - (\rho + \zeta_{k,t}) - \frac{\alpha x}{\Lambda_{k,t}} \frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} - \frac{\alpha (1-x) \Theta^n_{s,t}}{\Lambda_{k,t}} \frac{\dot{\Theta}^s_{k,t}}{\Theta^s_{k,t}} \\ i_{k,t} &\geq 0. \end{aligned}$$

for $\Lambda_{k,t} \equiv (1-\alpha) \Theta^n_{k,t} + \alpha x + \alpha (1-x) \Theta^n_{s,t}$

Optimal monetary policy

- if ZLB slacks, target $Y_{k,t} = \overline{Y} \equiv A (1-\alpha)^{\frac{1}{1+\phi}}$ by appropriately choosing $i_{k,t}$.
- if ZLB binds, delay exit to $\widehat{T}_k > T$.

- Optimal delay: keep $i_{k,t}$ at zero past liquidity trap to center output around target level $\overline{Y}$ (Eggertson-Woodford(2003), Werning (2012))

OPTIMAL MONETARY POLICY

- Monetary authority in country k solves

$$\max_{\{i_{k,t}\}} \int_0^\infty e^{-(\rho+\zeta_{k,h})dh} \left[(1-\alpha)\log Y_{k,t} - \frac{1}{1+\phi}\left(\frac{Y_{k,t}}{A}\right)^{1+\phi}\right] dt$$

subject to:

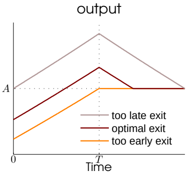
$$\begin{aligned} \frac{\dot{Y}_{k,t}}{Y_{k,t}} &= i_{k,t} - (\rho+\zeta_{k,t}) - \frac{\alpha x}{\Lambda_{k,t}}\frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} - \frac{\alpha(1-x)\Theta^n_{s,t}}{\Lambda_{k,t}}\frac{\dot{\Theta}^s_{k,t}}{\Theta^s_{k,t}} \\ i_{k,t} &\geq 0. \end{aligned}$$

for $\Lambda_{k,t} \equiv (1-\alpha)\Theta^n_{k,t} + \alpha x + \alpha(1-x)\Theta^n_{s,t}$

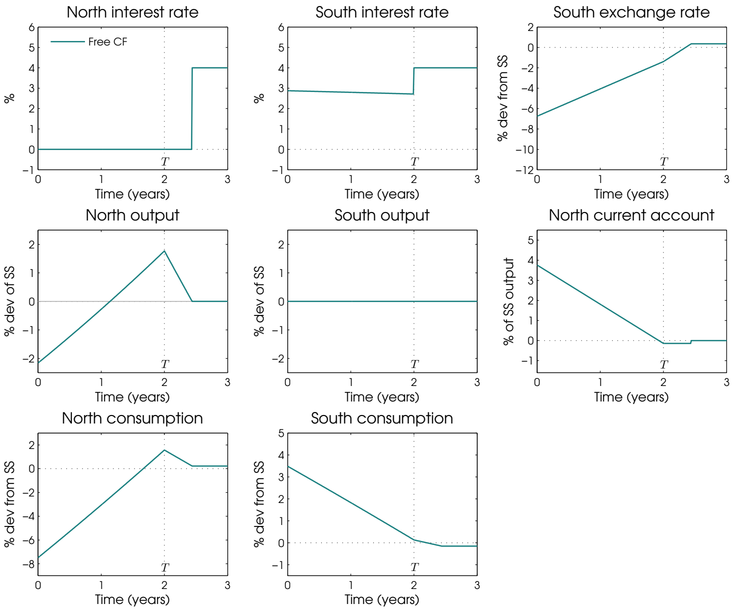
Optimal monetary policy

- if ZLB slacks, target $Y_{k,t} = \overline{Y} \equiv A(1-\alpha)^{\frac{1}{1+\phi}}$ by appropriately choosing $i_{k,t}$.
- if ZLB binds, delay exit to $\widehat{T}_k > T$.

