Cross-Country CIP Deviations

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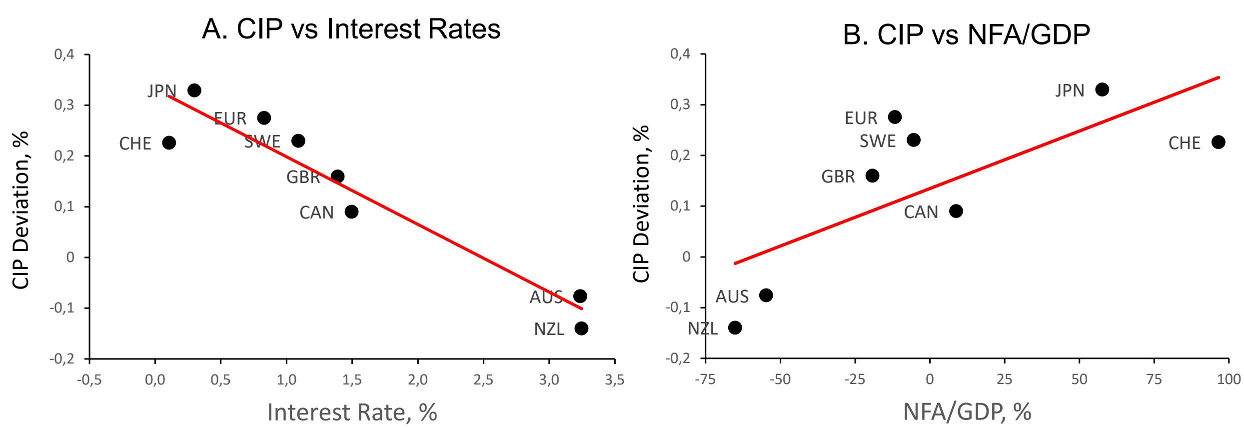
Abstract

Deviations from Covered Interest Parity (CIP) vary systematically across countries and are strongly correlated with cross-country differences in interest rates, net foreign asset positions, and the extent of hedging of dollar exposures. We develop a macroeconomic model of the United States and a set of smaller economies that introduces cross-country heterogeneity to account for these empirical relationships. The model is disciplined by evidence on the main participants in FX derivatives markets and their underlying hedging motives. We allow for heterogeneity in wealth, productivity, and safe-asset supply. Analytical results characterize how each source of heterogeneity affects CIP deviations, and a calibrated version of the model is shown to match key cross-sectional patterns in the data. In particular, heterogeneity in wealth—captured by differences in saving behavior across countries—emerges as the primary mechanism consistent with the observed evidence.

1 Introduction

Since the Global Financial Crisis, deviations from Covered Interest Parity (CIP) have emerged as a persistent feature of international financial markets, commonly attributed to limits to arbitrage associated with tighter post-crisis regulation. Importantly, these deviations vary systematically across countries and are closely related to differences in macroeconomic outcomes, most notably interest rates and net foreign asset positions. First, CIP deviations with respect to the US dollar are clearly related to the interest rate of the corresponding currency. The left panel of Figure 1 shows a negative relationship between CIP deviations and Libor interest rates for eight major currencies for the 2007-2020 period.[1] The CIP deviation is defined as the synthetic dollar rate (e.g., euro rate swapped into dollars) minus the dollar cash rate. Second, CIP deviations tend to be related to Net Foreign Asset Positions (NFA). The right panel of Figure 1 shows a positive relationship between CIP deviations and NFA (normalized by GDP) for the eight corresponding countries.

Figure 1: CIP Deviations vs Interest Rates and Net Foreign Assets



Notes: The CIP deviation is computed with respect to the USD, using 3-month Libor interest rates. EUR denotes Eurozone countries. The interest rate is the level of the Libor rate.

While most of the existing literature on CIP deviations adopts a micro-finance or partial-

[1] The CIP deviation is computed with Libor interest rates as they are available for the eight currencies we consider. Using OIS interest rates gives similar pictures, but for a smaller sample.

equilibrium perspective, emphasizing intermediary balance-sheet constraints, funding markets, or regulatory frictions, the patterns documented above raise inherently macroeconomic questions. Interest rate differentials, external positions, and hedging demands cannot be taken as exogenous: they are jointly determined in general equilibrium and interact with the same forces that generate CIP deviations. We therefore develop a multi-country general equilibrium model featuring the United States and a set of smaller economies, in which interest rates, net foreign asset positions, and CIP deviations are jointly determined. Cross-country heterogeneity in saving, productivity and safe asset supply, standard objects in international macroeconomics, are the exogenous drivers. Rather than focusing on the micro foundations of arbitrage frictions, we take limited CIP arbitrage capacity as a reduced-form constraint, in the spirit of macro models of limited UIP arbitrage (e.g., Gabaix and Maggiori (2015), Itskhoki and Mukhin (2021, 2025)).[2]

The model is characterized by simultaneous equilibrium in safe asset markets, FX forward markets and corporate bond markets of all countries. Equilibrium in the FX forward market is key to understanding CIP deviations. However, the open economy macro international portfolio choice literature has generally ignored the forward market as it is redundant without CIP arbitrage frictions. While there is a substantial literature on one of the key motives for forward market positions, hedging of currency risk associated with foreign assets, this literature adopts partial equilibrium frameworks that take portfolio allocation as given.

To discipline the structure of the forward market in the model, we draw on recent micro evidence on FX derivatives trading. Using data from the London FX derivatives market, Hacioğlu-Hoke, Ostry, Rey, Rousset Planat, Stavrakeva, and Tang (2024) provide insight into the main players in the FX forward market and their motives: dealer banks operate as CIP arbitrageurs, hedgers (asset managers, insurers, pension funds, investment funds and firms) hedge foreign FX positions and hedge funds take speculative positions. We develop a model with these three motives. The model implies that a hedging motive of forward market positions is key to account for a negative relationship between the interest rate and CIP deviation. The other two motives alone, CIP arbitrage and speculation, would imply a

[2] There are some papers that discuss CIP deviations in more macro oriented frameworks. Examples are Amador, Bianchi, Bocola, and Perri (2020), Fanelli and Straub (2021), Greenwood, Hanson, Stein, and Sunderam (2023), De Leo, Keller, and Zou (2025), Dao, Gourinchas, and Itskhoki (2025), Bacchetta, Davis, and van Wincoop (2025) and Bacchetta, Benhima, and Berthold (2023). Dao et al. (2025) is most related, but they do not develop a general equilibrium model.

positive relationship between the interest rate and CIP deviation.

The net supply of forward dollars arising from hedging activity plays a central role in the model. This net supply reflects the balance between foreign investors hedging dollar-denominated assets, US investors hedging foreign-currency exposures and foreign firms hedging dollar debts. With limited arbitrage capacity, countries that generate a large net supply of forward dollars face higher CIP deviations. This is consistent with Du and Huber (2024), who show that countries whose hedging volume of dollar assets is higher have a higher CIP deviation. However, they do not consider the other side of the market, for example US investors buying forward dollars to hedge foreign currency positions.

To account for a negative cross-country relationship between the CIP deviation and the interest rate, there must also be a connection between the interest rate and hedging. One way this occurs in the model we develop is through saving and wealth. A country with a relatively high saving rate has a low interest rate. But at the same time, high saving and wealth also lead to a large demand for dollar assets that needs to be hedged by selling dollars forward, raising the CIP deviation. The model also implies that a country with low productivity has a low interest rate and a large net hedging supply of forward dollars.

In these examples, wealth and productivity intermediate the link between the CIP deviation and the interest rate. They affect both the safe asset market equilibrium and the FX forward market equilibrium in a way that leads to a negative relationship between the CIP deviation and the interest rate. In addition, interest rate differentials can also have a direct effect on the forward market equilibrium through hedging of foreign currency exposures. This is the case when a low interest rate makes it attractive to invest abroad in dollar assets. The need to hedge these assets increases the supply of forward dollars, again raising the CIP deviation. However, we find that this is only the case when the hedge ratio (fraction of foreign currency exposure that is hedged) is less than 1.

The model contains the following agents: households, mutual funds, hedge funds, financial intermediaries, firms, and safe asset suppliers in the US and N small countries. Financial intermediaries conduct both CIP and UIP arbitrage for the N currencies relative to the dollar, but have limited arbitrage capacity. Households invest in a domestic safe asset and corporate bond and invest abroad through mutual funds. Specifically, households from each of the N countries invest in a mutual fund that holds US assets (safe asset and corporate dollar bond), while US households invest in the small country assets through mutual funds.

In the baseline model, we assume that these mutual funds perfectly hedge exchange rate risk, while later on we consider partial hedging. Firms in the small countries also operate as hedgers. They decide how much debt to issue in dollars and the domestic currency. In the baseline model they perfectly hedge dollar debt, leading the hedged cost of dollar debt to be equated to the cost of domestic currency debt, consistent with evidence in Liao (2020) for corporate debt. Hedge funds only take a speculative position in the forward market. Their position depends on expected profits from speculation. Finally, safe asset suppliers generate an interest elastic net supply of safe assets.

