Foreign Exchange Intervention with UIP and CIP Deviations: The Case of Small Safe Haven Economies

Philippe Bacchetta
U. of Lausanne
Swiss Finance Institute
CEPR

Kenza Benhima
U. of Lausanne
CEPR

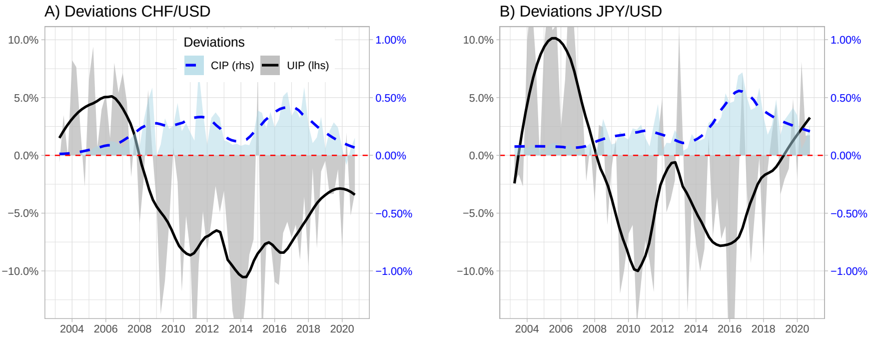
Brendan Berthold
U. of Lausanne

July 2024

Introduction

- Small safe haven countries face appreciating pressure. May lead to substantial accumulation of FX reserves. Swiss National Bank (SNB): up to 120% of GDP in 2021
- What is the opportunity cost of reserves accumulation ?
- Deviation from Covered Interest rate Parity (CIP)?
  - Amador, Bianchi, Bocola and Perri (ReStud, 2020), Fanelli and Straub (ReStud, 2021)
- Or deviations from Uncovered Interest Parity (UIP)?
  - Adler and Mano (2021)

UIP and CIP Deviations



Definitions: Excess returns

- UIP deviation: excess return in domestic currency, expressed in foreign currency

$$X^*_{t+1} \equiv (1+i_t)\frac{S_t}{S_{t+1}} - (1+i^*_t)$$

- CIP deviation: excess return hedged by forward rate

$$Z^*_{t+1} \equiv (1+i_t)\frac{S_t}{F_t} - (1+i^*_t)$$

- For Switzerland and Japan we have $Z^*_{t+1} > 0$ and $E_t X^*_{t+1} < 0$

Objectives

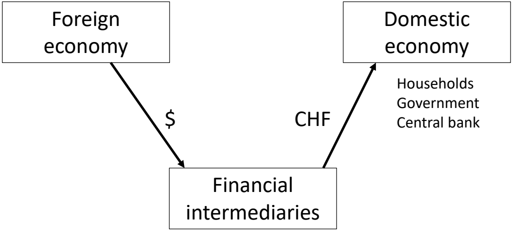
- Develop a framework where CIP and UIP deviations can be of different signs
- What is the **welfare-based opportunity cost of reserves**?
- Implications for the optimal behavior of the central bank, modeling it as a constrained planner
  - Introduce other benefits of FX intervention (e.g. stabilizing the real exchange rate or avoiding sudden stops, here: relax households' credit constraints)

Outline

- Small economy model
- International Arbitrage - CIP and UIP deviations
- Utility cost of reserves - theory and evidence
- Optimal FX accumulation
- Linear-quadratic model of a safe haven economy

The Model

- Two-period small open economy with two currencies (domestic and foreign): financial intermediaries, households, central bank and government
  - Constrained international financial intermediaries (Gabaix-Maggiori)
  - Limited FX position of domestic households (no short-selling of domestic or foreign bonds)
  - Government is passive (fixed supply of gov. bonds)
  - Central Bank performs sterilized (and unsterilized) interventions



The Model

- Structure is similar to Amador et al. (2020), Fanelli and Straub (2021), Cavallino (2019), Itskhoki and Mukhin (2021), but both **financial intermediaries and households are risk averse** (like Fang and Liu, 2021)