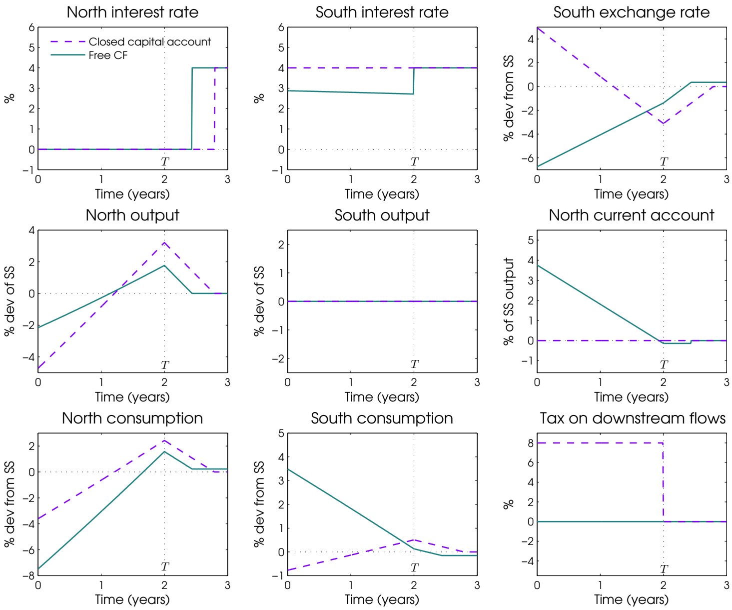
- Optimal delay: keep $i_{k,t}$ at zero past liquidity trap to center output around target level $\overline{Y}$ (Eggertson-Woodford(2003), Werning (2012))



EQUILIBRIUM UNDER FREE CAPITAL FLOWS



FREE CAPITAL FLOWS VS CLOSED CAPITAL ACCOUNTS



CAPITAL FLOW EFFICIENCY

Is capital efficiently flowing across countries in liquidity trap?

- Consider constrained planner who taxes/subsidizes capital flows from North to South
- Planner maximize global welfare, subject to
  1. making all countries at least as well off as under free CF
  2. interest rate policy set by domestic monetary authorities
  3. private implementability constraints

  ▸ Formal problem
- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

Is capital efficiently flowing across countries in liquidity trap?

- Consider constrained planner who taxes/subsidizes capital flows from North to South
- Planner maximize global welfare, subject to
  1. making all countries at least as well off as under free CF
  2. interest rate policy set by domestic monetary authorities
  3. private implementability constraints

  Formal problem
- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

Is capital efficiently flowing across countries in liquidity trap?

- Consider constrained planner who taxes/subsidizes capital flows from North to South
- Planner maximize global welfare, subject to
  1. making all countries at least as well off as under free CF
  2. interest rate policy set by domestic monetary authorities
  3. private implementability constraints

  Formal problem
- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

CAPITAL FLOW EFFICIENCY

Is capital efficiently flowing across countries in liquidity trap?

- Consider constrained planner who taxes/subsidizes capital flows from North to South
- Planner maximize global welfare, subject to
  1. making all countries at least as well off as under free CF
  2. interest rate policy set by domestic monetary authorities
  3. private implementability constraints

  ▸ Formal problem
- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

Are free capital flows constrained efficient?

Inefficiency of free capital flows

At ZLB, regime of free capital mobility is constrained inefficient.

- Source of inefficiency: aggregate demand externality associated with agents' debt choices due to

  nominal rigidity + constraints on monetary policy

What do constrained efficient capital flows look like?