Within this framework, we consider three types of heterogeneity across the N countries: heterogeneous household wealth due to heterogeneous saving rates, heterogeneous firm productivity and heterogeneous safe asset supply. Using a linearized version of the model, we first examine analytically the implications of these sources of heterogeneity for CIP deviations, interest rates and corporate spreads. We find that differences in safe asset supplies cannot explain the empirical evidence in Figure 1. On the other hand, differences in productivity and wealth can be consistent with the evidence under some theoretical conditions that we discuss.

While those results are based on the theory, we also consider the empirical relationship between each type of heterogeneity and both the interest rate and CIP deviation. Cross-country differences in productivity have virtually no relationship with CIP deviations and interest rates. Differences across countries in safe asset supply (public debt) are negatively correlated with interest rates. If asset supply heterogeneity were important, this relationship should be positive. In contrast, differences in saving rates and wealth are strongly positively correlated with CIP deviations and strongly negatively correlated with interest rates.

Therefore, we focus on country wealth heterogeneity and calibrate a full version of the model for the eight countries in Figure 1. The calibrated model successfully reproduces the observed cross-sectional relationships between CIP deviations, interest rates, net foreign asset positions, wealth, and hedging volumes. These results are robust to allowing for partial hedging by mutual funds and firms. Taken together, the results highlight how cross-country differences in saving and wealth, central variables in international macroeconomics, shape equilibrium outcomes in FX forward markets and generate persistent deviations from covered interest parity.

Related Literature

Most of the literature on CIP deviations focuses on its time-series dimension. The relationship between cross-country CIP deviations and interest rate levels was first reported by Du, Tepper, and Verdelhan (2018), who document a negative correlation for G10 countries. Their hypothesis (Prediction 2) is that investors from low-interest countries invest more in US dollars and hedge some of it (see also Du and Schreger, 2022). This carry-trade mechanism is present in our model, but only when hedging is partial.

Various papers document a positive correlation between the CIP deviation and net dollar NIIP positions (as a share of GDP). Examples are Liao and Zhang (2024), Dao and Gourinchas (2025), and Dao et al. (2025). Our focus will be on total NFA, as shown in Figure 1.[3] While Dao et al. (2025) do not develop a general equilibrium model, some of their intuition about the relationship between the NFA, interest rate and CIP deviation aligns with our findings.

Borio, Iqbal, McCauley, McGuire, and Sushko (2018) empirically document a significant relationship between FX hedging demand and CIP deviations. Du and Huber (2024) find a negative cross-country relationship between the cross-currency basis and the estimated hedging volume to GDP ratio for foreign institutional investors holding US dollar assets.[4] We will consider the implications of our model for this correlation as well.

There is only limited evidence on the degree of FX hedging. Du and Huber (2024) and Bräuer and Hau (2024) document that international investors only partially hedge their dollar asset positions. Cheema-Fox and Greenwood (2024), focusing on a subset of funds that are active in the FX market, report higher hedge ratios, with near perfect hedging for fixed income funds. Sialm and Zhu (2024) and Opie and Riddiough (2025) report lower hedging for US investors. On the firms side, the evidence also indicates partial hedging (see Alfaro, Calani, and Varela, 2024, for a survey). For convenience, we assume full hedging in our benchmark analysis, but in the numerical analysis we also consider partial hedging.

The theoretical literature on FX hedging has focused on currency overlay decisions of exogenously given foreign currency exposures. In this literature, the demand for FX forwards or swaps can be decomposed into a pure hedging motive and a pure speculative motive. Glen

[3] Avdjiev, Du, Koch, and Shin (2019) show that CIP deviations are correlated with the dollar beta. We do not focus on exchange rate fluctuations in this paper.

[4] The cross-currency basis is opposite in sign to our definition of the CIP deviation.

and Jorion (1993) discuss the demand for forwards, relating to the more general framework of Anderson and Danthine (1981). Recent papers with endogenous hedging include Du and Huber (2024), Liao and Zhang (2024), De Leo et al. (2025), Hacioğlu-Hoke et al. (2024), Bräuer and Hau (2024), and Bacchetta, Davis, and Van Wincoop (2024).

Departing from this literature, we will combine portfolio allocation decisions with hedging decisions. While hedging decisions by mutual funds and firms are exogenous in the model (either perfect hedging or partial hedging), we show in the Online Appendix that optimal forward market positions include a hedge portfolio (either perfect or partial) plus a speculative portfolio.[5] For convenience of analysis, we simply assume that all speculative positions come from hedge funds. This is consistent with evidence by Hacioğlu-Hoke et al. (2024). Bräuer and Hau (2024) also report evidence for European investment funds suggesting that the FX derivatives position is mainly driven by the hedging motive as opposed to a speculative motive.

We also assume limited arbitrage by global financial intermediaries, in the spirit of Gabaix and Maggiori (2015). Recent papers have considered intermediaries that undertake both CIP and UIP arbitrage, using somewhat different constraints on intermediaries: see Bacchetta et al. (2023), Dao and Gourinchas (2025) and Dao et al. (2025).[6] In our specification, financial intermediaries face exchange risk associated with UIP trades and regulatory costs associated with CIP trades.

While households in our model are not CIP arbitrageurs like financial intermediaries, indirectly (through mutual funds) they take forward market positions that depend on CIP deviations. For example, a higher CIP deviation makes it more costly for small country households to invest in hedged US dollar assets. This reduces investment by these households in mutual funds that invest in the US and therefore reduces the supply of forward dollars. Kubitza, Sigaux, and Vandeweyer (2025) provide evidence of this mechanism for European investors in the US.

[5]Different from the partial equilibrium literature above, additional assumptions are needed to justify a hedging motive when portfolio allocation decisions are made simultaneously. This will be discussed further in the next section.

[6]Some papers only consider CIP arbitrage, either by assumption as in Moskowitz, Ross, Ross, and Vasudevan (2026) or because financial intermediaries are risk neutral or there is no exchange rate uncertainty (either by assumption or due to linearization), e.g., Gabaix and Maggiori (2015), Fanelli and Straub (2021), Amador et al. (2020) or Basu, Boz, Gopinath, Roch, and Unsal (2020).

The rest of the paper is organized as follows. Section 2 discusses the need for a hedging motive in the model and assumptions needed to justify a hedging motive. Section 3 describes the model. Section 4 discusses equilibrium and Section 5 derives analytical results. Section 6 presents a numerical illustration in the calibrated model. Section 7 presents results with partial hedging. Section 8 concludes.

2 FX Forward Market and Hedging Motive

Before we describe the particular model that we will employ, in this section we first discuss more broadly what we can learn from the forward market equilibrium based on the three motives for forward market positions (CIP arbitrage, speculation and hedging). We argue that the hedging motive is key to accounting for the cross-country relationship between CIP deviations and interest rates.

2.1 Some Notation

Since we are interested in cross-sectional evidence, throughout the paper we assume that the expected change in the spot exchange rate is zero, so that the UIP deviation is also equal to the interest differential.[7] Without loss of generality, we then set the current spot rate and expected future spot rate equal to zero. The CIP deviation for currency i relative to the dollar is then defined as

$$cip_i = r_i + f_i - r_\$ \tag{1}$$

Here r_i and $r_\$$ are the interest rates on the safe country i and dollar assets, while f_i is the (log) forward rate. $r_i + f_i$ is the synthetic dollar rate, the rate obtained when swapping the safe country i asset into dollars.

We wish to explain why a country with a higher CIP deviation cip_i has a lower interest rate r_i. Note that it follows immediately from the CIP definition that this country also has a relatively high forward rate f_i.

[7] Therefore, the interest differential in the model is the same as the UIP deviation, consistent with evidence reported by Dao et al. (2025) when expected exchange rate expectations are based on survey data.

2.2 Forward Market Equilibrium

We will allow demand and supply of forward dollars to be driven by three motives that commonly feature in the literature: CIP arbitrage, speculation, and hedging. If the CIP deviation is positive, it is attractive to borrow in the safe dollar asset and lend dollars synthetically by lending in currency i and buying dollars forward. A higher CIP deviation therefore leads to a higher demand for forward dollars due to arbitrage. The speculative motive leads to a demand for forward dollars that depends on the expected profit from buying dollars forward, which is equal to the forward rate f_i minus the expected future spot rate. Since we assume the latter to be zero, a higher forward rate f_i leads to a greater speculative demand for forward dollars.