- Home country is a **safe haven**

- Incentive for central banks to buy foreign assets when households are constrained

- Flexible prices. Foreign price normalized to one: $P_t^* = 1$, Law of one price: $S_t = P_t$

The Model: Domestic Households

- Hold money, h_t^H, domestic-currency bonds b_t^H, and foreign-currency bonds b_t^F (all expressed in real terms)

- Their utility function is:

$$U(c_t) + \beta E_t U(c_{t+1})$$

- Budget constraints:

$$c_t = y_t - h_t - b_t^H - b_t^F + t_t$$
$$c_{t+1} = y_{t+1} + \frac{S_t}{S_{t+1}} h_t^H - h_{t+1}^H + (1 + i_t) \frac{S_t}{S_{t+1}} b_t^H + (1 + i_t^*) b_t^F + t_{t+1}$$

- Short-selling constraints: $b^H \geq 0, \; b^F \geq 0$
- Cash-in-advance constraints: $h_t^H \geq y_t, \; h_{t+1}^H \geq y_{t+1}$

The Model: the domestic bond market

- Equilibrium on the domestic bond market:
$$\underbrace{b_t^{H*}}_{\text{Foreign demand}} = \underbrace{b_t^G - b_t^H - b_t^{CB}}_{\text{Domestic supply}}$$

- b_t^G: government debt, b_t^H: households' holdings, b_t^{CB}: central bank holdings Central bank Government

- Foreign exchange interventions (FXI): $\underbrace{b_t^{CBF}}_{\$} = \underbrace{h_t - b_t^{CB}}_{CHF}$

- Sterilized FXI purchases b_t^{CBF} increase the supply of domestic bonds b_t^{H*} $\Rightarrow$ increase in the **gross foreign assets and liabilities** (FXI are not neutral because of the households' short-selling constraints)

UIP deviation: a free lunch?

- Intertemporal resource constraint:

$$(1+r_t)c_t + c_{t+1} = (1+r_t)y_t + y_{t+1} - X^*_{t+1} b_t^{H*}$$

- If $X^*_{t+1} < 0$, central bank reserve interventions (b_t^{CB}) can increase resources

- But X^*_{t+1} is risky and we need to evaluate this from utility perspective

- **Utility cost of FX intervention**

$$UCFX_t = \frac{E_t(m_{t+1} X^*_{t+1})}{E_t(m_{t+1})} \tag{1}$$

- m_{t+1} is the sdf of households

International Financial Intermediaries

- Objective function is (in dollars):

$$V_t^* = E_t \left\{ m_{t+1}^* \left[b_t^{H*} \left((1+i_t)\frac{S_t}{S_{t+1}} - (1+i_t^*) \right) - f_t^* \left(\frac{1}{S_{t+1}} - \frac{1}{F_t} \right) \right] \right\} - \chi b_t^{H*}$$

- They can divert a fraction Γb_t^{H*} of the invested funds
  - As in Gabaix and Maggiori
  - After investment decisions are taken, but before shocks are realized

- Participation constraint:

$$V_t^* \geq \Gamma (b_t^{H*})^2 \tag{2}$$

International Financial Intermediaries

- CIP deviation: If (2) is binding and take FOC w/f_t^*, we find

$$Z_{t+1}^* = \frac{\overbrace{\Gamma b_t^{H*}}^{\text{Limited arbitrage}} + \overbrace{\chi}^{\text{Convenience yield}}}{E_t m_{t+1}^*}$$

- UIP deviation:

$$E_t X_{t+1}^* = Z_{t+1}^* - \overbrace{\frac{cov\left(m_{t+1}^*, X_{t+1}^*\right)}{E_t m_{t+1}^*}}^{-\text{Risk premium}} \tag{3}$$