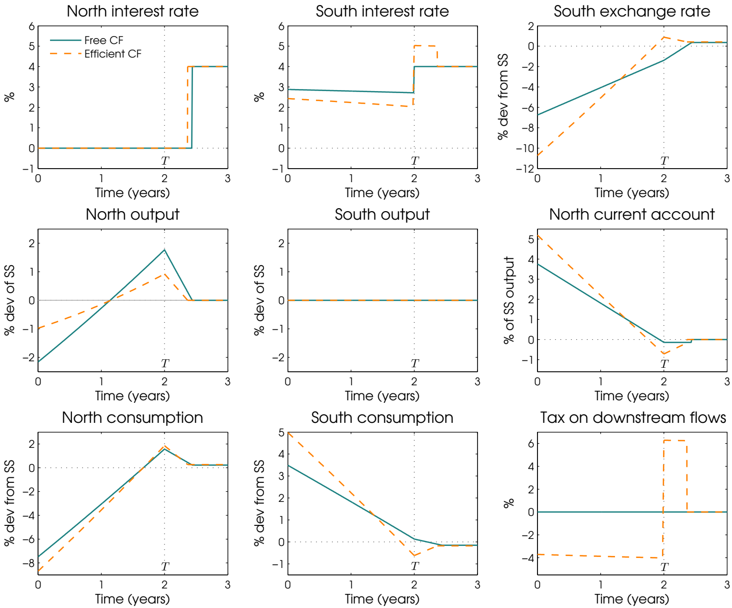
Optimal capital flow tax

For small enough degree of openess α, optimal tax satisfies

$$\begin{aligned} \tau_{s,t} &< 0 \quad \text{for } 0 \leq t < T \\ \tau_{s,t} &> 0 \quad \text{for } T \leq t < \widehat{T}_n \\ \tau_{s,t} &= 0 \quad \text{for } t \geq \widehat{T}_n \end{aligned}$$

limit of extreme home bias

EFFICIENT CAPITAL FLOW MANAGEMENT



▸ Labor wedge

Should countries manage their capital account in liquidity trap?

- Consider local planners who taxe/subsidize capital flows into their countries
- Planners maximize domestic welfare, subject to
  1. private implementability constraints

  Formal problem
- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

Should countries manage their capital account in liquidity trap?

- Consider local planners who taxe/subsidize capital flows into their countries
- Planners maximize domestic welfare, subject to
  1. private implementability constraints

  Formal problem
- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

UNCOORDINATED CAPITAL FLOW MANAGEMENT

Should countries manage their capital account in liquidity trap?

- Consider local planners who taxe/subsidize capital flows into their countries
- Planners maximize domestic welfare, subject to
  1. private implementabilty constraints

  ▸ Formal problem

- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

UNCOORDINATED CAPITAL FLOW MANAGEMENT

Should countries manage their capital account in liquidity trap?

- Consider local planners who taxe/subsidize capital flows into their countries
- Planners maximize domestic welfare, subject to
  1. private implementability constraints

  ▸ Formal problem

- Questions:
  1. Is zero tax path optimal?
  2. How does optimal tax path look like?

UNCOORDINATED CAPITAL FLOW MANAGEMENT

Individually optimal capital flow taxes

Country k's optimal capital inflow tax satisfies:

$$\tau_{k,t} = \underbrace{\Omega^1_{k,t} \left[(1-x)\, \Theta^n_{s,t} \left(\zeta_{k,t} + \tau_{s,t} \right) + x \left(\zeta_{k,t} - \zeta_{n,t} + \tau_{n,t} \right) \right]}_{\text{dynamic terms of trade management}} + \underbrace{\Omega^2_{k,t} \frac{\dot{Y}_{k,t}}{Y_{k,t}}}_{\text{aggregate demand management}}$$

for $\Omega^1_{k,t}, \Omega^2_{k,t} > 0$.

1. Independently from ZLB, countries tame capital flows to manipulate dynamic terms of trade (Costinot et al., 2014)
   - tax inflows in response to foreign negative or home positive demand shocks
   - taxes are strategic complements
2. Countries at ZLB also use capital flow management to stabilize aggregate demand, in effort to compensate for impotency of MP

1. Only South uses taxes

Currency war among South

If only South manages capital flows, then taxes slow down but neither shut down nor reverse global capital flows ($0 < \tau_{s,t} < \bar{\zeta}$ for $0 \leq t < T$ and $\tau_{s,t} = 0$ for $t \geq T$) .