Denote the demand for forward dollars associated with the CIP arbitrage and speculation as X_i^{arb} and X_i^{spec}. Similarly, denote the net supply of forward dollars in exchange for currency i for currency hedging reasons as X_i^{hedge}. Forward market equilibrium can then be written as

$$X_i^{arb}(\overset{+}{cip_i}) + X_i^{spec}(\overset{+}{f_i}) = X_i^{hedge} \tag{2}$$

Here the "+" sign indicates that X_i^{arb} and X_i^{spec} depend positively on respectively cip_i and f_i.

Without a hedging motive, a high CIP deviation is positively related to the interest rate. This can be seen by setting $X_i^{hedge} = 0$ and using $f_i = cip_i - r_i + r_\$$. The forward market equilibrium is then

$$X_i^{arb}(\overset{+}{cip_i}) + X_i^{spec}(\overbrace{cip_i - r_i + r_\$}^{+}) = 0 \tag{3}$$

Therefore, a hedging motive is needed if we wish to account for the negative relationship between the CIP deviation and interest rate. Moreover, as discussed in the introduction, the supply of forward dollars X_i^{hedge} associated with the hedging motive must be negatively related to the interest rate. This will be further developed in the model that follows.

2.3 Introducing a Hedging Motive

In contrast to the papers discussed in the literature review that consider optimal hedging for a given portfolio of assets, additional assumptions are needed to motivate hedging when investors make simultaneous hedging and portfolio decisions. We need to introduce risky assets and restrict the assets to which investors have access. The Online Appendix shows that without risky assets, demand for forward dollars is only driven by the CIP arbitrage motive and speculative motive. We will introduce risky assets in the form of corporate bonds.

But we also need to restrict the assets that agents have access to. We show in the Online Appendix that when investors have access to both the safe foreign and domestic asset, the forward market position is driven by CIP arbitrage even with a risky asset. The safe foreign asset, as opposed to the forward market, is then used to offset the exchange rate risk on foreign corporate bonds. One option is to assume that investors do not have access to the safe foreign asset (as in Du and Huber (2024) and Kubitza et al. (2025)) or that they do not have access to the safe domestic asset. In the Online Appendix we show that a true hedging motive arises with these constraints.

Here we choose a slightly different approach of restricting access to assets. We know, for example, that in reality foreign investors hold a lot of safe dollar debt. We allow households from country i to hold safe dollar assets, but only through a mutual fund that invests in US dollar assets. Since the mutual fund invests in a combination of safe dollar assets and risky dollar assets (corporate bonds), households cannot take a separate position in safe dollar assets.

Mutual funds are restricted in that they can only hold foreign assets and, therefore, cannot hold the domestic safe asset. As we discuss further below, mutual funds then choose a forward market position to optimally hedge their foreign currency portfolio. If they could also hold the domestic safe asset, their forward market position would instead be driven by the CIP arbitrage motive.

While we need a hedging motive, it is also clear that the speculative motive cannot be too strong if we wish to explain the negative relationship between the CIP deviation and the interest rate. The expected profit from speculation is the sum of the CIP and UIP deviation: $f_i = cip_i + (r_\$ - r_i)$. Therefore, when speculative demand for forward dollars X_i^{spec} is sufficiently sensitive to the forward rate, from equation (2) we get a counterfactual positive cross-country relationship between the CIP deviation and the interest rate.

3 Model Description

We consider a two-period model with N+1 countries: the US and N smaller foreign countries. In each country, there are households that can invest in the domestic safe asset, the domestic corporate bond and mutual funds. Mutual funds choose a portfolio of safe assets and corporate bonds in foreign countries. In this section, we assume that mutual funds perfectly hedge currency risk. We consider partially hedged mutual funds in Section 7.

There are also firms, hedge funds, financial intermediaries that conduct UIP and CIP arbitrage, and safe asset suppliers. Firms in the US issue corporate dollar bonds, while those in the N countries issue both domestic currency and dollar bonds. For now we assume that they perfectly hedge dollar bonds, but we will extend this later as well. Hedge funds take a speculative position in the forward market of each of the N currencies relative to the dollar. Financial intermediaries that conduct UIP and CIP arbitrage have limited arbitrage capacity for the N currencies relative to the dollar. Finally, safe asset suppliers in the US and the N countries provide an interest elastic supply of safe assets.

We will be relatively vague about the goods market as our focus is on financial markets. We make several assumptions that have implications for relative prices of goods and real exchange rates. Specifically, we assume that period 1 exchange rates are 1 and that period 2 exchange rates have an exogenous distribution. We also assume that central banks target a consumer price index of 1 in the domestic currency in both periods and that endowments and output are in units of the domestic consumption index. In the Online Appendix we show that these assumptions are consistent with goods market equilibrium when we make appropriate assumptions about the composition of goods that make up the endowments and output in each country.

3.1 Assets

In each country, there are safe assets and corporate bonds. We have already described the safe assets in Section 2. We will denote gross interest rates with upper case letters, $R_\$$ for the safe dollar bonds and R_i for the safe bond from small country i. These are returns from period 1 to period 2.

US firms only issue dollar denominated corporate bonds. Firms in country i issue both dollar bonds and bonds in the domestic currency. All bonds have a promised payment of one unit in period 2 in the currency of denomination. The respective yields on US corporate dollar bonds, country i corporate dollar bonds and country i corporate bonds in the country i currency are

$$R_{\$,c} = \frac{1}{P_\$} \qquad R_{\$,i,c} = \frac{1}{P_{\$,i}} \qquad R_{i,c} = \frac{1}{P_i}$$

The prices of the bonds are shown in the denominators.

In addition to currency risk when investing in a foreign currency bond, there is also a risk of default on all corporate bonds. The perceived probability of default varies across agents. Foreign bonds are considered to be riskier than domestic bonds. Both US and foreign households perceive the probability of default of their domestic firms to be π. Assuming full default in case of bankruptcy, this implies a variance of the return on domestic corporate bonds of $v = \pi(1 - \pi)$, evaluated at bond yields of 1. We assume that mutual funds are just as informed as households of the country in which they invest, and therefore also consider the probability of default to be π.

In contrast, US households perceive the probability of default of firms in each small country to be $\tilde{\pi}$, with $\tilde{\pi} > \pi$, and the corresponding variance of the return as $\tilde{v} = \tilde{\pi}(1 - \tilde{\pi})$. This generates portfolio home bias. Similarly, households in each small country perceive the probability of default of US firms to be $\tilde{\pi}_d$. We assume that the perceived variance of the return is $\tilde{v}_d/\mathrm{N}$ with $\tilde{v}_d = \tilde{\pi}_d(1 - \tilde{\pi}_d)$. This is because we can think of the US as of the same size as the sum of N small countries, with uncorrelated default outcomes. We assume that default outcomes are uncorrelated across countries and with the exchange rate.

Period 1 exchange rates of the N currencies relative to the dollar are assumed to be 1. The period 2 spot and forward rates are denoted S_i and F_i, which is dollars per unit of currency i. If an agent buys 1 dollar forward, the agent receives 1 dollar at time 2 in exchange for $1/F_i$ units of currency i. The expectation and variance of the period 2 log exchange rate s_i are 0 and σ^2, so that the expected change in the log exchange rate is zero.

3.2 Mutual Funds

We first assume that mutual funds fully hedge exchange rate risk, while in Section 7 we assume that they adopt an exogenous partial hedge ratio. The assumption that mutual funds fully hedge exchange rate risk may seem rather exogenous, but the results will be the same when we allow them to choose an optimal position in the forward market. As we show in the Online Appendix, in that case the optimal position in the forward market has two components. One component is the perfect hedge position that we assume here.[8] The second component is a speculative position. However, for convenience, we assume that all speculative positions are held by hedge funds. This is also more consistent with Hacioğlu-Hoke et al. (2024), who find that speculative positions in the London FX derivatives market are mostly taken by hedge funds.

Households from each small country i can invest in a mutual fund that holds the US safe dollar asset and the US corporate dollar bond.[9] Exchange rate risk is fully hedged through a forward market position. As shown in Appendix A, after log-linearization the expectation and variance of the return of the mutual fund can be written as

$$\begin{aligned} ER_{i,m} &= 1 + (1 - \mu_{i,m})r_{\$} + \mu_{i,m}\,(r_{\$,c} - \pi) - f_i \\ var(R_{i,m}) &= \mu_{i,m}^2 v \end{aligned}$$

Here lower case letters for returns and the forward rate denote logs. μ_{im} is the share that the fund invests in the US corporate dollar bond, while $1 - \mu_{i,m}$ is the share that it invests in the safe dollar bond.

Assume that the mutual fund maximizes a standard mean-variance objective with risk-aversion γ_m:

$$E(R_{i,m}) - 0.5\gamma_m var(R_{i,m}) \tag{4}$$

The first-order condition with respect to $\mu_{i,m}$ is

$$\mu_{i,m} = \frac{r_{\$,c} - \pi - r_{\$}}{\gamma_m v} \tag{5}$$

The share invested in the corporate dollar bond depends on the difference between its expected return, $r_{\$,c} - \pi$, and the safe dollar interest rate $r_{\$}$.

