

# Foreign Exchange Intervention with UIP and CIP Deviations<sup>1</sup>

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## **Abstract**

We examine the welfare-based opportunity cost of foreign exchange (FX) intervention when both CIP and UIP deviations are present. We consider a small open economy that receives international capital flows through constrained international financial intermediaries. Deviations from CIP come from limited arbitrage or through a convenience yield, while UIP deviations are also affected by global risk. We show that the sign of CIP and UIP deviations may differ for safe haven countries. We find that FX reserves may provide a net benefit, rather than a cost, when international intermediaries value the safe-haven properties of a currency more than domestic households. We show that this has been the case for the Swiss franc and the Japanese Yen. We examine the optimal policy of a constrained central bank planner in this context.

# 1 Introduction

A vast literature examines the optimal level of central bank international reserves (see [Bianchi and Lorenzoni \(2022\)](#) for a recent survey). A recurrent feature is that the accumulation of reserves bears an opportunity cost arising from a return differential between the liabilities and the assets of the central bank. In the recent literature on optimal Foreign Exchange (FX) interventions, some authors focus on Uncovered Interest Rate Parity (UIP) wedges (see [Cavallino, 2019](#); [Basu et al., 2025](#); [Maggiori, 2021](#); [Itskhoki and Mukhin, 2022](#)). In contrast, other researchers argue that what matters are deviations from Covered Interest Rate Parity (CIP) (e.g., [Amador et al., 2020](#); [Fanelli and Straub, 2021](#)).<sup>1</sup> The distinction between CIP and UIP deviations appears particularly relevant for safe haven countries such as Switzerland and Japan, since these deviations may be of different sign. On the one hand, hedged returns in these currencies (equal to CIP deviations) have been positive since the GFC.<sup>2</sup> On the other hand, investors accept lower unhedged excess return (equal to UIP deviations) for safe haven currencies, given their hedging properties in bad times. UIP deviations measured with survey exchange rate expectation data show systematic negative expected excess returns for these currencies as shown in [Appendix A](#).

To clarify these issues, we develop a model where both CIP and UIP deviations are present. We consider a small open economy that receives international capital flows through international financial intermediaries as in [Gabaix and Maggiori \(2015\)](#). The structure of the model is similar to that in recent papers examining the role of international reserves (see [Cavallino, 2019](#); [Amador et al., 2020](#); [Fanelli and Straub, 2021](#); [Basu et al., 2025](#); [Maggiori, 2021](#)), but financial intermediaries are risk averse. [Fang and Liu \(2021\)](#) propose a related framework in a two-country model, but they focus on the US dollar and do not analyze FX interventions. The international financial intermediaries are the marginal investors and determine both UIP and CIP deviations through their unhedged and hedged portfolio choices. These deviations typically do not coincide and may even be of different sign.

In this environment, we examine the opportunity costs of FX intervention in terms of welfare. We identify the conditions under which CIP or UIP deviations matter for this cost. We find that there may be no opportunity cost, and that there may even be a benefit, of FX intervention in a safe haven country, even if that country faces a positive CIP deviation. We examine the implications for optimal FX intervention in these cases.

The presence of systematic deviations from CIP in the wake of the Global Financial Crisis is a major development in international finance (see [Du and Schreger \(2022\)](#) or

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<sup>1</sup>Note that in this literature, the cost of reserves is driven by the currency excess return, while in other frameworks the cost of reserves is determined by an external finance premium independent of the currency position, for example due to a government default premium (e.g., [Alfaro and Kanczuk, 2009](#); [Bianchi et al., 2018](#); [Samano, 2022](#)).

<sup>2</sup>[Rime et al. \(2022\)](#) show that CIP deviations for the CHF and the JPY with respect to the USD have been the most profitable for financial institutions.

Cerutti et al. (2021) for recent surveys). The theoretical literature has provided explanations for CIP deviations, but has devoted limited attention to the link between CIP and UIP deviations. Several papers analyzing interest rate differentials assume perfect risk sharing so that either there are no UIP deviations or CIP deviations are equal to UIP deviations. This is not consistent with the data.

The recent literature has followed two main approaches to explain interest rate differentials. First, there may be financial frictions that limit arbitrage, for example, by assuming constrained financial intermediaries. The other approach is to assume differences in convenience yields. The two approaches are present in our model and determine deviations from CIP. However, we do not assume complete markets, so that UIP deviations differ from CIP deviations. A basic result from this analysis is the following relationship between UIP and CIP deviations:

$$devUIP = devCIP - \frac{cov(m^*, X^*)}{\mathbb{E}m^*} \quad (1)$$

where  $m^*$  is the stochastic discount factor (SDF) of financial intermediaries and  $X^*$  is the domestic currency excess return from the international intermediary perspective. The covariance term in (1) represents the risk premium for a UIP, or carry-trade, investment strategy, which involves exchange-rate risk in contrast with a CIP strategy. This risk premium arises because we assume that international financial intermediaries are risk averse. They could hedge exchange-rate risk on the forward market, but it may not be optimal to fully hedge.

Safe-haven currencies are of particular interest since in that case we have  $cov(m^*, X^*) > 0$ , that is, the safe-haven currency yields a higher return in bad times. Therefore, it is possible to have a positive CIP deviation with a negative UIP deviation.

We analyze the impact and the welfare cost of accumulating international reserves in this framework. While sterilized FX interventions by the central bank affect the currency composition of a country's assets, it could be undone by domestic households if they are unconstrained. However, we assume that households face short-selling constraints. We show that, when these constraints are binding, FX interventions are effective, and that there is room for welfare improvement. The welfare impact of FX interventions depends on how households value currency risk in comparison to financial intermediaries.

For safe-haven currencies, we show that if domestic households attribute less value to the safe-haven properties of their currency than international financial intermediaries (i.e., the domestic SDF is less correlated to the excess return than for financial intermediaries), then FX reserves may have a benefit, not a cost. We examine this issue empirically by estimating the SDF of financial intermediaries following He et al. (2017). When considering the CHF and JPY with respect to the USD, we find that the SDF of financial intermediaries covaries more strongly with excess returns than the SDF of domestic households.

This paper complements the literature on the estimation of the opportunity cost of FX reserves. There is a long tradition of estimating the cost and benefits of accumulating

FX reserves (e.g., [Jeanne and Rancière, 2011](#)). [Adler and Mano \(2021\)](#) estimate the quasi-fiscal cost of interventions for 73 countries using UIP deviations. Using survey expectations or assuming a random walk for the nominal exchange rate, they find that the ex ante cost of intervention is negative for Japan and Switzerland in the period 2002-2013, while it is positive for most other countries.<sup>3</sup> In this paper, we examine the cost of intervention from the welfare point of view, and find that it is also negative for Japan and Switzerland, but that it is not equal to UIP deviations in general.

By focusing on countries like Switzerland or Japan, this paper provides a different perspective on safe haven economies. A growing literature has been analyzing the special role of the US dollar as a reserve currency. In particular, several papers have focused on the role of convenience yields in generating currency movements and expected excess returns (e.g., [Jiang et al., 2021, 2023](#); [Valchev, 2020](#); [Kekre and Lenel, 2024](#); [Bianchi et al., 2022](#)). We show that convenience yields are not the sole determinant for exchange rate movements and UIP deviations in safe haven economies.

The rest of the paper is organized as follows. Section 2 describes the model and Section 3 discusses the decentralized equilibrium and the impact of FX interventions. Section 4 analyzes the opportunity cost of reserves in this context. Section 5 examines optimal FX intervention and Section 6 concludes. Additional results are found in the Online Appendix.

## 2 The Model

This section presents a two-period model of a small open economy facing international financial intermediaries in the spirit of [Gabaix and Maggiori \(2015\)](#). These intermediaries buy domestic bonds and are the marginal investors in both the spot and the forward markets, since households are financially constrained. Intermediaries are risk averse, so there is a difference between their covered and uncovered positions. After presenting the financial intermediaries, we describe the households, the government and the central bank, as well as the equilibrium in the asset markets.

We call the foreign currency the dollar and assume that the foreign interest rate  $i^*$  is given. The domestic interest rate for period-one bonds is  $i$ .  $S_t$  is the spot price of dollars in terms of domestic currency for  $t = 1, 2$  and  $F$  is the forward rate priced in period one for period two. The second-period spot rate,  $S_2$  is exogenous. The price of goods in dollars is normalized to one and purchasing power parity (PPP) is assumed to hold. Let  $Z^*$  be the excess return hedged by a forward contract, from the perspective of

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<sup>3</sup>In the case of developing or emerging economies, the opportunity cost may be based on the country's borrowing cost, which implies a credit risk (e.g., [Edwards, 1985](#)). However, [Yeyati and Gómez \(2022\)](#) argue that when reserves are used for leaning-against-the-wind interventions, it is more appropriate to use UIP deviations.

international financial intermediaries, or the CIP deviation:

$$Z^* \equiv (1+i) \frac{S_1}{F} - (1+i^*) \quad (2)$$

and  $X^*$  the domestic currency excess return, expressed in foreign currency:

$$X^* \equiv (1+i) \frac{S_1}{S_2} - (1+i^*) \quad (3)$$

## 2.1 International Financial Intermediaries

International financial intermediaries value their state-contingent profits using their stochastic discount factor  $m^*$ , which we assume to be related to a risky global factor  $y^*$  in period 2. More precisely, we assume that  $\log(y^*) \sim N(\sigma^2/2, \sigma^2)$ , with  $\sigma > 0$  and that  $\log(m^*) = \log(\beta) - \log(y^*)$ . This implies that  $m^*$  and  $y^*$  are negatively correlated and that  $\mathbb{E}(m^*) = \beta$ . This is a small economy so the world interest rate  $i^*$  is exogenous. It is set to  $\beta^{-1} - 1$  so that  $\mathbb{E}[m^*(1+i^*)] = 1$ , without loss of generality.

In period 1, intermediaries invest in domestic bonds in quantity  $b^{H^*}$ , expressed in dollars. They have a zero net position and fund their investments by borrowing in dollars. We also assume that they can use forward contracts in quantity  $f^*$  and that they are the only players in the forward market.<sup>4</sup>

Moreover, financial intermediaries may value the liquidity of dollar assets. We assume that investors have operating costs that are increasing in non-dollar assets holdings  $b^{H^*}$  and that it is a linear function:  $\chi \cdot b^{H^*}$ , with  $\chi \geq 0$ . Their objective function is in dollars (and equivalently, in terms of goods, since the dollar price is constant):

$$V^* = \mathbb{E} \left\{ m^* \left[ b^{H^*} \left( (1+i) \frac{S_1}{S_2} - (1+i^*) \right) - f^* \left( \frac{1}{S_2} - \frac{1}{F} \right) \right] \right\} - \chi b^{H^*}$$

$b^{H^*}$  represents the total funds invested in the domestic currency, covered or uncovered.  $f^*/(1+i)S_1$  is the covered amount, and  $b^{H^*} - f^*/(1+i)S_1$  is the uncovered amount.