- Safe haven: $cov\left(m_{t+1}^*, X_{t+1}^*\right) > 0$

Marginal utility cost of reserves

- Remember

$$UCFX_t = \frac{E_t(m_{t+1}X^*_{t+1})}{E_t(m_{t+1})}$$

- We find:

$$UCFX_t = \underbrace{\overbrace{\frac{\Gamma b_t^{H*} + \chi}{E_t m^*_{t+1}}}^{devCIP} - \frac{cov_t(m^*_{t+1}, X^*_{t+1})}{E_t m^*_{t+1}}}_{devUIP} + \frac{cov_t(m_{t+1}, X^*_{t+1})}{E_t m_{t+1}}$$

- If $\frac{cov_t(m^*_{t+1}, X^*_{t+1})}{E_t m^*_{t+1}} = \frac{cov_t(m_{t+1}, X^*_{t+1})}{E_t m_{t+1}}$, then CIP matters

- If $cov_t(m_{t+1}, X^*_{t+1}) = 0$, then UIP matters

Proposition

Estimating Covariances

- Compute covariances between x^*_{t+1} (X^*_{t+1} in logs) at 3 months and m^*_{t+1} or m_{t+1}, quarterly data for 1999-2021, CHF and JPY vs USD
- Assume:

$$m^*_{t+1} = \beta \left(\frac{NW^*_{t+1}}{NW^*_t} \right)^{-\gamma}$$

  - NW^*_t: net worth of financial intermediaries (recent literature on intermediary asset pricing), measured as equity capital ratios of US financial intermediaries $\times$ wealth of intermediaries (He, Kelly, and Manela 2017, Adrian, Etula, and Muir 2014)
- For the SDF of Swiss and Japanese households, use real total consumption
- $\beta = 0.99$, $\gamma = 5$

Estimating Covariances

Table: $Cov(x^*_{t+1}, m^*_{t+1})$ and $Cov(x^*_{t+1}, m_{t+1})$

A) CHF domestic currency, USD foreign currency

	Fin. Intermediaries				HH
$NW_{t+1} =$	$\eta^{HKM}_{t+1} \times W^{MSCI}_{t+1}$	$\eta^{AEM}_{t+1} \times W^{MSCI}_{t+1}$	$\eta^{HKM}_{t+1} \times W^{GDP}_{t+1}$	$\eta^{AEM}_{t+1} \times W^{GDP}_{t+1}$	C^{CH}_{t+1}
1999-2010	1.61	1.74	0.2	-1.17	0.25***
2010-2020	2.82**	1.32	5.1*	2.13**	0.01

B) JPY domestic currency, USD foreign currency

$NW_{t+1} =$	$\eta^{HKM}_{t+1} \times W^{MSCI}_{t+1}$	$\eta^{AEM}_{t+1} \times W^{MSCI}_{t+1}$	$\eta^{HKM}_{t+1} \times W^{GDP}_{t+1}$	$\eta^{AEM}_{t+1} \times W^{GDP}_{t+1}$	C^{JP}_{t+1}
1999-2010	1.85	-2.9	-3.57	-2.56**	0.7***
2010-2020	6.39***	3.31**	7.93***	2.63**	0.33

- Japan and CH 2010-2020: $\Delta Cov > 0$
- CH: $cov_t(m_{t+1}, X^*_{t+1})$ close to zero $\Rightarrow$ Only UIP matters!

$\Rightarrow$ Benefit of holding reserves Risk

Optimal FX Intervention

- Implications for FX interventions?
- Central bank as a constrained planner Constrained planner
- For sterilized intervention (or unsterilized at the ZLB), we find:

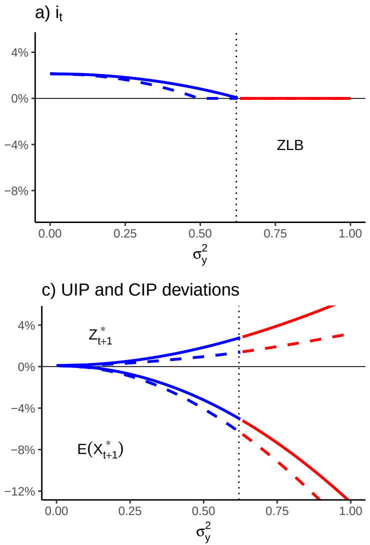
$$\underbrace{\overbrace{-E_t X^*_{t+1} - \frac{cov\left(m_{t+1}, X^*_{t+1}\right)}{E_t m_{t+1}}}^{-UCFX_t} + \overbrace{\frac{\alpha_0}{\eta_t E_t m_{t+1}}}^{<0}\Gamma}_{MBFX_t} = 0$$