We could not address cross-country differences in CIP deviations if we introduced a single

[8]A partial hedge ratio as we consider in Section 7 can be derived when we allow for a quadratic cost associated with forward market positions.

[9]Department of the Treasury (2025) shows that over 80% of foreign holdings of US corporate debt is denominated in dollars.

mutual fund held by US households that invests in all of the N countries. This fund would conduct perfect cross-currency CIP arbitrage, so that CIP deviations relative to the dollar would be the same for all N currencies. We therefore assume that US households can invest in N separate mutual funds that each invest in the assets of one of the N small countries. The country i fund invests in the safe asset of country i and the corporate dollar bond issued by firms of country i.[10] The fund fully hedges the exchange rate risk associated with the safe asset that is denominated in the currency of country i. As shown in Appendix A, after log-linearization the expectation and variance of the return of the mutual fund can be written as

$$ER_{i,m,d} = 1 + (1 - \phi_{i,m})(r_i + f_i) + \phi_{i,m}(r_{\$,i,c} - \pi)$$
$$var(R_{i,m,d}) = \phi_{i,m}^2 v$$

Here $\phi_{i,m}$ is the portfolio share allocated to the corporate dollar bond of country i and $1-\phi_{i,m}$ is the share allocated to the safe asset of country i.

The fund maximizes the mean-variance objective $ER_{i,m,d} - 0.5\gamma_m var(R_{i,m,d})$. The first-order condition can be written as

$$\phi_{i,m} = \frac{r_{\$,i,c} - \pi - r_i - f_i}{\gamma_m v} \tag{6}$$

The portfolio share allocated to the corporate dollar bond is based on the excess return of the country i corporate dollar bond over the hedged country i safe asset. The expected return on the country i corporate dollar bond is $r_{\$,i,c} - \pi$. The hedged return on the country i safe asset is $r_i + f_i$.

[10] Department of the Treasury (2024) shows that of US holdings of debt of other advanced countries, 88% of government debt is denominated in the local currency, while 83% of private sector debt is denominated in dollars.

3.3 Households

3.3.1 Small Country Households

In period 1 households in country i start with a real endowment of Z. Let $W_i = Z - C_{1,i}$ be wealth in period 1 after consumption. Utility is

$$ln(C_{1,i}) + \beta_i ln \left[E\left(C_{2,i}\right)^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{7}$$

We have $C_{2,i} = R_{p,i}(Z - C_{1,i})$, where $R_{p,i}$ is a stochastic portfolio return. Maximizing utility with respect to $C_{1,i}$ gives $C_{1,i} = \frac{1}{1+\beta_i}Z$, so that

$$W_i = \frac{\beta_i}{1+\beta_i}Z \tag{8}$$

We allow household wealth W_i to vary across small countries. Countries with high wealth have high household saving as a result of a high time discount rate β_i.

In addition, households maximize

$$\left[E\left(R_{p,i}\right)^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$$

One can show that this can be approximated as maximizing[11]

$$E(R_{p,i}) - 0.5\gamma var(R_{p,i}) \tag{9}$$

Country i households invest a share $\alpha_{i,c}$ in the country i corporate bond in the country i currency, a share $\alpha_{i,m}$ in the mutual fund that invests in the US, and the remainder in the country i safe asset. As shown in Appendix A, after log-linearization, we have

$$ER_{p,i} = 1 + r_i + \alpha_{i,c}\left(r_{i,c} - \pi - r_i\right) + \alpha_{i,m}\left((1-\mu_{i,m})r_\$ + \mu_{i,m}\left(r_{\$,c} - \tilde{\pi}_d\right) - r_i - f_i\right)$$
$$var(R_{p,i}) = \alpha_{i,c}^2 v + (\alpha_{i,m}\mu_{i,m})^2 \frac{\tilde{v}_d}{\mathrm{N}}$$

[11] A second-order Taylor expansion gives $(R_{p,i})^{1-\gamma} = (ER_{p,i})^{1-\gamma} + (1-\gamma_i)(ER_{p,i})^{-\gamma}(R_{p,i} - ER_{p,i}) - 0.5\gamma(1-\gamma)(ER_{p,i})^{-\gamma-1}(R_{p,i} - ER_{p,i})^2$. Taking the expectation, we have $E(R_{p,i})^{1-\gamma} = (ER_{p,i})^{1-\gamma} - 0.5\gamma(1-\gamma)(ER_{p,i})^{-\gamma-1}var(R_{p,i})$. Taking this to the power $1/(1-\gamma)$, and linearly expanding around $ER_{p,i} = 1$ and $var(R_{p,i}) = 0$, gives (9).

This uses that country i households perceive the expectation and variance of default on corporate bonds to be π and v for domestic bonds and $\tilde{\pi}_d$ and $\tilde{v}_d/\mathrm{N}$ for US bonds. The last term in the expectation is the expected excess return on the portfolio of hedged US assets that the mutual fund invests in.

The first-order conditions with respect to $\alpha_{i,c}$ and $\alpha_{i,m}$ imply

$$\alpha_{i,c} = \frac{r_{i,c} - \pi - r_i}{\gamma v} \tag{10}$$

$$\alpha_{i,m} = \frac{r_\$ - r_i - f_i + \mu_{i,m}\left(r_{\$,c} - \tilde{\pi}_d - r_\$\right)}{\gamma \mu_{i,m}^2 \frac{\tilde{v}_d}{\mathrm{N}}} \tag{11}$$

The share $\alpha_{i,c}$ allocated to domestic corporate bonds is a standard mean-variance portfolio.

The first term in the numerator of the foreign portfolio share $\alpha_{i,m}$ is $r_\$ - r_i - f_i$. This is the excess return on the hedged US safe asset over the country i safe asset. It is the CIP deviation with the sign reversed. A higher CIP deviation makes it more costly to hedge, leading to lower investment in the US. The second term in the numerator is the expected excess return of US corporate bonds over the US safe asset, multiplied by the fraction that the mutual fund allocates to corporate dollar bonds. If US corporate bonds are expected to deliver a higher return than the US safe asset, it raises the allocation to the mutual fund to the extent that it invests in US corporate bonds. The denominator depends on the default risk associated with US corporate dollar bonds.

3.3.2 US Households

Now consider US households. They start period 1 with a real endowment of $Z_d = \mathrm{N}Z$, so the same as the aggregate of non-US households. They have the same utility as small country households, with discount rate β_d. Therefore, their period 1 consumption is $Z_d/(1+\beta_d)$ and wealth is

$$W_d = \frac{\beta_d}{1+\beta_d} Z_d \tag{12}$$

Their portfolio return is $R_{p,US}$. Similarly to small country households, the utility function implies that they maximize $ER_{p,US} - 0.5\gamma var(R_{p,US})$. Let $\omega_{d,c}$ be the fraction that US households invest in the US corporate dollar bond and $\omega_{i,m}$ the fraction they invest in country i mutual fund with dollar return $R_{m,d,i}$. As shown in Appendix A, after log-linearization we have

$$ER_{p,US} = 1 + r_{\$} + \omega_{d,c}(r_{\$,c} - \pi - r_{\$}) + \sum_{i=1}^{N} \omega_{i,m} \left[(1 - \phi_{i,m})(r_i + f_i - r_{\$}) + \phi_{i,m}(r_{\$,i,c} - \tilde{\pi} - r_{\$})\right]$$

$$var(R_{p,US}) = \tilde{v} \sum_{i=1}^{N} (\omega_{i,m}\phi_{i,m})^2 + \omega_{d,c}^2 v$$

The optimal portfolios are then

$$\omega_{d,c} = \frac{r_{\$,c} - \pi - r_{\$}}{\gamma v} \tag{13}$$

$$\omega_{i,m} = \frac{r_i + f_i - r_{\$} + \phi_{i,m}(r_{\$,i,c} - \tilde{\pi} - r_i - f_i)}{\gamma \tilde{v} \phi_{i,m}^2} \tag{14}$$

The share allocated to the domestic corporate dollar bond depends on the expected excess return of the domestic corporate bond over the domestic safe asset. Similarly to small country households, the share allocated to the country i mutual fund depends on two expected excess returns. The first is the expected excess return of the hedged country i safe asset over the dollar safe asset, which is the CIP deviation. A higher CIP deviation raises investment in country i. The second is the the expected excess return of the country i corporate dollar bond over the hedged country i safe asset, times the share the mutual fund allocates to the country i corporate dollar bond.

3.4 Firms

First, consider firms in the N small countries. A firm from country i issues dollar and country i currency bonds that pay respectively 1 dollar and 1 unit of currency i in period 2. Their period 2 output is

$$Y_i = A_i K_i^{\nu} \tag{15}$$

Assume that the price of capital is 1.[12] A fraction η_i of capital is financed through dollar bonds. The firm fully hedges currency risk associated with issuing dollar bonds through the

[12] We can think of capital as the same index of goods as consumption, whose price index is targeted to be 1 by the central bank.

forward market. Firm productivity A_i may vary across countries.