From the first-order condition with respect to  $f^*$ , we find a relationship between the covered and uncovered excess returns:

$$\mathbb{E}(m^* X^*) = \mathbb{E}(m^* Z^*) \quad (4)$$

Equation (4) holds due to frictionless hedging. It can be rewritten as a relationship between the UIP deviation,  $\mathbb{E}X^*$ , and the CIP deviation,  $Z^*$  (an equivalent of Equation (1)):

$$\mathbb{E}X^* = Z^* - \frac{\text{cov}(m^*, X^*)}{\mathbb{E}m^*} \quad (5)$$

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<sup>4</sup>For concreteness, we can think of foreign financial intermediaries made of both banks and non-banks. In the domestic bonds market, their total holdings are  $b^{H^*}$ . In the forward market, non-bank financial intermediaries demand forward contracts to hedge their position while banks supply these contracts. On net their position  $f^*$  is equal to zero. Allowing domestic households to participate in the forward market would not change the analysis, since households positions are limited.

Covered and uncovered carry trades yield the same returns in expectation, up to a covariance term, which corresponds to minus the currency risk premium, because intermediaries are risk averse. In most of the existing literature, the risk premium is equal to zero. This is the case because of the effective risk neutrality of financial intermediaries, as in [Gabaix and Maggiori \(2015\)](#), [Amador et al. \(2020\)](#), [Basu et al. \(2025\)](#); or in the absence of uncertainty, as in [Fanelli and Straub \(2021\)](#). In these cases, there is no distinction between UIP and CIP deviations.

A difference between these two deviations may arise if we introduce additional frictions for CIP arbitrage, as discussed by [Fanelli and Straub \(2021\)](#) and [Fang and Liu \(2021\)](#). For example, if there were a cost to the forward position  $f^*$ , there would be a wedge in Equations (4) and (5). We will assume that this wedge is zero throughout the paper. While such a wedge may be useful to empirically explain the comovement between UIP and CIP deviations, it does not affect our main results.<sup>5</sup>

We assume that financial intermediaries are constrained as in [Gabaix and Maggiori \(2015\)](#). Intermediaries can divert a fraction  $\Gamma b^{H^*}$  of the total borrowed funds, after the investment decisions are taken, but before shocks are realized. This yields a participation constraint for investors:<sup>6</sup>

$$V^* \geq \Gamma(b^{H^*})^2$$

If the participation constraint is binding, we have:

$$\mathbb{E}(m^* X^*) = \Gamma b^{H^*} + \chi \tag{6}$$

The term  $\Gamma b^{H^*} + \chi$  can be interpreted as the intermediation wedge implied by the participation constraint and the convenience yield. Equation (6) can be rewritten as:

$$\mathbb{E}X^* = \frac{\Gamma b^{H^*} + \chi}{\mathbb{E}m^*} - \frac{\text{cov}(m^*, X^*)}{\mathbb{E}m^*} \tag{7}$$

The UIP deviation is the sum of the intermediation wedge and the covariance term.

Equation (4) implies:

$$Z^* = \frac{\Gamma b^{H^*} + \chi}{\mathbb{E}m^*} \tag{8}$$

The CIP deviation is equal to the intermediation wedge when hedging is frictionless.

To gain more insight on the covariance term in (5), we consider a specific stochastic distribution for  $S_2$ . We assume that  $\log(S_2) = \rho[\log(y^*) - (1 - \rho)\sigma^2/2]$  for some real  $\rho$ . This implies  $\mathbb{E}(1/S_2) = 1$ .

In this case, we can show that  $\text{cov}(m^*, 1/S_2)/\mathbb{E}m^* = e^{\rho\sigma^2} - 1$ . When  $\rho > 0$ , the domestic currency tends to appreciate in bad times, i.e., when the global factor decreases. This is typical for safe-haven currencies. In this case,  $\text{cov}(m^*, X^*) = (1+i)S_1 \text{cov}(m^*, 1/S_2) > 0$

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<sup>5</sup>[Dao et al. \(2025\)](#) consider a model with different costs on CIP and UIP arbitrage for their empirical analysis. However, they abstract from the covariance term.

<sup>6</sup>Notice that we assume that the financial constraint applies to the whole foreign exchange investment of financial intermediaries, whether hedged or not.

and  $\mathbb{E}X^* < Z^*$ : the hedging properties of the currency make it attractive to financial intermediaries, who accept a lower expected return. This effect is stronger when  $\rho$  and  $\sigma^2$  increase, which makes the UIP deviation  $\mathbb{E}X^*$  more negative, for a given level of  $b^{H*}$ . When  $\rho < 0$ , we have the opposite effect and the UIP deviation is larger than the CIP deviation and increases with  $\sigma^2$ .

## 2.2 Domestic Households

Households receive a real endowment  $y_1 = 1$  in period 1. In period 2, they receive  $y_2$ , which we assume to be correlated to the global factor:  $\log(y_2) = g + \alpha[\log(y^*) - (1 - \alpha)\sigma^2/2]$  for some real  $\alpha$ . This implies that  $\mathbb{E}(1/y_2) = e^{-g}$ , where  $g$  can be thought of as the average growth rate of the home endowment. They can hold domestic-currency bonds  $b^H$  (expressed in real terms) and foreign-currency bonds  $b^F$ . They consume  $c_1$  in period 1 and  $c_2$  in period 2. We assume that households do not use the forward exchange market.

Their budget constraint can be written as:

$$c_1 = y_1 - b^H - b^F + t_1 \quad (9)$$

$$c_2 = y_2 + \frac{1+i}{1+\pi}b^H + (1+i^*)b^F + t_2 \quad (10)$$

where  $1 + \pi = P_2/P_1$  is the inflation rate,  $b^H$  is the real level of domestic bonds and  $t_1$  and  $t_2$  are real transfers.

Households face short-selling constraints :

$$b^H \geq 0, \quad b^F \geq 0 \quad (11)$$

Their utility function is:

$$U(c_1) + \beta\mathbb{E}U(c_2) \quad (12)$$

Domestic households choose bond holdings to maximize (12) subject to constraints (11). Using the assumption of PPP ( $P_t = S_t$ ,  $t = 1, 2$ ), the first-order conditions associated with bond portfolio choices are:

$$1 - \mathbb{E}(m(1+i^*)) \quad -\lambda^F = 0 \quad (13)$$

$$\mathbb{E}(mX^*) \quad +\lambda^H - \lambda^F = 0 \quad (14)$$

where  $m = \beta U'(c_2)/U'(c_1)$  is the households' intertemporal marginal rate of substitution or stochastic discount factor and  $\lambda^H$  and  $\lambda^F$  are the multipliers associated with the short-selling constraints (11).

Equations (13) and (14) describe whether households are able to achieve, respectively, their optimal intertemporal allocation and their optimal portfolio allocation between currencies. These concepts are defined as follows:

**Definition 1** *We introduce the following optimality concepts:*

- *Intertemporal optimality is characterized by  $\mathbb{E}(m(1 + i^*)) = 1$ .*
- *Portfolio optimality is characterized by  $\mathbb{E}(mX^*) = 0$ .*

For example, if  $\lambda^F = \lambda^H = 0$ , then both the intertemporal and portfolio allocations are optimal. If, in contrast,  $\lambda^F > 0$  and  $\lambda^H > 0$ , then households can neither implement their optimal intertemporal allocation nor their optimal portfolio allocation, except if  $\lambda^F = \lambda^H$ . In this knife-edge case, despite being unable to borrow, households' exposure to domestic and foreign currency happens to be optimal. If  $\lambda^F = 0$  and  $\lambda^H > 0$ , then households can implement their optimal intertemporal allocation through their holdings of foreign currency bonds but cannot implement their optimal portfolio allocation because they cannot borrow in domestic currency.

### 2.3 The Government

At time 1 the government issues a positive amount of domestic debt  $b^G > 0$  (expressed in real terms) and transfers the funds to households:

$$b^G = t_1 \quad (15)$$

At time 2, the government receives the central bank profits,  $\tau_2^{CB}$  and repays its debt :

$$t_2 = -\frac{1+i}{1+\pi}b^G + \tau_2^{CB} \quad (16)$$

We assume that the government is passive and that the level of debt  $b^G$  is exogenous.

### 2.4 The Central Bank

In period 1, the central bank uses the domestic nominal interest rate  $i$  as an instrument. Because we specify the policy in terms of the interest rate, we do not need to introduce money explicitly. The interest rate policy can follow a Taylor rule or target a fixed exchange rate. At this stage, we do not specify the nominal policy rule, but we assume a general policy function of the form  $f(i, S_1) = 0$ . This general form can accommodate an interest rate or exchange rate peg, or a Taylor rule that relates the interest rate to the price level (since  $S_1 = P_1$ ). However, notice that in the absence of nominal rigidity, this policy rule is neutral.

The central bank also uses foreign reserves  $b^{CBF}$  as an instrument. We assume that foreign reserves are positive:  $b^{CBF} \geq 0$ . Changes in foreign reserves take the form of sterilized FX interventions, that is, they are compensated for by a change in the central bank holdings of domestic currency bonds  $b^{CB}$  (expressed in real terms). In period 2, the central bank distributes its profits  $\tau_2^{CB}$  to the government. The central bank's budget constraints write as follows:

$$b^{CBF} + b^{CB} = 0 \quad (17)$$

$$\tau_2^{CB} = (1 + i^*)b^{CBF} + \frac{1+i}{1+\pi}b^{CB} \quad (18)$$

By focusing on a cashless economy, we ignore the money component of the central bank's balance sheet. We also assume no transfers from the government to the central bank in period 1. In an extension, we examine unsterilized interventions, where an increase in  $b^{CBF}$  can be financed by a transfer from the government.

### 3 On the Impact of Foreign Reserves

In this section, we define a set of conditions under which FX interventions are effective in affecting equilibrium cross-border asset holdings and asset prices, and we discuss their impact. For most of the analysis, we focus on the case of safe-haven economies, which is defined more precisely below.

#### 3.1 Gross and Net Foreign Position

For the rest of our analysis, it is convenient to focus on the Home country's period 1 net and gross foreign liabilities. Gross foreign liabilities are the foreign holdings of domestic bonds  $b^{H*}$ . They are equal to the amount of domestic bonds not held domestically:

$$b^{H*} = b^G - b^{CB} - b^H = b^G + b^{CBF} - b^H \quad (19)$$

The second equality is obtained by using the central bank's budget constraint. It shows that, everything else equal, sterilized FX interventions affect the supply of domestic bonds to foreigners. The central bank can increase its holding of foreign currency assets only through a balance-sheet expansion, and hence through an increase in its domestic liabilities.