- Central bank buys fewer foreign assets than households would like (dynamic terms of trade externality Bond market equilibrium)

A Linear-Quadratic Version of a Safe Haven Economy

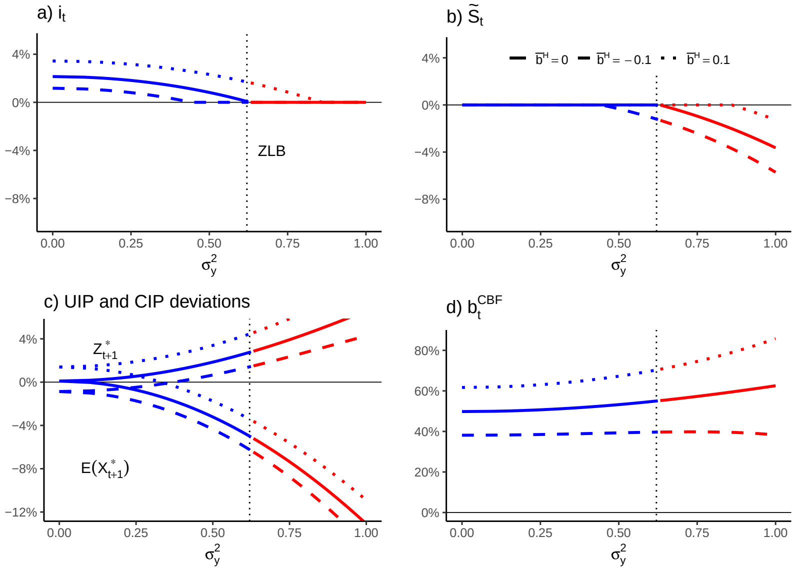
- The SDF of international financial intermediaries is inversely proportional to a global factor y_t^*
- y_{t+1}^* is log-normal with $log(y_{t+1}^*) \sim N(\sigma_y^2/2, \sigma_y^2)$. σ_y^2 measures global risk
- Safe haven assumption:
  1. Currency appreciates when global factor is low
  2. Domestic output only partially correlated with global factor
- ΔCov is positive and FXI are optimal More

Numerical Illustration: Impact of σ_y^2 Constraints Social and private optimum



Notes: Baseline parameters : $\beta = 0.98, \chi = 0.002\, \Gamma = 0.5, \alpha = 0.6, \rho = 0.2$. We assume that $\bar{b}^H = \bar{b}^F = 0$.

Numerical Illustration: With a “domestic motive” for FXI



Conclusion

- We provide a simple framework where UIP and CIP deviations can be of different signs for a safe haven economy
- We examine the opportunity cost of FX reserves in this context
- UIP should matter if domestic households give less value to the safe haven than international investors
- For Switzerland, the SNB has an opportunity gain of holding reserves
- For Japan, not optimal given high public debt

The Model: The Central Bank

- In t, issues money H_t, buys domestic and foreign bonds B_t^{CB} and b_t^{CBF}

$$b_t^{CBF} + b_t^{CB} = h_t$$

- Two ways to change b_t^{CBF}:
  1. Sterilized intervention, changing b_t^{CB}
  2. Unsterilized intervention, changing total money supply h_t

- No transfers! (no "fiscal" intervention)

- In $t+1$, issues new money and distributes its profits Π_{t+1}^{CB} to the government

$$\Pi_{t+1}^{CB} = (1+i_t^*)b_t^{CBF} + (1+i_t)\frac{S_t}{S_{t+1}}b_t^{CB} + h_{t+1} - \frac{S_t}{S_{t+1}}h_t$$

Back

The Model: The Government

- Issues debt b_t^G and transfers the funds to households:

$$b_t^G = t_t^G$$

- At $t+1$, receives the central bank profits, Π_{t+1}^{CB} and repays its debt :

$$t_{t+1}^G = -(1+i_t)\frac{S_t}{S_{t+1}} b_t^G + \Pi_{t+1}^{CB}$$

- We assume that the government is passive and that the level of real debt b_t^G is exogenous.