Log-linearizing the cost of capital, profits are

$$\Pi_i = A_i K_i^{\nu} - K_i \left[1 + \eta_i(r_{\$,i,c} - f_i) + (1 - \eta_i) r_{i,c}\right] \tag{16}$$

Here $r_{\$,i,c} - f_i$ is the hedged cost of dollar bonds. Maximizing profits with respect to η_i and K_i gives

$$r_{\$,i,c} - r_{i,c} - f_i = 0 \tag{17}$$

$$A_i \nu K_i^{\nu-1} = 1 + r_{i,c} \tag{18}$$

Equation (17) implies arbitrage such that the hedged cost of dollar bonds is the same as the cost of currency i bonds. Liao (2020) has shown that this condition holds well in both cross-section and time series data for corporate bonds. It implies that the difference in the credit spread between the dollar bond ($r_{\$,i,c} - r_{\$}$) and the currency i corporate bond ($r_{i,c} - r_i$) corresponds to the CIP deviation $r_i + f_i - r_{\$}$. (18) equates the marginal return on capital to the cost of capital.

US firms only issue dollar bonds. Their output is $Y_d = A_d K_d^{\nu}$ and they maximize profits $A_d K_d^{\nu} - R_{\$,c} K_d$. Log-linearizing $R_{\$,c}$ as $1 + r_{\$,c}$, the first-order condition is

$$A_d \nu K_d^{\nu-1} = 1 + r_{\$,c} \tag{19}$$

Similarly to country i firms, this equates the marginal product of capital to the cost of capital.

3.5 Financial Intermediaries

There are financial intermediaries that conduct both UIP and CIP arbitrage. For what follows, it does not matter whether they are located in the US or in the small countries. For each small country i there is a financial intermediary that conducts UIP and CIP arbitrage for currency i relative to the dollar. The intermediary can choose positions in the country i safe asset, the dollar safe asset and the forward market for currency i relative to the dollar. It starts period 1 with zero wealth, so that opposite positions are taken in the two safe assets. Let ψ_i be the period 1 holding of the country i safe asset. Therefore, the holding of the dollar safe asset is $-\psi_i$. Let λ_i be dollars bought forward.

In terms of dollars, the log-linearized period 2 profits of these arbitrageurs are

$$\Pi_i^a = \psi_i \left(r_i + s_i - r_\$\right) + \lambda_i \left(f_i - s_i\right) = B_i^{CIP}(r_i + f_i - r_\$) + B_i^{UIP}(r_i + s_i - r_\$) \tag{20}$$

Here $B_i^{CIP} = \lambda_i$ is a CIP arbitrage position and $B_i^{UIP} = \psi_i - \lambda_i$ is a UIP arbitrage position.

Assume that these arbitrageurs maximize

$$E\left(\Pi_i^a\right) - 0.5\gamma_a var\left(\Pi_i^a\right) - 0.5\frac{1}{\Gamma}\left(B_i^{CIP}\right)^2 \tag{21}$$

The first two terms are the risk-adjusted expected profits, while the last term subtracts a quadratic cost associated with the CIP arbitrage position. Otherwise intermediaries would conduct perfect CIP arbitrage. These costs are meant to reflect various regulations that have limited CIP arbitrage since 2008.

Maximizing the objective with respect to B_i^{CIP} and B_i^{UIP} implies

$$B_i^{CIP} = \Gamma\left(r_i + f_i - r_\$\right) \tag{22}$$

$$B_i^{UIP} = \Gamma_a\left(r_i - r_\$\right) \tag{23}$$

where $\Gamma_a = 1/[\gamma_a\sigma^2]$. Γ_a is what Gabaix and Maggiori (2015) refer to as the risk-bearing capacity of the intermediary, which determines their portfolio response to UIP deviations. Since we assume that the expected period 2 exchange rate is 0, the UIP deviation is $r_i - r_\$$. Γ is the CIP arbitrage capacity of the intermediary. The larger it is, the more responsive the intermediary is to the CIP deviation $r_i + f_i - r_\$$.

3.6 Hedge Funds

Hedge funds in country i choose a position h_i in speculative forward trade in currency i relative to the dollar. Specifically, they buy h_i dollars forward. This gives a log-linearized profit in the currency of country i of

$$\Pi_h = h_i(f_i - s_i) \tag{24}$$

Assume that hedge funds maximize $E(\Pi_h) - 0.5\gamma_h var(\Pi_h)$. This implies

$$h_i = \frac{f_i}{\gamma_h \sigma^2} \tag{25}$$

If there are n_h hedge funds, total demand for forward dollars by hedge funds is

$$H_i = \Gamma_h f_i \tag{26}$$

where $\Gamma_h = n_h/(\gamma_h \sigma^2)$. The extent of speculation in the forward market therefore depends on the number of hedge funds n_h.

3.7 Safe Asset Suppliers

In order for households/mutual funds to be able to have a positive investment in safe assets, we introduce safe asset suppliers. This can also be thought of as a net safe asset supply. For example, it may be equal to government safe asset supply minus the holdings of safe assets by agents that exclusively hold safe assets. When these agents save more, the net safe asset supply drops. Of course, the same happens when the government saves more and reduces the supply of safe assets or the central bank buys government bonds and therefore removes safe assets from the market.

Allowing it to be interest-rate elastic, we model the period 1 supply of safe assets in country i as

$$D_i = d_{i,0} - d_1 r_i \tag{27}$$

We allow the constant term to vary across countries. As shown in Appendix B, this supply of safe assets can be formally derived from agents solving a two-period optimal consumption problem with an endowment only in the second period. Analogously, for the US we assume that the safe asset supply is

$$D_d = d_{\$,0} - \mathrm{N} d_1 r_{\$} \tag{28}$$

3.8 Market Clearing

For each country i there are three market clearing conditions. The first is the safe asset market clearing condition:

$$(1 - \alpha_{i,c} - \alpha_{i,m})W_i + \omega_{i,m}(1 - \phi_{i,m})W_d + B_i^{CIP} + B_i^{UIP} = D_i \tag{29}$$

The first two terms are demand of country i safe assets by domestic and US households, the latter through mutual funds. The next two terms are the demand for the country i safe asset by CIP and UIP arbitrageurs. The total demand is equal to the supply D_i by the safe asset suppliers.

The second market clearing condition equates supply and demand for corporate capital of country i:

$$\left(\frac{A_i \nu}{1 + r_{i,c}}\right)^{\frac{1}{1-\nu}} = \alpha_{i,c} W_i + \phi_{i,m}\omega_{i,m}W_d \tag{30}$$

The left hand side is the supply of capital K_i from (18). It is larger the lower the cost of capital (corporate yield) and the higher productivity. The right hand side is the demand for corporate capital by households. The first term is demand by country i households, while the second term is demand by US households (through mutual funds).

Finally, the third market clearing condition is equilibrium in the forward market:

$$B_i^{CIP} + \omega_{i,m}W_d - \alpha_{i,m}W_i + H_i = 0 \quad i = 1, .., \mathrm{N} \tag{31}$$

The first term is demand for forward dollars by CIP arbitrageurs. The second term is demand for forward dollars associated with investment by the US in country i. This involves the country i safe asset and the country i dollar bond, both held through a mutual fund. The mutual fund buys dollars forward to hedge currency risk associated with the country i safe asset. Firms in country i buy dollars forward to hedge dollar denominated debt held by US households through the mutual fund. The third term is the supply of forward dollars to hedge US dollar assets held by households in country i through a mutual fund. The last term is the demand for forward dollars by hedge funds.

Finally, for the US there are analogous equilibrium conditions for safe assets and corporate capital:

$$\left(1-\omega_{d,c}-\sum_{i=1}^{\mathrm{N}}\omega_{i,m}\right)W_d+\sum_{i=1}^{\mathrm{N}}\alpha_{i,m}(1-\mu_{i,m})W_i-\sum_{i=1}^{\mathrm{N}}B_i^{CIP}-\sum_{i=1}^{\mathrm{N}}B_i^{UIP}=D_d \tag{32}$$

$$\left(\frac{A_d\nu}{1+r_{\$,c}}\right)^{\frac{1}{1-\nu}}=\sum_{i=1}^{\mathrm{N}}\alpha_{i,m}\mu_{i,m}W_i+\omega_{d,c}W_d \tag{33}$$

These $3\mathrm{N}+2$ equilibrium conditions can be used to solved for r_i, $r_{i,c}$, f_i, $r_\$$ and $r_{\$,c}$. We also use that $r_{\$,i,c}=r_{i,c}+f_i$ from (17).