2. All countries use taxes: full blown currency war
   - North faces trade-off btween ToT manip and AD management, and may subsidize outflows, but South fights back by taxing inflows
   - North and South neutralize each other, resulting in near zero tax wedge $\tau_{s,t} - \tau_{n,t}$

Nash equilibrium of currency war game

1. Only South uses taxes

Currency war among South

If only South manages capital flows, then taxes slow down but neither shut down nor reverse global capital flows ($0 < \tau_{s,t} < \bar{\zeta}$ for $0 \leq t < T$ and $\tau_{s,t} = 0$ for $t \geq T$) .

2. All countries use taxes: full blown currency war
   - North faces trade-off btween ToT manip and AD management, and may subsidize outflows, but South fights back by taxing inflows
   - North and South neutralize each other, resulting in near zero tax wedge $\tau_{s,t} - \tau_{n,t}$

CONCLUSION

1. In liquidity trap, capital flows
    - promote reallocation of demand and expenditure
    - alleviates harm caused by ZLB in most inflicted region
2. Capital flows too slowly to promote efficient reallocation
3. Uncoordinated capital controls particularly harmful during liquidity trap, as ToT management motive works against efficient AD stabilization

Thank you.

BACKUP SLIDES

Model: nested CES goods structure (without Cole-Obstfeld)

Consumption basket

$$\mathbb{C}_k \equiv \left[(1-\alpha)^{\frac{1}{\eta}} \left(C_k^H\right)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(C_k^F\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

- $1-\alpha$: degree of home-bias
- home goods

$$C_k^H \equiv \left[\int_0^1 C_k^H(\ell)^{\frac{\epsilon-1}{\epsilon}} d\ell\right]^{\frac{\epsilon}{\epsilon-1}}$$

- foreign goods

$$C_k^F \equiv \left[\int_0^1 C_k^{j\,\frac{\gamma-1}{\gamma}} dj\right]^{\frac{\gamma}{\gamma-1}}$$

Price indices | Back

MODEL: PRICE INDICES

- domestic CPI

$$\mathbb{P}_k \equiv \left(P_k^H\right)^{1-\alpha} \left(P_k^F\right)^{\alpha}$$

- domestic PPI

$$P_k^H \equiv \left[\int_0^1 P_k^H(\ell)^{1-\epsilon} d\ell\right]^{\frac{1}{1-\epsilon}}$$

- foreign PPI

$$P_k^F \equiv \exp\left(\int_0^1 \log P_k^j dj\right)$$

▸ Price indices without Cole-Obstfeld ▸ Back

Model: price indices (without Cole-Obstfeld)

- domestic CPI

$$\mathbb{P}_k \equiv \left[(1-\alpha)\left(P_k^H\right)^{1-\eta} + \alpha\left(P_k^F\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

- domestic PPI

$$P_k^H \equiv \left[\int_0^1 P_k^H(\ell)^{1-\epsilon} d\ell\right]^{\frac{1}{1-\epsilon}}$$

- foreign PPI

$$P_k^F \equiv \left[\int_0^1 {P_k^j}^{1-\gamma} dj\right]^{\frac{1}{1-\gamma}}$$

Back

- bilateral terms of trade & real exchange rate

$$\mathcal{S}_j^k \equiv \frac{\mathcal{E}_k^j P_j^j}{P_k^k} \qquad \& \qquad \mathcal{Q}_k^j \equiv \frac{\mathcal{E}_k^j \mathbb{P}_j}{\mathbb{P}_k}$$