Back

Decentralized Equilibrium

- Equilibrium in the domestic bonds market is given by:

$$b_t^{H*} = b_t^G - b_t^H - b_t^{CB}$$

- Arbitrage Equation (3) implies:

$$\Gamma b_t^{H*} = \\ (1+i_t)S_t E_t \frac{1}{S_{t+1}} - (1+i_t^*) + \frac{cov_t(m_t^*, X_{t+1}^*)}{E_t m_{t+1}^*} - \chi$$

- Determines $(1+i_t)S_t$ and hence X_{t+1}^*

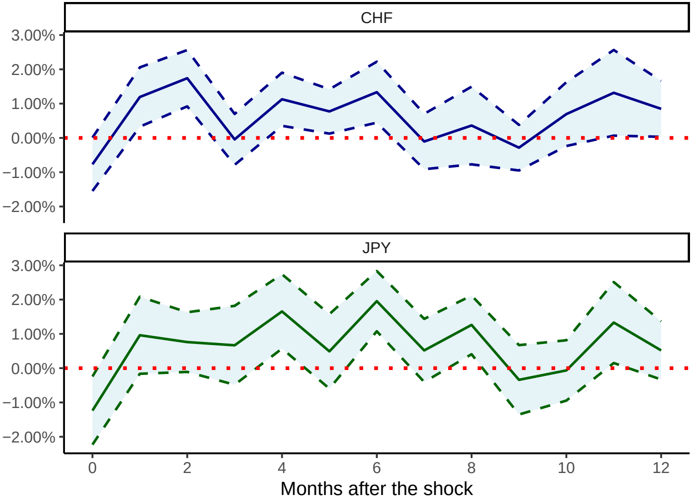
Optimal FXI

Correlation between UIP deviations and selected (global) risk variables

$Corr(RiskVariables, E(x^*_{t+1}))$						
	A) CHF/USD			B) JPY/USD		
Sample	USEPU	GEPU	WUI	USEPU	GEPU	WUI
1999-2021	-0.23	-0.29	-0.30	-0.11	-0.03	0.06
2010-2021	0.14	0.26	0.41	0.14	0.32	0.43

Back

Local Projections to a Global EPU shock Back



Optimal Policy

- Define gross and net financial liabilities:

$$gfl_t = \left(b_t^G - \frac{B_t^{CB}}{S_t} - b_t^H \right) + \left(\frac{H_t}{S_t} - h_t^H \right)$$

  First term: foreign holdings of domestic bonds. Second term: foreign holdings of domestic money. In equilibrium, $gfl_t = b_t^{H*}$.

- Net foreign liabilities are given by

$$nfl_t = gfl_t - (b_t^F + b_t^{CBF}) = b_t^G - b_t^H - b_t^F - h_t^H$$

  where $b_t^F + b_t^{CBF}$ are the domestic holding of foreign assets.

Back

Central Bank's Program

$$\max E\Bigg\{ U(c_t) + \beta U(c_{t+1})$$
$$+\eta_t \left(y_t - c_t + nfl_t\right)$$
$$+\eta_{t+1}\left[y_{t+1} - c_{t+1} - (1+i_t^*)nfl_t + \left[(1+i_t^*) - (1+i_t)\frac{S_t}{S_{t+1}}\right] gfl_t + i_t \frac{S_t}{S_{t+1}}\left(\frac{H_t}{S_t} - h_t^H\right)\right]$$
$$+\xi i_t$$
$$+\Delta_t^H \left(h_t^H - y_t\right)$$
$$+\Delta_t^F \left(\frac{H_t}{S_t} - h_t^H\right)$$
$$+\Lambda \left(gfl_t - b_t^{CBF} - nfl_t\right)$$
$$+\tilde{\Lambda} \left(b_t^G + b_t^{CBF} - h_t^H - gfl_t\right)$$
$$+\alpha_0 \left(E_t \left(m_{t+1}^* \left[(1+i_t^*) - (1+i_t)\frac{S_t}{S_{t+1}}\right]\right) + \Gamma gfl_t + \chi\right)\Bigg\}$$