3.9 NFA and Hedging

From the forward market clearing condition (31) we can derive some results regarding the net foreign asset position and the net supply of forward dollars associated with hedging. With perfect hedging, we have

$$NFA_i=\alpha_{i,m}W_i-\omega_{i,m}W_d-B_i^{UIP}-B_i^{CIP}=-B_i^{UIP}+\Gamma_h f_i=-\Gamma_a(r_i-r_\$)+\Gamma_h\left(cip_i-r_i+r_\$\right) \tag{34}$$

The second equality uses the forward market equilibrium (31). If we can account for the fact that a country with a relatively high CIP deviation tends to have a relatively low interest rate, it follows that this country also has a relatively high net foreign asset position.

A low interest rate leads to net capital outflows by UIP arbitrageurs. When $\Gamma_h=0$ the net foreign asset position associated with households, $\alpha_{i,m}W_i-\omega_{i,m}W_d$, has no effect on NFA_i. This is because CIP arbitrageurs take the other side. Large holdings of dollar assets by households in country i imply a large supply of forward dollars. When CIP arbitrageurs take the other side, they lend dollars synthetically. This involves a short position in the safe dollar asset and long position in the safe country i asset, implying opposite net inflows into country i. But when $\Gamma_h>0$, this offset through CIP arbitrageurs is partial. Speculators take the other side as well since $f_i=cip_i-r_i+r_\$$ is relatively high.

Since the hedge ratio is 1, the net supply of forward dollars associated with hedging is $X_i^{hedge}=\alpha_{i,m}W_i-\omega_{i,m}W_d$. It follows from the forward market equilibrium (31) that

$$X_i^{hedge}=B_i^{CIP}+\Gamma_h f_i=\left(\Gamma+\Gamma_h\right)cip_i-\Gamma_h r_i+\Gamma_h r_\$ \tag{35}$$

If we can account for the fact that a country with a relatively high CIP deviation tends to have a relatively low interest rate, it follows that this country also has a relatively high net supply of forward dollars associated with hedging. This is consistent with empirical evidence in Du and Huber (2024), although they only consider hedging of dollar assets by foreign institutional investors and not the demand for forward dollars associated with US investors hedging their holdings of foreign currency assets and foreign firms hedging their dollar borrowing.

4 Solution

We first describe parameter assumptions that lead to a symmetric equilibrium and then introduce various asymmetries across countries. We use this framework to discuss an analytical solution to the model in Section 5. The analytical solution is obtained by considering marginal cross-country asymmetries when starting from the symmetric equilibrium. In Section 6 we consider a calibrated version of the model that is solved numerically and allows for large cross-country heterogeneity.

4.1 Symmetric Equilibrium

We consider a "symmetric" equilibrium where all small countries are identical and therefore have the same safe rate, corporate yield and forward rate. In addition, the safe rate and corporate yield are the same in the US as in the small countries and CIP deviations are all zero. Therefore $r_i - r_\$ = f_i = 0$ and all corporate spreads are the same: $r_{i,c} - r_i = r_{\$,c} - r_\$$. We also set parameters such that all countries invest the same share h in domestic assets and $1-h$ in foreign assets, and within both portfolios of domestic and foreign assets they invest a share c in corporate bonds and $1-c$ in safe assets.

We accomplish this as follows. We assume that the N countries have the same household wealth, productivity and safe asset supply: $W_i = W$, $A_i = A$ and $d_{i,0} = d_0$.[13] We also assume that the US is the same size as the sum of the N small countries, so that $d_{\$,0} = \mathrm{N}d_0$, $W_d = \mathrm{N}W$ and in equilibrium output and the capital stock are N times that in each small county. The latter is accomplished by setting $A_d = A\mathrm{N}^{1-\nu}$.

[13]Household wealth is the same when the discount rates β_i are the same, leading to identical saving.

The previous assumptions imply that a share $1-c$ of assets are safe, so that $D_i = (1-c)W$ and $D_d = (1-c)W_d$. It follows that

$$r_i = r_\$ = (d_0 - (1-c)W)/d_1 \tag{36}$$

We set productivity A_i and A_d so that the marginal product of capital is equal to $1 + r_{i,c} = 1 + r_{\$,c}$ when $K_i = cW$ and $K_d = cW_d$.

The assumptions regarding the foreign share $1-h$ and corporate share c imply that $\mu_{i,m} = \phi_{i,m} = c$, $\alpha_{i,c} = \omega_{d,c} = hc$, $\alpha_{i,m} = N\omega_{i,m} = 1-h$. Using these portfolio shares, it is easy to check that the market equilibrium conditions (29)-(33) are satisfied. Next we need to make sure that the 6 portfolio shares take on these values. It follows from (5) and (6), setting $\mu_{i,m} = \phi_{i,m} = c$, that

$$r_{i,c} = r_{\$,c} = r_i + \pi + \gamma_m vc \tag{37}$$

We set $\gamma_h = h\gamma$, so that we also have $\alpha_{i,c} = \omega_{d,c} = hc$. Finally, to make sure that the foreign portfolio shares $\alpha_{i,m} = N\omega_{i,m}$ are $1-h$, we set $\tilde{\pi}_d = \tilde{\pi}$ such that $\tilde{\pi} - \pi + (1/N)(1-h)c\gamma\tilde{v} = \gamma vhc$.

4.2 Asymmetric Equilibrium

We next derive three types of asymmetric equilibria, with heterogeneity across the small countries in household wealth, firm productivity and safe asset supply. Otherwise we keep parameters the same as in the symmetric equilibria. These three forms of heterogeneity take the form

$$W_i = W + \epsilon_{i,w} \tag{38}$$

$$A_i = A + \epsilon_{i,a} \tag{39}$$

$$d_{i,0} = d_0 + \epsilon_{i,d} \tag{40}$$

where $\sum_i \epsilon_{i,w} = 0$, $\sum_i \epsilon_{i,a} = 0$ and $\sum_i \epsilon_{i,d} = 0$. While these variables now vary across countries, their average level remains the same as in the symmetric equilibrium.

To obtain analytical results in Section 5, we simply take derivatives of the 3N + 2 market equilibrium conditions with respect to $\epsilon_{i,w}$, $\epsilon_{i,a}$ and $\epsilon_{i,d}$, evaluated at the symmetric equilibrium where they are zero. It may sound hard to solve 3N + 2 variables analytically, but ultimately we only need to solve 3 variables. Since nothing changes for the average of the small countries, averages of all variables remain unchanged. This also means that $r_\$$ and $r_{\$,c}$ do not change. We can then solve for r_i, $r_{i,c}$ and f_i from the linearized market equilibrium conditions for country i. Defining $\hat{r}_i$, $\hat{r}_{i,c}$ and $\hat{f}_i$ as the change relative to the symmetric equilibrium, we can solve these as a linear function of $\epsilon_{i,w}$, $\epsilon_{i,a}$ and $\epsilon_{i,d}$.

When discussing the solution, it will be more intuitive to focus on the safe rate r_i, the corporate spread $\delta_i = r_{i,c} - r_i$ and the CIP deviation $cip_i = r_i + f_i - r_\$$. Since the safe dollar rate will not be affected by the asymmetry, we have $\widehat{cip}_i = \hat{r}_i + \hat{f}_i$.

5 Analytical Results

This section studies how heterogeneity in wealth, productivity, and safe-asset supply affects the relationship between the safe interest rate and the CIP deviation. We provide intuition and discuss three Propositions that summarize the impact of these sources of heterogeneity. Full algebra for solving $\left[\hat{r}_i, \hat{\delta}_i, \widehat{cip}_i\right]$ and deriving the propositions is provided in the Online Appendix.

5.1 Key Parameters

The Propositions below refer to four key parameters. Linearizing (18), we have

$$\hat{K}_i = k_1 \epsilon_{i,a} - k_2 \hat{r}^{i,c} \tag{41}$$

where $k_1 = \bar{K}/[(1-\nu)A]$ and $k_2 = 1/[A\nu(1-\nu)\bar{K}^{\nu-2}]$. Our first key parameter is k_2, the sensitivity of the supply of corporate capital to the corporate yield. The second parameter is Γ_h, the sensitivity of demand for forward dollars by hedge funds to the forward rate. The third parameter is $\rho = d_1 + \Gamma_a$, the interest rate sensitivity of the net demand for safe assets associated with UIP arbitrageurs and safe asset suppliers. The final key parameter is the portfolio share c allocated to corporate bonds in the symmetric equilibrium of the model.

5.2 Household Wealth Asymmetry

Countries with high household saving have relatively high household wealth. The following results are based on taking marginal derivatives with respect to $\epsilon_{i,w}$ at the symmetric equilibrium.

Proposition 1 *A country with higher household wealth has a lower safe interest rate. The CIP deviation is higher, unless either (i) speculative forward demand is strong (Γ_h is large) or (ii) the corporate spread is much higher. The corporate spread is higher in a high wealth country when ρ is small or k_2 is large. Otherwise, the corporate spread is lower.*

As expected, a country with high saving, and therefore high wealth, has a low safe interest rate. The higher wealth implies a higher demand for the domestic safe asset, which lowers the interest rate.