Net foreign liabilities in period one are gross foreign liabilities minus gross foreign assets

$$nfl = b^{H*} - (b^{CBF} + b^F) = b^G - b^H - b^F \quad (20)$$

where gross foreign assets  $b^F + b^{CBF}$  are the domestic holding of foreign assets. For given net foreign liabilities  $nfl$ , the level of gross foreign liabilities  $b^{H*}$  determines gross foreign assets  $b^{CBF} + b^F = b^{H*} - nfl$ . For a given  $nfl$ , a higher  $b^{H*}$  is a measure of the economy's gross foreign position.

The second equality is obtained by replacing  $b^{H*}$  using (19). It is useful to note that, everything equal, sterilized FX interventions affect  $b^{H*}$ , but not  $nfl$ . An increase in  $b^{CBF}$  increases  $b^{H*}$  one for one, through a decrease in  $b^{CB}$ , but it also increases gross foreign assets  $b^F + b^{CBF}$  one for one. Therefore, FX interventions affect the gross foreign position of the economy and its currency exposure, but not the net foreign position.

### 3.2 Equilibrium in Asset Markets

In equilibrium, gross foreign liabilities are equal to the net domestic supply of domestic currency bonds:  $b^{H*}$ . From Equations (8) and (7), we have:

$$\mathbb{E}X^* = \underbrace{\frac{1}{\mathbb{E}m^*} (\Gamma b^{H*} + \chi)}_{Z^*} - \frac{cov(m^*, X^*)}{\mathbb{E}m^*} \quad (21)$$

The net supply of domestic liabilities to foreigners determines the equilibrium expected domestic currency excess return  $\mathbb{E}X^*$  (the UIP deviation). A higher domestic supply can only be absorbed by intermediaries if it offers a higher excess return (the same holds for the CIP deviation  $Z^*$ ). In contrast, an increase in  $cov(m^*, X^*)$  leads to a decrease in the excess return of the domestic currency. Intuitively, the increase in covariance makes domestic bonds more attractive to foreigners and generates an excess demand for domestic bonds. The decline in the excess return of the domestic currency clears this excess demand.

How does the excess return in domestic currency adjust in practice? Consider, for instance, an increase in the excess return. Since the foreign interest rate  $i^*$  is exogenous, this implies a higher domestic real interest rate  $(1+i)S_1\mathbb{E}(1/S_2)$ .  $\mathbb{E}(1/S_2)$  is exogenous and equal to 1. As a result, a higher  $b^{H*}$  increases  $(1+i)S_1$ . Whether it affects  $i$  or  $S_1$  depends on the policy rule  $f(i, S_1)$ , and does not matter for our analysis.

### 3.3 When Are Foreign Exchange Reserve Interventions Effective?

As apparent in Equation (19), everything else equal, sterilized FX interventions  $b^{CBF}$  affect  $b^{H*}$ , the gross foreign liabilities of the economy. However, in equilibrium, households' portfolio adjustments, and especially adjustments in  $b^H$ , could offset the central bank intervention. In what follows, we consider FX interventions to be “effective” only if they affect the gross foreign liabilities of the economy  $b^{H*}$  in equilibrium. When interventions are effective, they affect  $(1+i)S_1$  through the change in  $b^{H*}$ , the effect of which is discussed in the previous subsection.

To understand, consider the consolidated household's budget constraints, which are obtained using the equilibrium in the domestic asset markets, and substituting transfers in the household's budget constraint:

$$\begin{aligned} c_1 &= y_1 + nfl \\ c_2 &= y_2 - (1+i^*)nfl - X^*b^{H*} \end{aligned} \quad (22)$$

If households are unconstrained, they can affect the gross foreign position  $b^{H*}$  by changing their holdings of domestic and foreign bonds. To study FX intervention effectiveness, we introduce the concept of “desired” gross foreign liabilities. The desired gross

foreign liabilities is the level of gross foreign liabilities that would satisfy portfolio optimality (as introduced in Definition 1). When the amount of publicly-issued domestic bonds  $b^G + b^{CBF}$  is below the desired level of gross foreign liabilities, households are constrained because they would like to choose a negative  $b^H$ .

To solve the model, we now assume a logarithmic utility function:  $U(.) = \log(.)$  and use an approximation of the model (see Online Appendix D). We focus on a safe haven economy that is characterized by an exchange rate that is positively correlated with the global factor  $y^*$  (and negatively correlated with the foreign intermediaries' SDF) and by an output that is weakly correlated with the global factor. More precisely, we assume:

**Condition 1 (Safe haven economy)** *A safe haven economy is an economy where  $0 \leq \alpha < 1$  and  $\rho \geq 0$ .*

To characterize the solution more precisely, it is useful to introduce the following two conditions:

**Condition 2 (Risky environment)** *A risky environment is an environment where  $\Gamma$  and  $\chi$  are small relative to  $\sigma^2$ .*

This condition ensures that risk is more relevant than financial frictions. CIP deviations will be smaller in magnitude than UIP deviations.

**Condition 3 (Technical condition)**  *$g$ ,  $\Gamma$ ,  $\chi$  and  $\sigma^2$  are small relative to 1.*

This technical condition ensures the existence of a unique and well-behaved solution. It implies that the parameters are such that the net foreign position and the excess returns are small, which is realistic.<sup>7</sup>

In Online Appendix D.4.3, we show that, under these three conditions,  $b^{max} = \frac{(1-\alpha)\rho\sigma^2 - \chi}{\Gamma + \rho^2\sigma^2} - \frac{\alpha\rho\sigma^2 \min(nfl^{opt}, b^G)}{\Gamma + \rho^2\sigma^2}$  satisfies portfolio optimality, where  $nfl^{opt}$  is the level of net foreign liabilities that holds under both intertemporal and portfolio optimality.  $nfl^{opt}$  is independent of fiscal and central bank policy.  $b^{max}$  corresponds to the desired level of gross foreign liabilities.

The impact of FX interventions can then be described formally in the following proposition (see proof in Online Appendix D.4):

**Proposition 1** *We assume that Conditions 1, 2, and 3 hold. If  $b^{CBF} + b^G < b^{max}$ , then FX interventions are effective:  $b^{H*} = b^G + b^{CBF}$  and  $b^H = 0$ . FX interventions that increase  $b^{CBF}$  increase gross foreign liabilities  $b^{H*}$  one-for-one, and increase  $\mathbb{E}X^*$  and  $Z^*$ .*

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<sup>7</sup>Online Appendix D provides more details about the model's properties in a linear-quadratic approximation. Sections D.1, D.2 and D.3 derive, respectively, the asset pricing equations, the households' stochastic discount factor, and the households' first-order conditions.

According to the Wallace Irrelevance Proposition (Wallace, 1978), if households are free to adjust their portfolio, FX interventions are neutral, because households can offset any central bank open-market operation. In our model though, households face short-selling constraints, which breaks the Wallace Irrelevance under some conditions. In particular, sterilized FX interventions cannot be offset when the sum of government bonds and foreign reserves  $b^G + b^{CBF}$  is below  $b^{max}$ , because offsetting would require households to issue domestic currency bonds, which they cannot. In that case,  $b^{H^*} = b^G + b^{CBF}$ , and the effective supply of domestic bonds  $b^{H^*}$  responds directly to FX interventions  $b^{CBF}$ . This extra supply of domestic bonds is absorbed by financial intermediaries through an increase in the excess returns  $\mathbb{E}X^*$  and  $Z^*$  as discussed above. The Wallace Irrelevance result therefore breaks in situations where households are constrained in their ability to issue or save domestic currency bonds. This implies that FX interventions are effective when they do not satiate the households' need for gross foreign liabilities.

Note that the condition  $b^{CBF} + b^G < b^{max}$  implies that, for FX interventions to be effective, domestic supply needs to be small *relative* to demand. This means that even with a large supply of public debt  $b^G$ , as in Japan, FX interventions can still be effective, as long as  $b^{max}$  is large enough. Under Condition 2,  $b^{max}$  can be arbitrarily large when  $\alpha$  and  $\rho$  go to zero.<sup>8</sup> Therefore, the supply of public debt is not the only determinant of the effectiveness of FX interventions. The properties of the domestic currency (parameters  $\alpha$  and  $\rho$ ) also play a key role by affecting the domestic demand for gross foreign liabilities.

An interesting question is whether FX interventions can affect net foreign liabilities. Online Appendix D.5 shows that there is no impact on  $nfl$  when  $b^G$  is small. When  $b^G$  is large, there may be an impact, as households are able to smooth their consumption when FX interventions affect their period-2 income, using their foreign-currency bond holdings.<sup>9</sup>

Under the conditions of Proposition 1,  $b^{H^*}$  depends only on  $b^{CBF}$  and  $b^G$ . According to the CIP expression (8), this implies that the intermediation friction parameters  $\Gamma$  and  $\chi$  directly affect the CIP deviation: an increase in collateral requirements  $\Gamma$ , or an

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<sup>8</sup>When  $\alpha$  is small, the hedging benefits of domestic currency for domestic consumption is small relative to its hedging benefits to international intermediaries, so high-return foreign-currency positions come with little costs in terms of forgone hedging. When  $\rho$  is small, the hedging properties of the domestic currency are reduced, which has a negative impact on the UIP returns, and hence on domestic demand. But the variance of the exchange rate and the riskiness of foreign-currency positions are also reduced, which has a positive impact. The latter effect dominates, leading to a potentially very large demand for gross foreign liabilities as  $\rho$  becomes small.

<sup>9</sup> In that case, FX interventions increase  $nfl$  (see Online Appendix D.5). This is because FX interventions increase period-2 income, so that a higher  $nfl$  helps households' smooth their consumption. In models where households are allowed to borrow, but are facing a higher interest rate due to an external finance premium, sterilized FX interventions have an impact on the economy's net position through a "spread channel" (e.g., see Bianchi and Lorenzoni, 2022). FX interventions widen the spread, which affects households' borrowing decisions and increases the economy's net foreign assets, through an intertemporal substitution channel.

increase in the convenience yield, generate a more positive CIP deviation. Given that  $cov(m^*, X^*)/\mathbb{E}m^* = e^{\rho\sigma^2} - 1$  only depends on  $\rho$  and  $\sigma$ , shocks to  $\Gamma$  and  $\chi$  move the UIP deviation in the same direction and with the same magnitude as the CIP deviation, according to the UIP expression (7). Shocks to global risk  $\sigma$ , in contrast, only move the UIP deviation: an increase in global risk makes the UIP deviation more negative, while the CIP deviation remains the same.