S_{t+1} is exogenous variable since $S_{t+1} = He^h / y_{t+1}$.

Back

First Order Conditions

$$
\begin{aligned}
/\,nfl_t: \quad & \eta_t - E_t\left(\eta_{t+1}(1+i_t^*)\right) && -\Lambda && = 0 \\
/\,gfl_t: \quad & E_t\left(\eta_{t+1}\left[(1+i_t^*) - (1+i_t)\frac{S_t}{S_{t+1}}\right]\right) && +\Lambda - \tilde{\Lambda} + \alpha_0\Gamma && = 0 \\
/\,H_t: \quad & E_t\left(\eta_{t+1}\left[i_t\frac{S_t}{S_{t+1}}\right]\right) && +\Delta_t^F && = 0 \\
/\,b_t^{CBF}: \quad & && -\Lambda + \tilde{\Lambda} && = 0
\end{aligned}
$$

Back

Proposition 1

Consider the SDF of domestic households, m_t, and of international financial intermediaries m_t^* and the excess return in foreign currency, X_{t+1}^*. The benefit (or cost) of foreign exchange intervention $UCFX_t$ depends on

(i) CIP deviations when $cov(m_{t+1}, X_{t+1}^*) = cov(m_{t+1}^*, X_{t+1}^*)$.

(ii) UIP deviations when $cov(m_{t+1}, X_{t+1}^*) = 0$.

Back

A Linear-Quadratic Version of a Safe Haven Economy

- The SDF of domestic households is proportional to domestic output y_t and

$$\log(y_{t+1}) = \alpha \log(y^*_{t+1})$$

$\Rightarrow$ $0 < \alpha < 1$: low exposure to global risk

- With the appropriate assumptions on money supply in $t+1$, we can assume

$$S_{t+1} = He^{\rho \log(y^*_{t+1})}$$

$\Rightarrow$ $\rho > 0$: currency appreciates when global variable is low

$\Rightarrow$ Domestic currency is a relatively better hedge to foreign intermediaries $\Rightarrow$ optimal to go short on domestic bonds and long on foreign bonds back

A Linear-Quadratic Version of a Safe Haven Economy

- If σ_y and ρ large and α small (safe haven) and $\bar{b}^H = 0$:
  - $\Delta Cov \sim \rho\sigma_y^2 \left[1 - \alpha(b_t^G + gfl_t) - \rho gfl_t\right]$ can be positive
  - FXI are optimal

$$\widehat{b}_t^{CBF} = \frac{\rho\sigma_y^2[1 - \alpha b_t^G] - \chi}{2\Gamma + \rho(\alpha+\rho)\sigma_y^2} - (b_t^G - 1)$$

- Domestic households less exposed to global risk $\Rightarrow$ optimal to go short on domestic bonds and long on foreign bonds

- The supply of public debt matters back

Proposition 2

Consider a safe haven economy. Suppose that $\bar{b}^H = 0$, $\widehat{gfl}_t \geq 0$ and $\widehat{nfl}_t = b^G - 1$. Then optimal foreign exchange interventions, $\widehat{b}_t^{CBF}$:

(i) are increasing in risk measures σ_y and ρ;

(ii) are decreasing in intermediaries financial frictions Γ and χ;

(iii) are decreasing in the domestic output exposure to global risk α, as long as $b_t^G > 0$;

(iv) are decreasing in the supply of government bonds b_t^G;