Higher household wealth impacts the equilibrium corporate spread through both the demand and supply of corporate capital. On the demand side, higher wealth raises the demand for corporate capital, which lowers the equilibrium corporate spread.

The supply of capital depends on the corporate yield. The lower safe rate decreases the corporate yield for a given corporate spread. This raises the supply of capital, which raises the equilibrium corporate spread. This supply channel is stronger when the supply elasticity k_2 of capital is high. This happens when the capital share ν is high (more linear production function). The supply channel is also strengthened when the safe rate falls more, which happens when the interest rate elasticity ρ of safe asset demand is relatively low.

To understand what happens to the CIP deviation in a country with high wealth, it helps to consider equilibrium in the market for forward dollars, which is

$$\Gamma \widehat{cip}_i + \Gamma_h \hat{f}_i = \hat{X}_i^{hedge} \tag{42}$$

The left hand side of (42) is the demand for forward dollars associated with CIP arbitrageurs and hedge funds. The right hand side is the net supply of forward dollars associated with hedging. After linearizing $X_i^{hedge} = \alpha_{i,m} W_i - \omega_{i,m} W_d$, in the Online Appendix we derive

$$\hat{X}_i^{hedge} = -2 \frac{\mathrm{N}\tilde{W}}{\gamma \tilde{v} c^2} \widehat{cip}_i - \frac{\tilde{W}}{\gamma c} \left(\frac{\mathrm{N}}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \hat{\delta}_i + (1-h)\epsilon_{i,w} \tag{43}$$

A higher CIP deviation increases the demand for forward dollars by CIP arbitrageurs, while it lowers the supply of forward dollars by households (through mutual funds). Intuitively, a higher CIP deviation raises the cost of hedging for foreign households investing in US dollar assets. This reduces investment in the US and, therefore, the supply of forward dollars to hedge these positions.

To highlight the key mechanism through which wealth heterogeneity affects the CIP deviation, we first abstract from speculative forward demand ($\Gamma_h = 0$) and the impact of the corporate spread on X_i^{hedge}. The exogenous driver of X_i^{hedge} is then the term $(1-h)\epsilon_{i,w}$. With a portfolio share $1-h$ allocated to US dollar assets, higher wealth in country i implies a higher demand for dollar assets, which leads to a higher supply of forward dollars for hedging purposes. A higher CIP deviation is then needed to clear the market. This is consistent with the cross-country evidence on interest rates and CIP deviations. A country with relatively high wealth has both a relatively low safe interest rate and a relatively high CIP deviation. Wealth intermediates this link between the CIP deviation and interest rate, separately affecting the interest rate through the safe asset market equilibrium and the CIP deviation through the forward market equilibrium.

But there are two additional terms that drive the equilibrium CIP deviation, related to the corporate spread and speculative forward demand. Both can potentially turn the result around and generate a lower CIP deviation in a country with high wealth. First, consider the corporate spread. The term in brackets multiplying $\hat{\delta}_i$ in the expression for X_i^{hedge} can be shown to be positive, so that a lower corporate spread increases the CIP deviation. Intuitively, a lower corporate spread reduces US demand for corporate dollar bonds from country i, which reduces the need of the country's firms to hedge by buying dollars forward. The reduced demand for forward dollars further raises the equilibrium CIP deviation.

But as we have seen, it is also possible for the corporate spread to rise. This happens when the interest rate elasticity ρ is relatively low or the supply elasticity k_2 of corporate capital is relatively high. When the increase in the corporate spread is sufficiently large, it is possible for the CIP deviation to be lower in a high wealth country.

The theory is also inconsistent with the cross-country relationship between the CIP deviations and interest rates when speculative forward demand is large enough. We have seen that a country with high wealth has large investments in the US and therefore a large supply of forward dollars for hedging purposes. The resulting higher forward rate increases the profits from buying dollars forward by hedge funds. When Γ_h is large enough, a lower CIP deviation may then be required to clear the market. This is most intuitive when we consider the limit of Γ_h to infinity. This implies $\hat{f}_i = 0$. Otherwise, there would be infinite speculative forward positions. But in that case we have $\widehat{cip}_i = \hat{r}_i$, implying a counterfactual positive cross-country relationship between CIP deviations and interest rates.

5.3 Productivity Asymmetry

The following results are based on taking marginal derivatives with respect to $\epsilon_{i,a}$ at the symmetric equilibrium.

Proposition 2 *A country with lower productivity has a lower capital stock and lower corporate spread. It also has a lower safe interest rate and a higher CIP deviation in the absence of speculative forward demand ($\Gamma_h = 0$). When speculative demand is strong enough (Γ_h sufficiently large), the safe rate and CIP deviation are either both smaller (when c is large enough) or both higher (when c is low enough).*

Proposition 2 tells us that unless the speculative demand for forward dollars is very strong (Γ_h very high), productivity heterogeneity can also explain the cross-country evidence on CIP deviations and interest rates. A country with low productivity has a low safe interest rate and a high CIP deviation, while the opposite is the case for a country with high productivity.

Independent of parameters, a low productivity country always has a low corporate spread. This is intuitive. Lower productivity reduces the supply of corporate capital. A drop in the corporate spread is needed to clear the market. To understand the implications for the CIP deviation and interest rate, first consider the case without speculative demand for forward dollars ($\Gamma_h = 0$).

A lower corporate spread raises demand for the safe asset, which lowers the interest rate. The forward market equilibrium (42), together with the expression (43), tells us that a lower corporate spread leads to a higher CIP deviation. Intuitively, a lower corporate spread decreases demand for the small country corporate bond by the US. This leads to reduced demand for forward dollars by firms in the country to hedge their corporate dollar debt. The lower demand for forward dollars increases the CIP deviation.

It follows that a country with a relatively high CIP deviation has a relatively low interest rate. In this case, instead of wealth, it is productivity that intermediates the link between the CIP deviation and the interest rate. Productivity affects the corporate spread. This affect the interest rate through the safe asset market equilibrium and the CIP deviation through the forward market equilibrium.

These results are based on $\Gamma_h = 0$. When speculative forward demand is strong enough, these results can again be overturned. A low productivity country either has both a low safe rate and low CIP deviation or both a high safe rate and high CIP deviation. This is immediate when we take the limit where Γ_h. As before, we must then have $\hat{f}_i = 0$, so that $\widehat{cip}_i = \hat{r}_i$. Therefore, with strong speculative demand, countries with a relatively high CIP deviation also have a relatively high safe rate. This is clearly inconsistent with the cross-section evidence.

5.4 Safe Asset Supply Asymmetry

Now consider a safe asset supply asymmetry. The following results are based on taking marginal derivatives with respect to $\epsilon_{i,d}$ at the symmetric equilibrium.

Proposition 3 *A country with smaller safe asset supply has a lower safe interest rate, a lower CIP deviation, and a higher corporate spread.*

Proposition 3 shows that this case is inconsistent with the evidence. A low safe rate caused by a low asset supply implies a low CIP deviation. One might think that a low safe rate increases the demand for dollar assets by households/mutual funds from the small country, which would raise the CIP deviation when they hedge these dollar positions. But under complete hedging what matters is the difference in hedged returns, which depends on the CIP deviation itself, not the interest rate differential. We will return to this issue in Section 7 when we consider partial hedging.[14]

For a given corporate spread, the lower safe rate implies a lower corporate yield. This raises the supply of corporate capital, which raises the equilibrium corporate spread.

The lower CIP deviation in the country with a lower safe rate can be explained as follows. First, the higher corporate spread raises demand for corporate dollar bonds by the US. This raises demand by the country's firms for forward dollars, which lowers the equilibrium CIP

[14] UIP arbitrageurs respond to a difference in safe returns, but since they do not hedge they do not impact the equilibrium CIP deviation.

Table 1: Correlation Coefficients

	with CIP deviation	with Libor interest rate
Libor rate	−0.95**	
NFA/GDP	0.73**	−0.88**
S_{priv}/GDP	0.86**	−0.78**
W_{priv}/GDP	0.82**	−0.78**
Productivity	−0.11	−0.05
Public Debt	0.64*	−0.56

Notes: Correlations of the 2007-2020 averages across the 8 countries in Figure 1. Variables are described in the text. ** (*) means significant at the 5% (10%) level.

deviation. Second, for a given CIP deviation the lower safe rate implies a higher forward rate. This increases demand for forward dollars associated with speculative forward positions, further lowering the equilibrium CIP deviation.