- effective terms of trade & real exchange rate

$$\mathcal{S}_k \equiv \frac{P_k^F}{P_k^k} = \left[\int_0^1 \mathcal{S}_k^j dj\right]^{\frac{1}{1-\gamma}} \qquad \& \qquad \mathcal{Q}_k \equiv \frac{P_k^F}{\mathbb{P}_k} = \frac{\mathcal{E}_k P^*}{\mathbb{P}_k}$$

where world price index & effective nominal exchange rate are

$$P^* \equiv \left[\int_0^1 P_j^{j\,1-\gamma} dj\right]^{\frac{1}{1-\gamma}} \qquad \& \qquad \mathcal{E}_k \equiv \left[\frac{\int_0^1 \left(\mathcal{E}_k^j P_j^j\right)^{1-\gamma} dj}{\int_0^1 P_j^{j\,1-\gamma} dj}\right]^{\frac{1}{1-\gamma}}$$

Back

Model: Key Equilibrium Conditions (without Cole-Obstfeld)

- Euler equation

$$\frac{\dot{\mathbb{C}}_{k,t}}{\mathbb{C}_{k,t}} = \frac{1}{\sigma}\left[i_{k,t} - \pi_{k,t} - (\rho + \zeta_{k,t})\right]$$

- Backus-Smith condition

$$\mathbb{C}_{k,t} = \Theta^{n}_{k,t}\mathbb{C}_{n,t}\left(\mathcal{Q}^{n}_{k,t}\right)^{\frac{1}{\sigma}} \qquad \text{with} \qquad \frac{\dot{\Theta}^{n}_{k,t}}{\Theta^{n}_{k,t}} = \frac{1}{\sigma}\left[(\zeta_{n,t} - \zeta_{k,t}) - (\tau_{n,t} - \tau_{k,t})\right]$$

- Market clearing condition

$$Y_{k,t} = (1-\alpha)\left(\frac{\mathcal{Q}_{k,t}}{\mathcal{S}_{k,t}}\right)^{-\eta}\mathbb{C}_{k,t} + \alpha x\left(\mathcal{S}^{n}_{k,t}\mathcal{S}_{n,t}\right)^{\gamma}\mathcal{Q}^{-\eta}_{n,t}\mathbb{C}_{n,t} + \alpha(1-x)\left(\mathcal{S}^{s}_{k,t}\mathcal{S}_{s,t}\right)^{\gamma}\mathcal{Q}^{-\eta}_{s,t}\mathbb{C}_{s,t}$$

- Country budget constraint

$$B_{k,0} = -\int_0^{\infty} e^{-\int_0^t\left[\rho+\zeta_{n,h}-\tau_{n,h}\right]dh}\,\mathbb{C}^{-\sigma}_{n,t}\left(\mathcal{Q}^{n}_{k,t}\right)^{-1}\left[\left(S_{k,t}\right)^{-\alpha}Y_{k,t} - \mathbb{C}_{k,t}\right]dt$$

Back

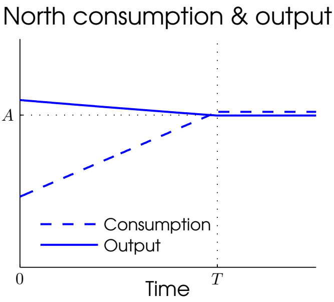
Parametrization

	Value	Source
Discount rate	$\rho = 0.04$	Gali-Monacelli (2005)
Home bias	$\alpha = 0.4$	Gali-Monacelli (2005)
Inverse elas. of labor supply	$\phi = 3$	Gali-Monacelli (2005)
Relative size of North	$x = 0.4$	Share of advanced economies in world GDP
Initial NFA	$B_{s,0} = 0$	Symmetric initial conditions
	Liquidity trap experiment	
Duration of liquidity trap	$T = 2$	Werning (2012)
Demand shock	$\bar{\zeta} = 0.08$	Werning (2012)