Back

Proposition 3

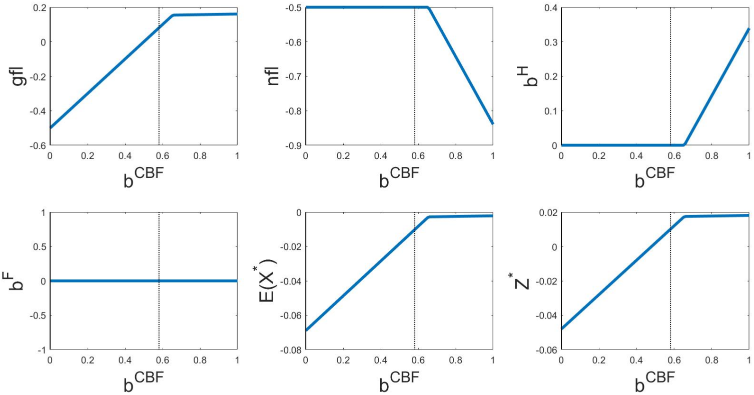
Suppose Suppose that $\widehat{gfl}_t \geq 0$ and $\widehat{nfl}_t = b^G - 1$. Then:

(i) Z^*_{t+1} is increasing in σ_y (it becomes more positive);

(ii) $E_t X^*_{t+1}$ is decreasing in σ_y (it becomes more negative) if Γ is not too large;

Back

Social and private optimum



Back

Social and private optimum

- First-order conditions associated with bond portfolio choices for the household:

$$-E_t X^*_{t+1} - \frac{cov_t(m_{t+1}, X^*_{t+1})}{E_t m_{t+1}} + \lambda^F - \lambda^H = 0$$

λ^H and λ^F: multipliers associated with short-selling constraints

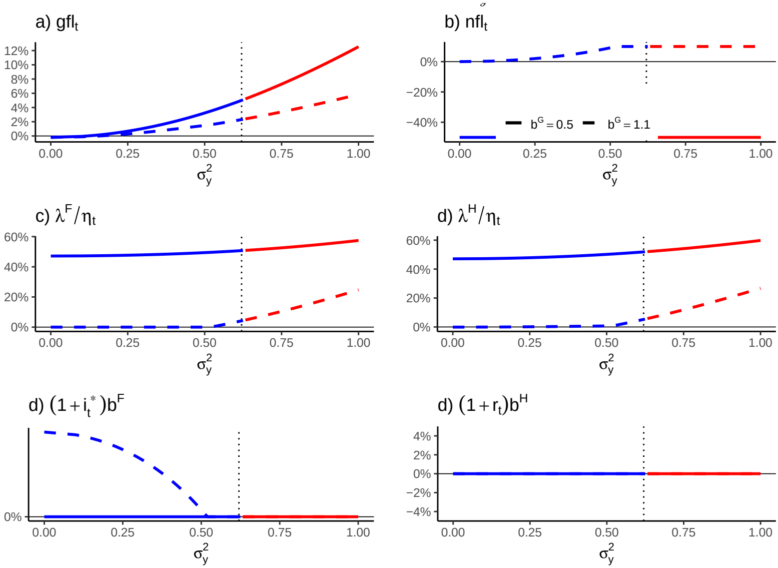
- Planner's optimum: $\underbrace{-\frac{\alpha_0}{\eta_t E_t m_{t+1}}}_{>0}\Gamma = \lambda^H - \lambda_F, \Rightarrow \lambda^H > 0.$

- Households do not internalize the intertemporal terms of trade externality $\Rightarrow$ The private optimum does not coincide with the social optimum

- The social optimum can be implemented if the household is constrained in her capacity to issue domestic bonds $\Rightarrow$ Not too much FXI to crowd out domestic savings

Back

Numerical Illustration: Financial constraints Back



Notes: Baseline parameters : $\beta = 0.98, \chi = 0.002\,\Gamma = 0.5, \alpha = 0.6, \rho = 0.2$. We assume that $\bar{b}^H = \bar{b}^F = 0$.