## 4 On the Cost of Foreign Reserves

In this section, we introduce the utility cost of FX reserves and assess its relation to UIP and CIP deviations. We show that the key determinant of this cost is the covariance between excess returns and the SDF of domestic households on the one hand, and the SDF of international financial intermediaries on the other. In the context of safe-haven currencies, it depends on whether international financial intermediaries value the safe-haven properties more than domestic investors. We examine this issue empirically and show that this is the case for Switzerland and Japan.

### 4.1 Utility Cost of Reserves with UIP and CIP Deviations

The cost of reserves, in the traditional sense of the literature, is the forgone earnings on reserve holdings.<sup>10</sup> In our framework, this corresponds to  $X^*$ . One can see this simply by noticing that the central bank’s resource constraints (17) and (18) imply that the central bank’s profits depend directly on  $X^*$ :  $\tau_2^{CB} = -X^*b^{CBF}$ .

In a safe haven case with  $\mathbb{E}X^* < 0$ , there is an expected gain of holding reserves, i.e., the central bank can exploit the UIP deviation. However, the increase in reserves also increases the exchange-rate risk faced by the central bank. Since the central bank’s profits are eventually distributed to households, the question is whether this could increase households’ utility. We therefore introduce a novel concept of the cost of reserves, the marginal *utility* cost of reserves, defined as the “traditional” monetary cost of reserves discounted by the household’s SDF:

**Definition 2 (The marginal utility cost of FX interventions)** *The marginal utility cost of FX interventions is the expected product of the UIP deviation  $X^*$  and the SDF of domestic households  $m$ , divided by the expected discount factor:*

$$UCFX = \frac{\mathbb{E}(mX^*)}{\mathbb{E}m} \quad (23)$$

The excess return on domestic bonds  $X^*$  is valued using the utility-based stochastic discount factor. It is normalized by the expected discount factor so that it coincides with

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<sup>10</sup>See for instance [Frenkel and Jovanovic \(1981\)](#), [Jeanne and Rancière \(2011\)](#), and more recently [Adler and Mano \(2021\)](#).

the traditional monetary cost  $X^*$  in the absence of risk. In that sense,  $UCFX$  can be seen as the certainty-equivalent cost of reserves. It can also be seen as a measure of the deviation from portfolio optimality (see Equation (14) and Definition 1), evaluated in units of future goods.

To see how FX intervention potentially affects utility, consider the resource constraints (22). Everything else equal, FX interventions increase the economy's gross foreign position and increase the economy's exposure to currency risk through changes in  $b^{H^*}$ .

## 4.2 A Decomposition of the Utility Cost of Reserves

The marginal utility cost of FX interventions can be rewritten as

$$UCFX = \mathbb{E}X^* + \frac{\text{cov}(m, X^*)}{\mathbb{E}m} \quad (24)$$

The utility cost is composed of the expected excess return on foreign bonds, minus the risk premium associated with this excess return. Since  $\mathbb{E}X^* < 0$  for safe haven countries, there may be a utility gain.

Substituting  $\mathbb{E}X^*$  using Equation (7), we can rewrite the utility cost of FX interventions:

$$UCFX = \underbrace{\frac{\Gamma b^{H^*} + \chi}{\mathbb{E}m^*} - \frac{\text{cov}(m^*, X^*)}{\mathbb{E}m^*}}_{\mathbb{E}X^*} + \frac{\text{cov}(m, X^*)}{\mathbb{E}m} \quad (25)$$

Equation (25) shows how CIP and UIP deviations affect the utility cost.<sup>11</sup> Notice that the risk premium terms  $\frac{\text{cov}(m^*, X^*)}{\mathbb{E}m^*}$  and  $\frac{\text{cov}(m, X^*)}{\mathbb{E}m}$  enter  $UCFX$  for very different reasons. The first risk premium affects the pricing of the excess return, since international financial intermediaries are the marginal investors. The second risk premium only affects its welfare valuation. The role of these risk premia can be summarized in the following proposition

**Proposition 2** *Consider the SDF of domestic households,  $m$ , and of international financial intermediaries  $m^*$  and the domestic currency excess return,  $X^*$ . The utility cost (or benefit) of FX intervention is equal to*

(i) *CIP deviations  $Z^*$  when  $\text{cov}(m, X^*)/\mathbb{E}m = \text{cov}(m^*, X^*)/\mathbb{E}m^*$ .*

(ii) *UIP deviations  $\mathbb{E}X^*$  when  $\text{cov}(m, X^*) = 0$ .*

In fact,  $UCFX$  is equal to the CIP deviation  $Z^*$ , which is a riskless excess return; minus the difference between the foreign and domestic risk premia, which we denote  $\Delta Cov = \text{cov}(m^*, X^*)/\mathbb{E}m^* - \text{cov}(m, X^*)/\mathbb{E}m$ :

$$UCFX = Z^* - \Delta Cov \quad (26)$$

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<sup>11</sup>If there were costs to FX hedging, there would be a wedge between the CIP deviation  $Z^*$  and the intermediation wedge  $\Gamma b^{H^*} + \chi$ .

The first term is an intermediation wedge and the second is a risk-sharing wedge. If foreign and domestic agents have the same risk premium, only CIP deviations  $Z^*$  matter. This is the case in the absence of risk, as in [Amador et al. \(2020\)](#), or when financial intermediaries have the same discount factor as households. In contrast, in the limit case where domestic agents have negligible risk aversion compared to financial intermediaries, the sum of the two wedges is equal to the UIP deviation and the cost of reserves would be equal to the UIP deviations.<sup>12</sup>

In general, the sum of the two wedges does not coincide with either the CIP or the UIP deviations. A safe haven currency may be more desirable for foreign investors as a diversification hedge than for domestic investors so that  $\Delta cov > 0$ . If the difference is large enough, there may be a utility gain from accumulating reserves, rather than a cost.

### 4.3 When Does a Utility Cost or Gain of Reserves Arise?

A non-zero utility cost of reserves represents an arbitrage opportunity. We can see that by using the households' FOC (14) and the definition of the utility cost of reserves (23):

$$-UCFX = \frac{\lambda^H - \lambda^F}{\mathbb{E}m} \quad (27)$$

A necessary condition for a negative  $UCFX$  is  $\lambda^H > 0$ , that is, a binding domestic currency bond short-selling constraint. A negative  $UCFX$  means that households would be willing to engage in a domestic currency carry trade: go short in domestic currency and long in foreign currency. This arbitrage opportunity is an equilibrium outcome only if households are prevented from going short in domestic currency.<sup>13</sup>

To understand, consider the budget constraints (22), which clearly show that consumption in period 2 depends on the foreign currency excess return  $-X^*$  and on the households' carry trade position  $b^{H*}$ . Suppose that  $UCFX$  is negative. From Equation (24), this means that the expected excess return on foreign currency  $-\mathbb{E}X^*$  is high relative to the households' currency risk premium  $Cov(m, X^*)/\mathbb{E}m$ . Then, a positive  $b^{H*}$  is attractive as it increases average consumption in period 2 without excessively exposing households to currency risk. If households are not constrained, they can set  $b^{H*}$  high enough by changing their domestic currency position  $b^H$ . As a result, the two wedges in Equation (26) adjust so that  $UCFX = 0$ . On the one hand, the more domestic bonds need to be absorbed by financial intermediaries, the higher the excess return ( $Z^*$  is higher). On the other hand, the more household consumption is exposed to currency risk, the higher the household covariance and the smaller the differential  $\Delta Cov$ . In Online Appendix D.6,

<sup>12</sup>This is what [Itskhoki and Mukhin \(2021\)](#) implicitly assume. In their linear approximation, they take the level of risk to zero but ensure that the risk premium of financial intermediaries remains a first-order object by rescaling their risk aversion, but not that of households. This implies that the intermediary risk aversion is an order of magnitude higher than that of households.

<sup>13</sup>In contrast, a positive utility cost of reserves can only arise if  $\lambda^F > 0$ , that is, households cannot go short in foreign currency.

we show that  $\Delta Cov$  depends indeed negatively on  $b^{H^*}$ , in a linear approximation:

$$\Delta Cov = \rho\sigma^2 [1 - \alpha(1 + nfl) - \rho b^{H^*}] \quad (28)$$

In contrast, when the domestic short-selling constraint is binding, these adjustments do not take place, so  $UCFX < 0$ .

The following proposition establishes that a utility gain of reserves arises when the supply of bonds by the central bank and government is insufficient (see proof in Online Appendix D.7):

**Proposition 3** *We assume that Conditions 1, 2, and 3 hold. If  $b^{CBF} + b^G < b^{max}$ , then  $UCFX < 0$  and  $UCFX$  is increasing in  $b^{CBF}$ .*

When the total supply of domestic bonds by the government and the central bank is below  $b^{max}$ , gross foreign liabilities  $b^{H^*}$  are not sufficient to exhaust the risk-adjusted excess return associated with domestic carry trade  $-UCFX$ . Households would like to issue domestic bonds so that their total exposure to currency risk  $b^{H^*}$  reaches  $b^{max}$ , but they face a short-selling constraint.

An implication of Propositions 1 and 3 is that a utility gain of reserves appears in situations where FX interventions are effective. In these situations, an increase in  $b^{CBF}$  increases  $b^{H^*}$ . FX intervention can thus generate a gain for the economy. However, these gains are not unlimited. As the central bank accumulates reserves,  $UCFX$  becomes less negative, until  $UCFX = 0$  when  $b^{CBF} = b^{max} - b^G$ .

**The role of financial frictions** What role do financial frictions play to generate a utility gain or cost of reserves? The key friction that makes  $UCFX$  strictly negative (or positive) is the households' limited bond market participation. This is evident from Equation (27), where a non-zero  $UCFX$  relies on at least one short-selling constraint being binding ( $\lambda^H > 0$  or  $\lambda^F > 0$ ), as discussed above. A utility gain or cost of reserves arises from the households' inability to exploit an arbitrage opportunity by themselves. However, for households to face an arbitrage opportunity, it must be that financial intermediaries do not fully exhaust it.

An arbitrage opportunity can have two origins in our framework, as shown by the decomposition of  $UCFX$  in (26). First, the CIP deviation  $Z^*$  is a return that is not fully arbitrated away by financial intermediaries, thus generating an arbitrage opportunity for households. As Equation (8) shows, this return is positive due to intermediation frictions: financial intermediaries face a participation constraint ( $\Gamma > 0$ ) and a foreign currency convenience yield ( $\chi > 0$ ).