Table: Parameter values

Back

FIRST BEST ALLOCATION



CONSTRAINED PLANNING PROBLEM

$$\max_{\{\tau_{s,t}, i_{s,t}, i_{n,t}\}} \quad \int_0^\infty e^{-\int_0^t \left(\rho+\zeta_{n,h}\right) dh} \left[\log \mathbb{C}_{n,t} - \frac{1}{1+\phi}\left(\frac{Y_{n,t}}{A}\right)^{1+\phi}\right] dt + \Xi^n_{s,0} \int_0^\infty e^{-\rho t} \left[\log \mathbb{C}_{s,t} - \frac{1}{1+\phi}\left(\frac{Y_{s,t}}{A}\right)^{1+\phi}\right] dt$$

subject to:

$$\begin{aligned}
\overline{\mathbb{W}}_{0,k} &\leq \int_0^\infty e^{-\int_0^t \left(\rho+\zeta_{k,h}\right) dh} \left[\log \mathbb{C}_{k,t} - \frac{1}{1+\phi}\left(\frac{Y_{k,t}}{A}\right)^{1+\phi}\right] dt \\
\mathbb{C}_{k,t} &= \Theta^n_{k,t}\left(\frac{Y_{k,t}}{\Lambda_{k,t}}\right)^{1-\alpha}\left(\frac{Y_{n,t}}{\Lambda_{n,t}}\right)^{\alpha x}\left(\frac{Y_{s,t}}{\Lambda_{s,t}}\right)^{\alpha(1-x)} \\
\frac{\dot{Y}_{k,t}}{Y_{k,t}} &= i_{k,t} - \left(\rho + \zeta_{k,t}\right) - \frac{\alpha x}{\Lambda_{k,t}}\frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} - \frac{\alpha\left(1-x\right)\Theta^n_{s,t}}{\Lambda_{k,t}}\frac{\dot{\Theta}^s_{k,t}}{\Theta^s_{k,t}} \\
-\dot{\mu}^y_{k,t} &= \frac{e^{-\int_0^t \left(\rho+\zeta_{k,t}\right) dh}}{Y_{k,t}}\left\{\left(1-\alpha\right) - \left(\frac{Y_{k,t}}{A}\right)^{1+\phi}\right\} + \mu^y_{k,t}\frac{\dot{Y}_{k,t}}{Y_{k,t}} \\
\mu^y_{k,t} i_{k,t} &= 0 \\
i_{k,t} &\geq 0 \\
\frac{\dot{\Theta}^n_{s,t}}{\Theta^n_{s,t}} &= \zeta_{n,t} + \tau_{s,t}
\end{aligned}$$

for $k \in \{s, n\}$, with $\Lambda_{k,t} \equiv \left[\left(1-\alpha\right)\Theta^n_{k,t} + \alpha x + \alpha\left(1-x\right)\Theta^n_{s,t}\right]$. ▸ Back

Define labor wedge for country k good as

$$\omega_{k,t} \equiv 1 - \left(\mathcal{S}^n_{k,t}\right)^{\alpha}\left(\mathcal{S}^n_{s,t}\right)^{-\alpha(1-x)} \frac{\mathbb{C}_{k,t} N^{\phi}_{k,t}}{A}$$

Optimal tax and labor wedges

The optimal tax is related to labor wedges via

$$\tau_{s,t} = \frac{\alpha x\left(1-\omega_{s,t}\right)\zeta_{n,t} + \left[\alpha x + (1-\alpha x)\,\Xi^n_{s,t}\right]\dot{\omega}_{s,t}}{\frac{1-\alpha}{1-\alpha x}\Xi^n_{s,t} - \left[\alpha x + (1-\alpha x)\,\Xi^n_{s,t}\right]\left(1-\omega_{s,t}\right)} + \frac{\dot{\omega}_{n,t}}{1-\omega_{n,t}}$$

back

Optimal tax under extreme home bias

In the limit of $\alpha \to 0$, the optimal tax is given by

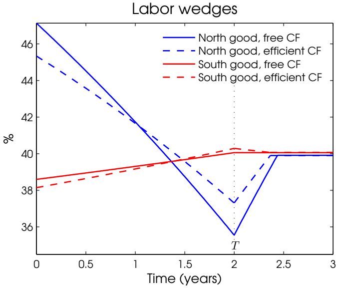
$$\tau_{s,t} = \begin{cases} (1+\phi)(\rho - \bar{\zeta}) < 0 & \text{for } 0 \leq t < T \\ (1+\phi)\rho > 0 & \text{for } T \leq t < \widehat{T}_n \\ 0 & \text{for } t \geq \widehat{T}_n \end{cases}$$