Second, the covariance differential  $\Delta Cov$  represents the discrepancy between the households' valuation of currency risk (the households' risk premium) and the price of that risk (the intermediaries' risk premium). Even if the intermediaries' arbitrage opportunity vanishes ( $Z^* = \mathbb{E}(m^* X^*) = 0$ ) – e.g., in the absence of intermediation frictions

–, an arbitrage opportunity could still persist from the point of view of households ( $UCFX = \mathbb{E}(mX^*) \neq 0$ ), because households value risk differently from intermediaries. This arbitrage opportunity thus hinges on the risky environment assumption. To see this, note that Equation (28) implies that  $\Delta Cov = 0$  if  $\sigma = 0$ .

**The role of finite horizon** The two-period assumption of our model allows us to assume that the period-2 exchange rate is exogenous and its correlation with the global factor is given. With more than two periods, anticipated future FX interventions could affect the exchange rate dynamics and its stochastic properties. However, the main properties of the model would still hold, since the exchange rate dynamics is taken as given by households and intermediaries. In particular, Proposition 2 and the equations for  $UCFX$  would remain unchanged. However, in a dynamic model, the stochastic properties of the exchange rate would be endogenous, and so would the safe-haven status of a currency. A comprehensive dynamic extension, in which a safe-haven currency emerges endogenously, presents an interesting avenue for future research.<sup>14</sup>

#### 4.4 Numerical illustration

We consider a numerical illustration of the mechanism, setting parameters that are consistent with Conditions 1, 2, and 3. We assume the following policy rule:

$$\begin{aligned} f(i, S_1) &= S_1 - 1 && \text{if } i > 0 \\ &= i && \text{if } S_1 < 1 \end{aligned} \tag{29}$$

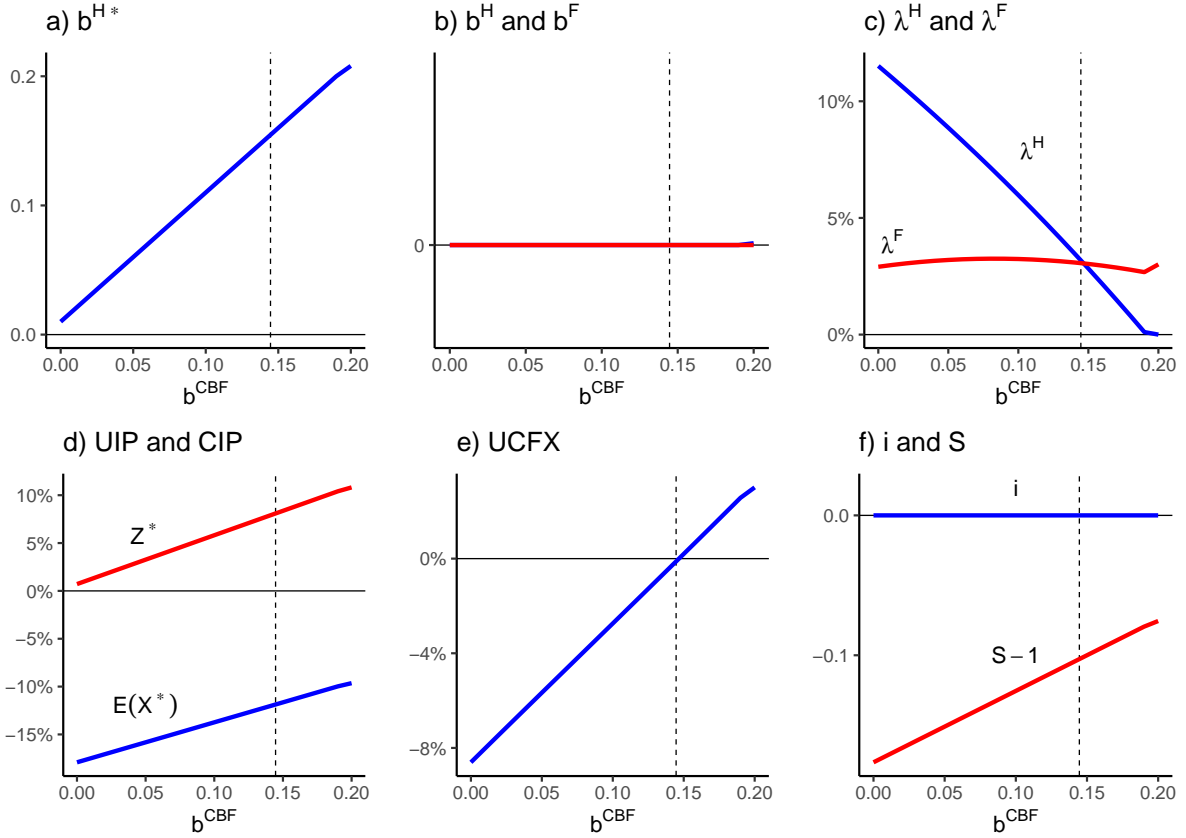
This policy rule assumes that the nominal interest adjusts to target a fixed exchange rate, but that it faces a zero lower bound (ZLB).

Figure 1 describes the equilibrium effect of FX reserves  $b^{CBF}$  when FX intervention is effective, i.e., when the increase in  $b^{CBF}$  increases  $b^{H*}$ . We consider the simpler case where the constraints are always binding ( $\lambda^H > 0$  and  $\lambda^F > 0$ ), which is obtained by setting a low  $b^G$ , and where the interest rate is at the ZLB.<sup>15</sup> The UIP deviation  $\mathbb{E}X^*$  is negative because the domestic currency has a safe-haven value for intermediaries, and the CIP deviation  $Z^*$  is positive because of the intermediaries' participation constraint (see Panel d)). As  $b^{CBF}$  increases, the CIP deviation becomes more positive (and the UIP less negative), as the excess supply of domestic bonds arising from FX interventions is absorbed by an increase in the real interest rate. This is achieved in equilibrium through an exchange rate depreciation, because the interest rate is at the ZLB (see Panel f)). Otherwise, it would be achieved through a nominal interest rate increase.

<sup>14</sup>There is a small literature that provides explanations for safe-haven effects, but the focus is on the US and the mechanisms do not apply to small countries. See Maggiori (2017) or Hassan et al. (2022). Papers that model time-varying safe haven effects include Gourinchas and Rey (2022), Devereux et al. (2022), and Kekre and Lenel (2024).

<sup>15</sup>Figure F.1 in Online Appendix F considers the more complex case where  $b^G$  is higher and constraints are not always binding.

Figure 1: The Effectiveness of FX Interventions and the Utility Cost of Reserves



Notes: Parameter values :  $\beta = 0.98$ ,  $\sigma^2 = 1$ ,  $\chi = 0.002$ ,  $\Gamma = 0.5$ ,  $\alpha = 0.6$ ,  $\rho = 0.2$ ,  $g = 0.05$ ,  $b^G = 0.01$ . The dashed vertical lines represent  $b^{CBF} = b^{max} - b^G$ .

In Panel e), a negative  $UCFX$  represents a carry-trade arbitrage opportunity for households. However, households cannot issue domestic bonds ( $\lambda^H$  is positive, as shown in Panel c)). This implies that FX interventions are effective, in the sense that the gross foreign position of the economy  $b^H^*$  increases with  $b^{CBF}$  (see Panel a)). This is consistent with Proposition 1.

As  $b^{CBF}$  increases,  $UCFX$  becomes less negative, due to the increase in  $Z^*$ , but also because households become more exposed to currency risk, as explained above. When  $b^{CBF}$  reaches  $b^{max} - b^G$ ,  $UCFX$  becomes equal to zero.

In this specification, FX interventions continue to be effective beyond  $b^{max} - b^G$ . This is because, for  $b^{CBF} > b^{max} - b^G$ ,  $UCFX$  becomes positive: households become excessively exposed to domestic currency. They want to offset FX interventions by engaging in another form of carry trade: going short in foreign currency, and long in domestic currency. However, households are constrained in their capacity to issue foreign bonds ( $\lambda^F$  is positive in Panel c)). As a result, FX interventions continue to be effective beyond  $b^{max} - b^G$ .

Here, FX interventions are always effective because households are always constrained for both domestic and foreign bonds. They are constrained because they would like to have a large net foreign position  $nfl$ , but  $b^G$  is too small to achieve that level of  $nfl$ . In Figure F.1 in Online Appendix F, we represent a specification with a larger  $b^G$ . In

that case,  $b^G$  can accommodate the desired  $nfl$  and, for  $b^{CBF} = b^{max} - b^G$ , households hold a positive amount of foreign bonds. Therefore, if  $b^{CBF}$  increases above  $b^{max} - b^G$ , households can offset FX interventions by liquidating foreign bonds and buying domestic bonds, but only up to the point where it exhausts their stock of foreign bonds.

## 4.5 Estimating the Utility Cost for Switzerland and Japan

The theoretical analysis has shown that the utility cost of FX interventions depends crucially on the difference between  $cov(m^*, X^*)/\mathbb{E}m^*$  and  $cov(m, X^*)/\mathbb{E}m$ . In this subsection, we provide estimates of these two terms for Switzerland and Japan. The safe-haven properties of the CHF and the JPY, that is, their tendency to appreciate in bad times, have been documented by various authors, for example [Stavrakeva and Tang \(2021\)](#), [Rinaldo and Söderlind \(2010\)](#), [Grisse and Nitschka \(2015\)](#), or [Fink et al. \(2022\)](#). This is consistent with the assumption we make about the hedging properties of the domestic currency (see [Condition 1](#)). Moreover, [Online Appendix A](#) confirms that the expected excess return of both currencies is negatively related to global risk variables ([Table A.1](#)). Since  $X^*$  is priced by financial intermediaries, we expect  $cov(m^*, X^*)/\mathbb{E}m^*$  to reflect the safe haven property of these currencies. In contrast, the model has no implications for  $cov(m, X^*)/\mathbb{E}m$ . For the rest of this section, we introduce time  $t$  in our notation.

A key issue is the measurement of stochastic discount factors  $m_{t+1}$  and  $m_{t+1}^*$ . The former is not reflected in asset prices, while the latter is. For domestic households, we assume, as a baseline, that  $m_{t+1}$  is given by Epstein-Zin recursive preferences with a coefficient of relative risk aversion  $\gamma$  and an elasticity of intertemporal substitution  $\psi$ . In line with the macro-finance literature following [Bansal and Yaron \(2004\)](#), we set  $\gamma = 10$  and  $\psi = 1.5$ . In [Online Appendix C](#), we consider alternative specifications for preferences, namely CRRA and Campbell-Cochrane habit formation, across a wide parameter grid. We show that results are robust to these choices.

For international financial intermediaries, we follow the literature on intermediary asset pricing (e.g., [He and Krishnamurthy, 2011](#); [Brunnermeier and Sannikov, 2014](#)), and assume that their SDF is proportional to the marginal utility of their net worth  $NW_t$ :<sup>16</sup>

$$m_{t+1}^* = \beta \left( \frac{NW_{t+1}}{NW_t} \right)^{-\gamma} \quad (30)$$

As in [He et al. \(2017\)](#), we assume that the financial intermediaries' net worth is equal to the aggregate wealth in the economy (denoted by  $W_t$ ) multiplied by the intermediaries' capital ratio (denoted by  $\eta_t$ ). This specification implies that the financial intermediaries' marginal utility of wealth rises when either the aggregate wealth in the economy or the

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<sup>16</sup>Here, we implicitly assume that, on top of the Gabaix-Maggiore constraint on their international arbitrage, financial intermediaries face a borrowing constraint on their overall balance sheet, such that their constraint depends on their net worth, e.g., as in [Gertler and Kiyotaki \(2010\)](#). This gives rise to intermediary asset pricing in the form of [Equation \(30\)](#).

equity capital ratio is low. The first term captures the asset pricing effect of weaker fundamentals, while the second captures the idea that the intermediaries' risk-bearing capacity is impaired when the capital ratio is low. As a result, risk aversion increases the marginal value of wealth. Using time-series and cross-sectional asset pricing tests, [He et al. \(2017\)](#) show that this specification captures well the marginal utility of the wealth of financial intermediaries, and find supporting evidence that financial intermediaries are indeed marginal investors for a wide class of assets. As a baseline, we set  $\beta = 0.99$  and  $\gamma = 10$ .

In our empirical exercise, we consider two measures of the capital ratio ( $\eta_t$ ) and two measures of aggregate wealth ( $W_t$ ), which give rise to four different possible specifications. For the first capital ratio measure, we consider the equity capital ratio of financial intermediaries (*Primary Dealer* counterparties of the New York Federal Reserve) from [He et al. \(2017\)](#), which we denote by  $\eta_{t+1}^{HKM}$ . The second measure is from [Adrian et al. \(2014\)](#), and is defined as the (inverse of) book leverage of security *Brokers & Dealers*.<sup>17</sup> We denote it as  $\eta_{t+1}^{AEM}$ . For total wealth, we consider a real measure using US GDP ( $W_t^{GDP}$ ) and a financial measure using the MSCI World Equity Index ( $W_t^{MSCI}$ ).

As in [He et al. \(2017\)](#), our measure of net worth is obtained by interacting the capital ratio measure with the total wealth measure:  $NW_t = \eta_t \times W_t$ . To convert net worth into a growth rate (as suggested by (30)), we adopt an approach similar to [He et al. \(2017\)](#). For the capital ratio, we define the intermediary capital risk factor by dividing the residual from a regression of the capital ratio on its lag by the lagged capital ratio. For the financial measure of wealth ( $W_t^{MSCI}$ ), we compute the excess returns on the equity index, using the 3-month US risk-free rate. For the real measure of wealth ( $W_t^{GDP}$ ), we simply compute the growth rate.  $\frac{NW_{t+1}}{NW_t}$  is then defined by the interaction of the intermediary capital risk factor and the growth rate measure of total wealth. Online Appendix B provides additional details about the sources of the data, as well as the construction of excess returns and stochastic discount factors for financial intermediaries.

We consider excess returns using the CHF and the JPY as the domestic currency and the USD as the foreign currency. We define the log excess returns of going long in the domestic currency from the international investors perspective:

$$x_{t+1}^* = i_t - i_t^* + s_t - s_{t+1} \quad (31)$$

We use  $x_{t+1}^*$  as an approximation of  $X_{t+1}^*$ .

Table 1 displays an estimate of  $cov(m_{t+1}^*, x_{t+1}^*)/\mathbb{E}_t m_{t+1}^*$  and  $cov(m_{t+1}, x_{t+1}^*)/\mathbb{E}_t m_{t+1}$  using either the CHF or the JPY as the domestic currency for the 2010-2022 post-GFC period. Columns 2 to 5 display the covariance terms from the perspective of financial intermediaries using the capital ratio measure from [He et al. \(2017\)](#) and [Adrian et al.](#)

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<sup>17</sup>It is obtained using balance sheet data reported in the Flow of Funds from the Federal Reserve Board and is computed as the ratio of total equity (total financial assets minus total financial liabilities) to total financial assets.

Table 1:  $\frac{Cov(x_{t+1}^*, m_{t+1}^*)}{\mathbb{E}_t(m_{t+1}^*)}$  and  $\frac{Cov(x_{t+1}^*, m_{t+1})}{\mathbb{E}_t(m_{t+1})}$

A) CHF domestic currency, USD foreign currency					
Fin. Intermediaries				HH	
$NW_{t+1} =$	$\eta_{t+1}^{HKM} \times W_{t+1}^{MSCI}$	$\eta_{t+1}^{AEM} \times W_{t+1}^{MSCI}$	$\eta_{t+1}^{HKM} \times W_{t+1}^{GDP}$	$\eta_{t+1}^{AEM} \times W_{t+1}^{GDP}$	$C_{t+1}^{CH}$
	5.23***	2.14*	4.37**	1.32**	0.51
B) JPY domestic currency, USD foreign currency					
$NW_{t+1} =$	$\eta_{t+1}^{HKM} \times W_{t+1}^{MSCI}$	$\eta_{t+1}^{AEM} \times W_{t+1}^{MSCI}$	$\eta_{t+1}^{HKM} \times W_{t+1}^{GDP}$	$\eta_{t+1}^{AEM} \times W_{t+1}^{GDP}$	$C_{t+1}^{JP}$
	6.81***	1.95	6.47***	1.93***	-2.59

*Note:*

This table estimates  $\frac{Cov(x_{t+1}^*, m_{t+1}^*)}{\mathbb{E}_t(m_{t+1}^*)}$  and  $\frac{Cov(x_{t+1}^*, m_{t+1})}{\mathbb{E}_t(m_{t+1})}$  using different proxies of the SDF of (international) financial intermediaries and Swiss and Japanese households. Values are expressed in percentage points. Online Appendix B and C provide details on their construction and the source of the data. Statistical significance is assessed by regressing excess returns on the different measures of the SDF using Newey-West standard errors. \*\*\* :  $p < 0.01$ , \*\* :  $p < 0.05$ , \* :  $p < 0.1$ .

(2014) and the two measures of total wealth to compute the SDF. Column 2 uses monthly data, while the other columns use quarterly data. The last column displays the covariance term for Swiss and Japanese households, using real consumption growth to compute the SDF. Statistical significance is assessed by regressing the excess returns on the different measures of SDF and using Newey-West standard errors.

The results show that the covariance term for financial intermediaries is clearly positive and statistically significant for most of the specifications of the stochastic discount factor, and quantitatively in line with the UIP deviations depicted in Figure A.1, reaching up to 6.8% for Japan and 5.2% for Switzerland. Being long in CHF or JPY tends to provide higher returns when the marginal utility of the wealth of financial intermediaries is high, indicating that the CHF and the JPY behave as hedges for international intermediaries. On the other hand, the covariance term between excess returns and SDF based on real domestic consumption growth is statistically insignificant. For Switzerland and Japan, Proposition 2 implies that it is not CIP but UIP deviations that should matter for FX interventions since  $cov(m_{t+1}, x_{t+1}^*)/\mathbb{E}_t m_{t+1}$  is not significantly different from zero.

Online Appendix C examines the robustness of the results to different household preferences. First, we consider CRRA utility with various levels of  $\gamma$  ( $\gamma \in \{2, 5, 10, 20\}$ ). Second, we extend the baseline Epstein-Zin recursive preferences to different parameters ( $\gamma \in \{2, 5, 10, 20\}$ ,  $\psi \in \{1.5, 2.0, 2.5\}$ ). Third, we consider Campbell-Cochrane habit formation ( $\gamma \in \{1, 2, 5\}$ ). Across all specifications and parameter values, the covariance between households SDF and excess currency returns is insignificant at the 5 percent level.

These results suggest that the utility cost of reserves is negative. According to Propo-

sition 3, this implies that the demand for gross foreign liabilities is not met by the supply, so that  $b^G + b^{CBF} < b^{max}$ . This may be surprising, given that Switzerland has accumulated a large amount of foreign reserves  $b^{CBF}$  during that period, that amount to about 100% of GDP, and that Japan has a level of public debt that exceeds 200% of GDP. However, as discussed above, the supply of liabilities  $b^G + b^{CBF}$  has to be compared to the desired liabilities  $b^{max}$ . Online Appendix B.3 shows that there is a simple and direct mapping from the moments in the data to a lower bound for  $b^{max}$ . Using a coefficient of risk aversion of 10 as for Table 1 and the data for 2010-2022, we find a very high lower bound for  $b^{max}$  in both Japan and Switzerland that is significantly above the supply of assets, for all measures of the intermediaries' wealth but one.

## 5 The Central Bank as a Constrained Planner

To determine how the cost of reserves influences the policy trade-offs of the central bank, we consider a central bank that maximizes households' welfare. We first reframe the central bank problem as that of a constrained central planner. We then show how the resulting optimal allocation can be decentralized using FX interventions.

Before that, we relate the country's consolidated financial liabilities to the households' short-selling constraint (11). Using the definition of  $b^{H*}$  in (19), we can show that the households constraint on domestic bond issuance translates into a constraint on gross foreign liabilities:

$$b^{H*} \leq b^G + b^{CBF} \quad (32)$$

However, (32) is not an effective constraint since the central bank can change its holding of foreign bonds  $b^{CBF}$ .

Similarly, the foreign currency no-borrowing constraint implies:

$$nfl \leq b^{H*} - b^{CBF} \quad (33)$$

This constraint cannot be relaxed by sterilized FX intervention since changes in  $b^{H*}$  are offset by changes in  $b^{CBF}$ .<sup>18</sup> This constraint is effective except if we allow the central bank to perform unsterilized interventions combined with fiscal transfers, where changes in  $b^{H*}$  need not be offset by changes in  $b^{CBF}$ . Equations (32) and (33) are equivalent to the no-borrowing constraints (11).

### 5.1 The Constrained Planner Program

Based on the previous equations, we can examine the planner's optimal choices.

**Definition 3 (Constrained planner equilibrium)** *A constrained planner equilibrium is an equilibrium in which a planner maximizes objective (12) subject to the economy's*

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<sup>18</sup>When capital controls are in place, however, Bacchetta et al. (2013) show that sterilized interventions can affect the country's intertemporal allocation.

resource constraints (22); the asset pricing equation (6); the policy rule  $f(i, S_1) = 0$ ; the foreign liability constraints (32) and (33); and the definition of UIP (3). The planner's choice variables are  $(i, S_1, b^{H*}, nfl, b^{CBF})$ .