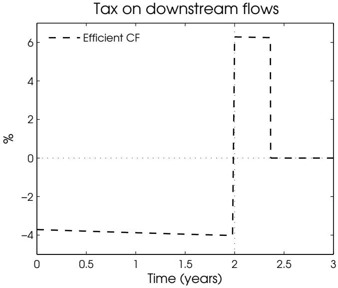
Back

OPTIMAL TAX AND LABOR WEDGES

Define labor wedge for country k good as

$$\omega_{k,t} \equiv 1 - \left(\mathcal{S}^n_{k,t}\right)^{\alpha} \left(\mathcal{S}^n_{s,t}\right)^{-\alpha(1-x)} \frac{\mathbb{C}_{k,t} N^{\phi}_{k,t}}{A}$$





Back

DOMESTIC PLANNING PROBLEM

$$\max_{\{\tau_{k,t}, i_{k,t}\}} \int_0^\infty e^{-\int_0^t \left(\rho+\zeta_{k,h}\right) dh} \left[\log \mathbb{C}_{k,t} - \frac{1}{1+\phi} \left(\frac{Y_{k,t}}{A}\right)^{1+\phi}\right] dt$$

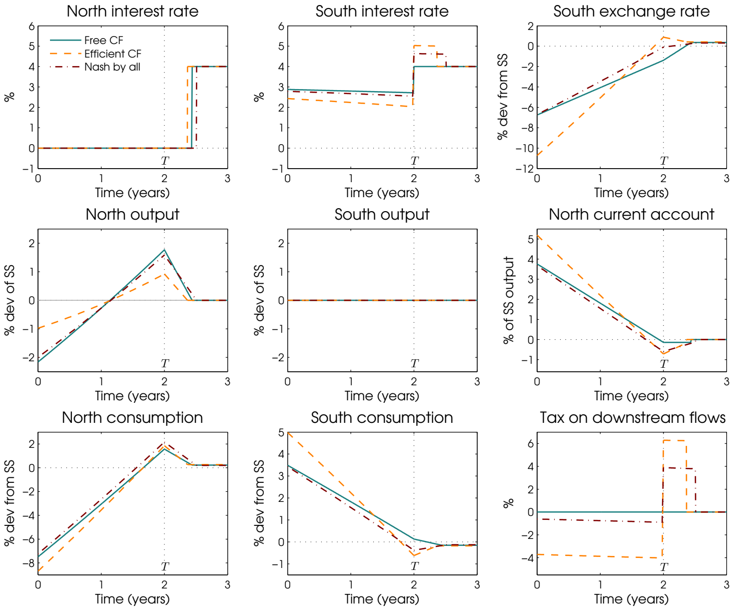
subject to:

$$\begin{aligned}
\mathbb{C}_{k,t} &= \Theta^n_{k,t} \left(\frac{Y_{k,t}}{\Lambda_{k,t}}\right)^{1-\alpha} \left(\frac{Y_{n,t}}{\Lambda_{n,t}}\right)^{\alpha x} \left(\frac{Y_{s,t}}{\Lambda_{s,t}}\right)^{\alpha(1-x)} \\
\frac{\dot{Y}_{k,t}}{Y_{k,t}} &= i_{k,t} - \left(\rho + \zeta_{k,t}\right) - \frac{\alpha x}{\Lambda_{k,t}} \frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} - \frac{\alpha\left(1-x\right)\Theta^n_{s,t}}{\Lambda_{k,t}} \frac{\dot{\Theta}^s_{k,t}}{\Theta^s_{k,t}} \\
i_{k,t} &\geq 0 \\
\frac{\dot{\Theta}^n_{k,t}}{\Theta^n_{k,t}} &= \zeta_{n,t} + \tau_{k,t} \\
B_{k,0} &= \alpha \int_0^\infty e^{-\int_0^t (\rho+\zeta_{n,s}-\tau_{n,s})] ds} \left[\Theta^n_{k,t} - x - \left(1-x\right)\Theta^n_{s,t}\right] dt
\end{aligned}$$

with $\Lambda_{k,t} \equiv \left[\left(1-\alpha\right)\Theta^n_{k,t} + \alpha x + \alpha\left(1-x\right)\Theta^n_{s,t}\right]$.

Back

CURRENCY WAR AMONG ALL



back

Define labor wedge for country k good as

$$\omega_{k,t} \equiv 1 - \left(\mathcal{S}_{k,t}^{n}\right)^{\alpha} \left(\mathcal{S}_{s,t}^{n}\right)^{-\alpha(1-x)} \frac{\mathbb{C}_{k,t} N_{k,t}^{\phi}}{A}$$

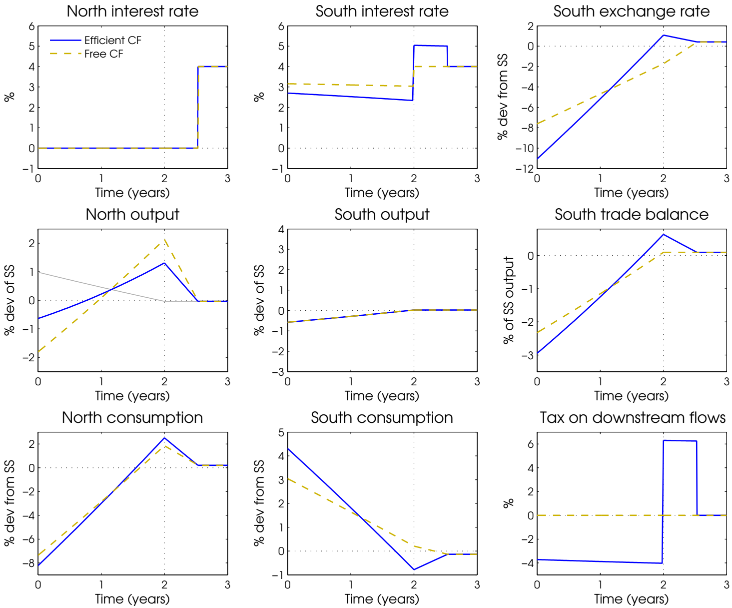
Optimal tax and labor wedges

The optimal tax is related to labor wedges via

$$\tau_{s,t} = \frac{(1-\alpha x)}{\alpha x + (1-\alpha x)\,\omega_{s,t}} \dot{\omega}_{s,t} + \frac{1}{1-\omega_{n,t}} \dot{\omega}_{n,t}$$

back

EFFICIENT CAPITAL FLOW MANAGEMENT WITH COOP MP

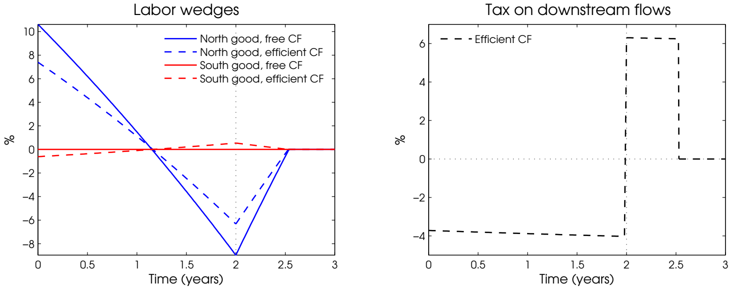


back

OPTIMAL TAX AND LABOR WEDGES (COOPERATIVE MP)

Define labor wedge for country k good as

$$\omega_{k,t} \equiv 1 - \left(\mathcal{S}^n_{k,t}\right)^{\alpha} \left(\mathcal{S}^n_{s,t}\right)^{-\alpha(1-x)} \frac{\mathbb{C}_{k,t} N^{\phi}_{k,t}}{A}$$



▸ back