The central bank's program is:

$$\begin{aligned} & \max \mathbb{E} \left\{ U(c_1) + \beta U(c_2) \right. \\ & + \eta_1 (y_1 - c_1 + nfl) \\ & + \eta_2 \left[ y_2 - c_2 - (1 + i^*)nfl - \left[ (1 + i) \frac{S_1}{S_2} - (1 + i^*) \right] b^{H*} \right] \\ & + \xi f(i, S_1) \\ & + \Lambda (b^{H*} - b^{CBF} - nfl) \\ & + \tilde{\Lambda} (b^G + b^{CBF} - b^{H*}) \\ & \left. + \alpha_0 \left( \mathbb{E} \left( m^* \left[ (1 + i) \frac{S_1}{S_2} - (1 + i^*) \right] \right) - \Gamma b^{H*} - \chi \right) \right\} \end{aligned}$$

Consider the first-order conditions for assets:

$$/nfl : \quad \eta_1 - \mathbb{E}(\eta_2(1 + i^*)) \quad -\Lambda \quad = 0 \quad (34)$$

$$/b^{H*} : \quad -\mathbb{E}(\eta_2 X^*) \quad + \Lambda - \tilde{\Lambda} - \alpha_0 \Gamma \quad = 0 \quad (35)$$

$$/b^{CBF} : \quad -\Lambda + \tilde{\Lambda} \quad = 0 \quad (36)$$

Equation (36) implies that  $\tilde{\Lambda} - \Lambda = 0$ . This means that the central bank equalizes the marginal benefit of relaxing the foreign-currency and domestic-currency debt constraints by adjusting its assets and liabilities and going shorter in the asset whose shadow cost is higher and longer in the asset whose shadow cost is lower. Also note that  $\eta_1 = U'(c_1)$ ,  $\eta_2 = \beta U'(c_2)$ , and that  $m = \eta_2/\eta_1$  is the central bank's discount factor, which coincides with the household's (see Online Appendix E.1).

## 5.2 Optimal foreign exchange interventions

Equation (35), with  $\Lambda - \tilde{\Lambda} = 0$ , and using other FOCs, can be rewritten as follows (see Online Appendix E.2):

$$\underbrace{\left( -\mathbb{E}X^* - \frac{\text{cov}(m, X^*)}{\mathbb{E}m} \right)}_{-UCFX} - \underbrace{\left( \Gamma b^{H*} \frac{\mathbb{E} \left( m \frac{S_1}{S_2} \right)}{\mathbb{E}m \mathbb{E} \left( m^* \frac{S_1}{S_2} \right)} \right)}_{\mu} = 0 \quad (37)$$

$MBFX$

The left-hand side,  $MBFX$ , corresponds to the marginal benefit of sterilized FX interventions, that is, of expanding the central bank's balance sheet by going long in foreign bonds and short in domestic bonds. This marginal benefit is composed of the marginal utility benefit of FX interventions  $-UCFX$  minus a dynamic terms-of-trade externality  $\mu$

(as in Costinot et al., 2014). If, in the absence of interventions,  $MBFX$  is positive, then it would be optimal for the central bank to accumulate FX reserves. These interventions can drive the marginal benefit to zero, achieving an optimal central bank balance sheet.<sup>19</sup>

Sterilized FX interventions cannot address intertemporal optimality. This can be seen from Equation (34), which implies that  $\Lambda/\eta_1 = 1 - \mathbb{E}[m(1 + i^*)] \geq 0$ . If  $\Lambda > 0$ , then  $nfl = b^G$  whatever the level of reserves, because households cannot change their net position. If  $\Lambda = 0$ , then households are not constrained in their intertemporal allocation and, as we have seen, interventions can affect  $nfl$ , but there is no intertemporal wedge to address ( $\mathbb{E}[m(1 + i^*)] = 1$ ).<sup>20</sup>

The dynamic terms-of-trade externality  $\mu$  arises from the distortions in prices (interest rate and exchange rate) implied by the central bank's interventions.  $\mu$  depends on  $\Gamma$ , because FX interventions have an impact on equilibrium prices only if  $\Gamma > 0$ . In that case, FX interventions decrease the excess return on foreign currency. If, additionally, the country is short in domestic currency ( $b^{H^*} > 0$ ), then reducing this excess return has a cost ( $\mu > 0$ ). This means that (i) the social benefit of FX interventions  $MBFX$  is strictly lower than the private benefit  $-UCFX$ , and (ii) the central bank has an incentive not to fully shut down its risk-adjusted foreign currency excess return in order to maximize its profit:  $-UCFX = \mu > 0$ . This term reflects the central bank's rent as a monopolistic issuer of domestic bonds.

If Equation (37) is satisfied, then Equation (27) implies  $\lambda^H - \lambda^F = \mu > 0$ . This means that the central bank policy does not satisfy the households' portfolio optimality. In fact, because  $MBFX < -UCFX$ , the level of gross foreign liabilities desired by the central bank is lower than the one desired by households ( $b^{max}$ ). By limiting the issuance of reserves, the central bank can keep the effective supply of domestic bonds by the economy below  $b^{max}$ .

The following lemma sets explicit expressions for optimal FX interventions.

**Lemma 1** *Suppose that Conditions 1, 2 and 3 are satisfied, and  $b^{max} > b^G$ . Let  $\widehat{nfl}^{opt}$  be the level of net foreign liabilities that holds under both intertemporal optimality and  $MBFX = 0$ , and denote by  $\widehat{b}$  the optimal gross foreign liabilities set by the central bank acting as a constrained planner. Then:*

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<sup>19</sup> $MBFX$ , the wedge addressed by the central bank, is a portfolio allocation wedge: issuing domestic-currency bonds to acquire foreign-currency bonds helps achieve the optimal currency composition for the country's portfolio. This is the case in other papers, like Basu et al. (2025), Maggiori (2021), Itskhoki and Mukhin (2022), where a similar wedge is called "UIP wedge", or "risk-sharing wedge".

<sup>20</sup>In other papers, the central bank addresses an intertemporal wedge due to financial constraints and pecuniary externalities. In Bianchi and Lorenzoni (2022), sterilized interventions can address the intertemporal wedge through a spread channel. In Arce et al. (2019); Davis et al. (2023); Kim and Zhang (2023), households are constrained, as in our framework, but the central bank is allowed to perform unsterilized interventions combined with fiscal transfers. In Online Appendix E.5, we consider an extension of our model where the central bank is allowed to perform these fiscally-backed interventions. We show that, in that case, the central bank achieves both intertemporal optimality and  $MBFX = 0$ .

(i)  $\widehat{b}$  is defined by

$$\widehat{b} = \frac{(1 - \alpha)\rho\sigma^2 - \chi}{2\Gamma + \rho^2\sigma^2} - \frac{\alpha\rho\sigma^2 \min(\widehat{nfl}^{opt}, b^G)}{2\Gamma + \rho^2\sigma^2} \quad (38)$$

(ii)  $\widehat{b} < b^{max}$  if  $\Gamma > 0$  and  $\widehat{b} = b^{max}$  if  $\Gamma = 0$ .

(iii) The optimal level of FX reserves is given by

$$\widehat{b}^{CBF} = \widehat{b} - b^G, \quad (39)$$

except if  $\Gamma = 0$  and  $b^G \geq \widehat{nfl}^{opt}$ , in which case the optimal level of FX reserves must satisfy  $\widehat{b}^{CBF} \geq \widehat{b} - b^G$ .

See the proof in Online Appendix E.3. Point (i) derives from the optimality condition with respect to  $b^{H*}$ , Equation (37). The level of gross domestic liabilities desired by the central bank  $\widehat{b}$  can be implemented because, first, the central bank is not constrained in its gross portfolio composition and, second, because, as argued above, the marginal benefit of accumulating reserves  $MBFX$  is higher than the households' utility gain  $UCFX$ . It is strictly higher when FX interventions affect the excess currency return, that is, when  $\Gamma > 0$ . This explains point (ii). The optimum is then easily implementable for the central bank by providing just the right amount of domestic liabilities to complement the existing public domestic supply and reach  $\widehat{b}$ , through FX interventions  $\widehat{b}^{CBF}$  (point (iii)). For that level of domestic currency bonds, households would like to issue more domestic currency bonds ( $b^H < 0$ ), but are prevented from doing so due to their short-selling constraints.

In what follows, we suppose that  $b^G < \widehat{nfl}^{opt}$  so that  $nfl = b^G$ , which makes the problem more tractable.<sup>21</sup> In that case, the optimal level of intervention is given by

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

where we used equations (38) and (39).

The comparative statics for optimal FX intervention is given in the following proposition:

**Proposition 4** *Suppose that Conditions 1, 2 and 3 are satisfied and that  $b^G < \widehat{nfl}^{opt}$  and  $b^{max} > b^G$ . Then optimal FX interventions,  $\widehat{b}^{CBF}$ :*

- (i) are increasing in global risk  $\sigma$ ;
- (ii) are decreasing in intermediaries financial frictions  $\Gamma$  and  $\chi$ ;
- (iii) are decreasing in the domestic output exposure to global risk  $\alpha$ ;
- (iv) are decreasing in the supply of government bonds  $b^G$ .

<sup>21</sup>We relax this condition in the numerical simulations.

Points (i) to (iv) can be shown by taking derivatives of  $\widehat{b}^{CBF}$  with respect to  $\sigma$ ,  $\Gamma$ ,  $\chi$ ,  $\alpha$ , and  $b^G$ . Risk tends to increase the covariance differential  $\Delta Cov$ , which generates an excess benefit of FX interventions, while the intermediation frictions generate a cost. Exposure of domestic output to global risk decreases the covariance differential and generates a cost. Point (iv) arises from the substitutability between government bonds and the central bank liabilities (see Equation (39)). If the government issues more bonds, then this reduces the need for the central bank to issue liabilities through FX interventions.

Interestingly, an increase in global risk, which increases optimal  $b^{H*}$ , typically generates both a more negative UIP deviation and a more positive CIP deviation, as the financial intermediaries have to absorb the excess domestic currency bonds. This is established formally in the following proposition:

**Proposition 5** *Suppose that Conditions 1, 2 and 3 are satisfied and that  $b^G < \widehat{nfl}^{opt}$ ,  $b^{max} > b^G$ , and  $\Gamma > 0$ . Then, under optimal FX intervention:*

- (i)  $Z^*$  is increasing in  $\sigma$  (it becomes more positive);
- (ii)  $\mathbb{E}X^*$  is decreasing in  $\sigma$  (it becomes more negative).
- (iii)  $UCFX$  is decreasing in  $\sigma$  (it becomes more negative).

See the proof in Online Appendix E.4. As risk increases, the UIP deviation becomes more negative because it positively affects the foreigners risk premium.  $UCFX$  also becomes more negative (the utility gain of reserves increases). The planner responds by increasing the stock of reserves through FX interventions. However, it is not in the planner's interest to completely offset the impact of risk on  $UCFX$ , because the monopoly rent increases with risk as the foreign intermediaries have more appetite for the domestic currency. The CIP deviation becomes more positive when risk increases, as financial intermediaries need to absorb more capital inflows to finance excess domestic liabilities  $b^{H*}$  resulting from interventions.

### 5.3 Numerical Illustration

We examine in more detail how the level of global risk  $\sigma^2$  affects the economy and optimal policy through a numerical example. We assume policy rule (29) is in place. Figure 2 shows the comparative statics of  $\sigma^2$  under a baseline specification of parameters similar to Figure 1. We also consider two levels of  $b^G$ : 0.5 and 1.1.

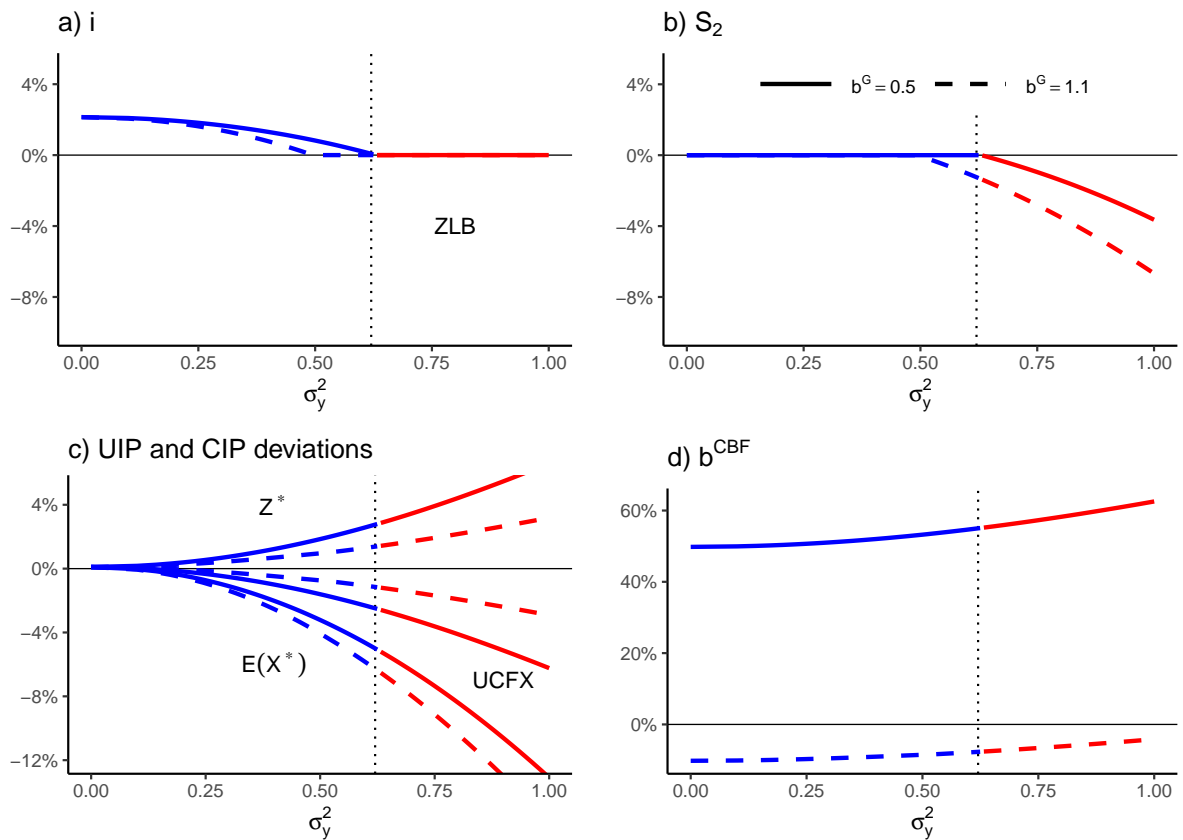
Panel a) shows the negative relationship between the domestic interest rate and global risk: the higher demand for domestic bonds is accommodated through a decline in the domestic nominal interest rate. The ZLB is attained at  $\sigma^2 \geq 0.62$ . At the ZLB, the exchange rate appreciates to accommodate the higher demand for domestic bonds (see Panel b)). Panel c) displays the deviations from CIP ( $Z^*$ ) and from UIP ( $\mathbb{E}X^*$ ), as well as the utility cost of reserves ( $UCFX$ ). As we can see, an increase in risk leads to a

more positive CIP deviation, and a more negative UIP deviation and cost of reserves, as explained in Proposition 5.

As shown in Panels a) to c), a higher public debt  $b^G$  reduces the domestic currency excess return (generating a less positive CIP deviation and a more negative UIP deviation) through a lower interest rate or an appreciated currency. As both short-selling constraints are binding, a higher level of public debt increases the level of net foreign liabilities  $nfl$ . With a higher  $nfl$ , households have a higher marginal utility in period 2, making them more risk averse. This tends to reduce the benefits of carry-trade, so the central bank targets lower domestic gross liabilities  $b^{H*}$ . Then, the lower equilibrium interest rate (or more appreciated exchange rate) results from the smaller supply of domestic assets.

Panel d) shows that  $\widehat{b}^{CBF}$  increases with global risk, as stated in Proposition 5. An increase in risk raises the benefit of FX interventions, which the central bank takes advantage of by buying FX reserves. However, the level of  $\widehat{b}^{CBF}$  is only positive when  $b^G = 0.5$ . When  $b^G$  is large, the central bank is long in domestic bonds rather than foreign bonds, and short in foreign bonds rather than domestic bonds. In that case, an increase in risk pushes the central bank to sell domestic bonds and decrease its foreign currency leverage. However, this is possible only if the central bank is allowed to be short in foreign currency. Otherwise, the central bank cannot exploit its advantage.

Figure 2: Comparative statics of  $\sigma^2$



Notes: Baseline parameters :  $\beta = 0.98$ ,  $\chi = 0.002$ ,  $\Gamma = 0.5$ ,  $\alpha = 0.6$ ,  $\rho = 0.2$ ,  $g = 0.05$ .

## 6 Conclusion

The GFC was followed by significant changes in the international monetary system. We have been observing systematic deviations from CIP, an increased demand for safe assets, and an expansion in central banks balance sheets. There has been a stronger demand for safe-haven currencies and more FX intervention by these countries' central banks. For example, the spectacular increase in the balance sheet of the Swiss National Bank has occurred exclusively through the purchase of foreign assets.

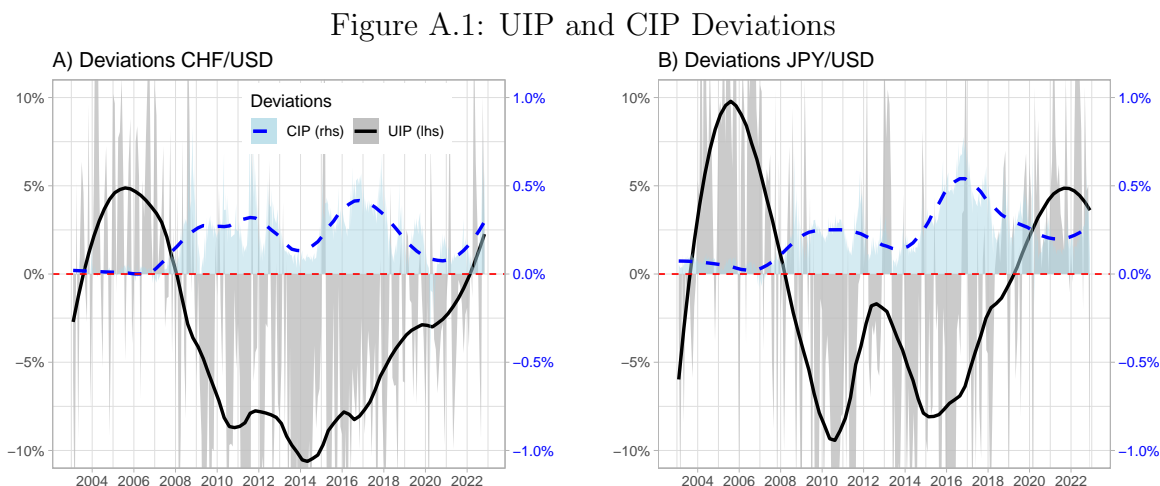
The objective of this paper is to provide a simple framework to clarify some aspects of these developments. To explain UIP and CIP deviations, we follow the recent literature that gives a key role to constrained international financial intermediaries. However, we assume that these intermediaries face exchange-rate risk, so that the UIP deviation incorporates a risk premium that is not present in the CIP deviation. In this context, financial intermediaries value the hedging properties of safe haven currencies.

We examine the opportunity cost of FX intervention when CIP and UIP deviations differ. We show that whether CIP or UIP deviations matter depends on how domestic residents value the hedging property of their currency compared to international investors. If they give no value to its hedging property, UIP deviations should matter. This may imply a benefit, and thus a higher incentive, for FX accumulation in a safe-haven economy. We show that incentives to accumulate FX reserves in safe haven countries increase with the level of global risk or of effective risk aversion of international intermediaries. In contrast, the incentives decrease with the level of debt.

We also attempt to estimate the opportunity cost of intervention for Switzerland and Japan. We find that in both countries, domestic households value the hedging properties of their currency less than international investors. This confirms the higher incentive for intervention in these countries

## A UIP and CIP deviations

In this Appendix, we show evidence on CIP and UIP deviations for Switzerland and Japan. Figure A.1 shows CIP and UIP deviations for Switzerland and Japan, computed in percentage points as defined in Equations (2) and (3), taking the USD as the foreign currency and considering a 3-month horizon. Panels A) and B) consider the CHF and the JPY as the domestic currencies. For the short-term risk-free rates, we rely on the 3-month Libor before 2020M1, and on the OIS rate for the subsequent period. The UIP deviations are computed using monthly data from Datastream for the risk-free rates and from Consensus Economics for the exchange rate forecasts and the spot exchange rates.<sup>22</sup> The CIP deviations are monthly averages of daily observations and are computed using 3-month risk-free rates, spot exchange rates and forward rates with a 3-month maturity from Datastream. All returns are annualized.



*Notes:* This figure shows UIP and CIP deviations at a 3-month horizon. The smoothed lines are obtained by applying the LOESS method with a bandwidth parameter set to 0.3. Exchange rate forecasts are from Consensus Economics.

<sup>22</sup>See [Kalemli-Özcan and Varela \(2021\)](#) for a recent analysis of UIP deviations using Consensus Economics survey.

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