5.5 Evaluating Asymmetries

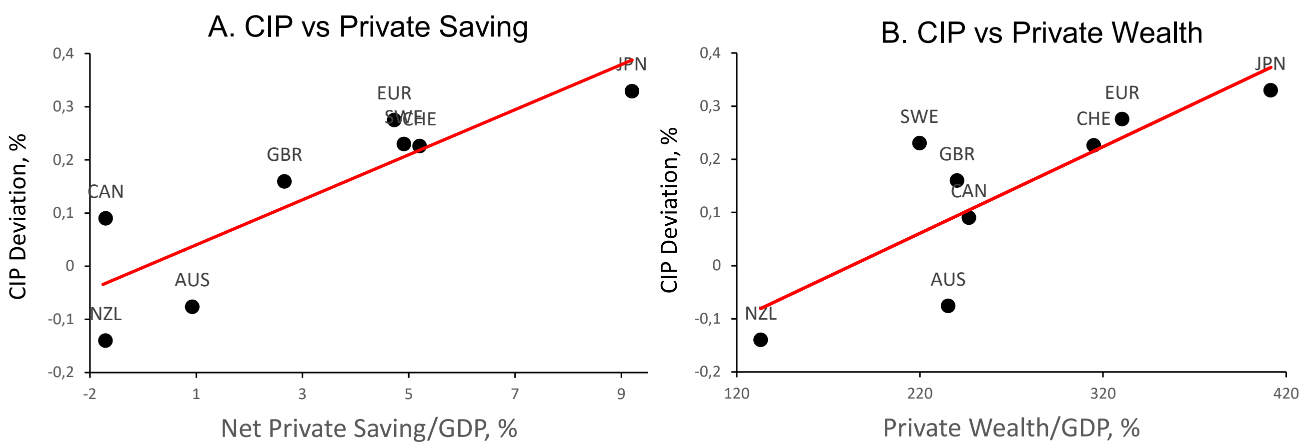
The previous subsections showed that cross-country differences in productivity or household saving or wealth can potentially explain CIP deviations and interest rate levels, while differences in safe asset supplies cannot. To verify whether these are empirically plausible explanations, in Table 1 we examine the relationship between these variables and CIP deviations and interest rate levels.

The first two correlations with CIP deviations correspond to the evidence shown in Figure 1. The other four lines correspond to the asymmetry variables. We first consider private saving, which is the sum of household and corporate net saving from the OECD database. For private wealth W, we use $W_{priv} = K_{priv} + NFW_{priv}$, as a fraction of GDP. Here K_{priv} is non-financial assets from the OECD Annual balance sheet and NFW_{priv} is net financial worth from the OECD Annual financial balance sheets.[15]

[15] For non-financial assets we use the average over 2007-2017 for New Zealand as there is no data for 2018-2020. For Switzerland, we use the net non financial capital stock computed by the Swiss Federal Statistical Office. GDP is from the OECD.

Both private saving and private wealth are strongly positively correlated with the CIP deviation and negatively with the interest rate level. It is consistent with Proposition 1 when there is limited speculation and parameters are such that the corporate spread is not too positively related to wealth. Figure 2, showing private saving and wealth as percent of GDP, confirms these strong relationships.

Figure 2: CIP Deviations vs Private Saving and Wealth



We measure productivity as TFP relative to that in the US, using data from the World Penn Table for 2007-2019. There is basically no relationship between productivity and CIP deviations or interest rates. While productivity heterogeneity implies a negative relationship between CIP deviations and interest rates in the theory when speculation is limited (Proposition 2), Table 1 implies that productivity is not the most important driver of this relationship.[16]

For the supply of safe assets, we consider the total supply of public debt minus central bank holdings, using data constructed by Fang, Hardy, and Lewis (2025). With the exception of some European countries, public debt in our sample countries can be considered as safe (dropping the Eurozone from the sample does not change the results). We see a positive relationship with the CIP deviation, but the negative relationship with interest rate levels is

[16] Other measures of productivity give a similar outcome. To explain the data, we would need much higher productivity in Australia and New Zealand compared to Switzerland or the Eurozone, which is counterfactual.

inconsistent with Proposition 3. It suggests that differences in safe rates are more associated with the asset demand side, related to wealth, than the asset supply side.

We conclude that only asymmetry in private saving or wealth can explain the empirical evidence on cross-country CIP deviations and interest rates. We further explore this source of asymmetry in the next section and show that a calibrated version of the model is quantitatively consistent with the empirical evidence.

6 Numerical Illustration with Wealth Heterogeneity

In this section, we calibrate the model with wealth heterogeneity using data for the 8 countries in Figures 1 and 2. The goal is to account for the observed cross-country relationship between the CIP deviation and the following four variables: interest rate, net foreign asset position, wealth and hedging volume of dollar exposure by foreign countries (Du and Huber, 2024).

There are three differences relative to the analytical solution discussed in Section 5. First, we now consider large cross-country heterogeneity. Second, we do not linearize the model, solving the $3\mathrm{N}+2$ variables numerically. Finally, we allow the size of the US to differ from the total size of the small countries. Specifically, we no longer set W_d and $d_{\$,0}$ equal to the the sum of W_i and $d_{i,0}$ across small countries. This is done to target a reasonable average CIP deviation. Lower US wealth implies lower demand for small country assets, which reduces demand for forward dollars, raising the forward rate and CIP deviation.

6.1 Calibration

Table 2 lists the parameters. Some parameters can be observed directly in the data. Consistent with Figure 1, we set the number of foreign countries equal to $\mathrm{N} = 8$.[17] We introduce wealth heterogeneity $W_i = W + \epsilon_{i,w}$ with $\epsilon_{i,w} = W\epsilon(\mathrm{N}+1-2i)/(\mathrm{N}-1)$ for $i = 1,..,\mathrm{N}$. This means that wealth varies from $W(1+\epsilon)$ for country $i = 1$ to $W(1-\epsilon)$ for country $i = \mathrm{N}$. We set ϵ to match the ratio of the highest to the lowest wealth of 3.1 across the 8 countries in Figure 2. This implies $\epsilon = 0.51$. We normalize the average wealth as $W = 1$.

[17] For the Eurozone, we take GDP weighted averages of 11 countries (Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain).

We set the standard deviation of the exchange rate equal to $\sigma = 0.1087$, which is the average annualized standard deviation of the 8 currencies relative to the dollar over the 2007-2020 period, using monthly data from Haver Analytics. We compute an average labor share of 0.6 using Penn World Table data for 2007-2019. We therefore set $\nu = 0.4$.[18]

Table 2: Calibrated Parameters

Parameter	Baseline	Partial Hedging	Description
N	8	8	number of countries
ϵ	0.51	0.51	measure of cross-country wealth dispersion
W	1	1	average wealth of the N countries
σ	0.1087	0.1087	standard deviation exchange rate
ν	0.4	0.4	capital share output
d_0	0.5912	0.5252	constant term safe asset supply small countries
$d_{\$,0}$	3.0630	1.5445	constant term safe asset supply US
ρ	30.92	21.60	interest rate sensitivity safe asset supply
A_i	1.9402	1.7710	productivity of the N countries
A_d	6.5380	5.5752	productivity US
π	0.00244	0.00244	probability of default domestic firms
$\tilde{\pi}_d$	0.01647	0.003028	prob. default US firms–small country perspective
$\tilde{\pi}$	0.01898	0.01262	prob. default small country firms–US perspective
γ	26.28	26.28	risk-aversion households
γ_m	17.082	17.082	risk-aversion mutual funds
W_d	6.0715	3.2311	US wealth
Γ	46.752	97.839	arbitrage capacity CIP arbitrageurs
Γ_h	0	0	arbitrage capacity hedge funds

The remaining parameters are set to target various moments in the data. Below we list how parameters are set based on specific moments, although in reality the parameters are set jointly to target all the moments.

[18] The labor share of 0.6 is the average for the 8 countries, but remains the same if we include the US.

We set the intercept d_0 of the supply of safe assets of the N countries such that the average of the safe rates r_i equals the average of the 3-month Libor rates of the 8 countries in Figure 1, which is 0.0146. We set the intercept $d_{\$,0}$ of the supply of safe assets in the US to generate the same safe rate of dollar assets, $r_\$$, of 0.0146 (the actual average dollar Libor dollar rate is 0.0130 over the 2007-2020 period). We set ρ such that the highest minus the lowest safe rate r_i across countries matches the highest minus lowest 3-month Libor rate in Figure 1, which is 0.0314.[19]

We set productivity $A_i = A$ for $i = 1, .., \mathrm{N}$ such that the average share invested in risky assets (corporate bonds) by the N countries is 0.7. The average share invested in safe assets is then 0.3, which is reported by Castells-Jauregui, Kuvshinov, Richter, and Vanasco (2025) for 16 advanced countries from 1987 to 2018. We set productivity A_d for the US such that the US corporate yield $r_{\$,c}$ is the same as the average of the corporate yields $r_{i,c}$ for the N countries.

We set $\pi = 0.00244$ to match a standard deviation of 0.0493 of corporate bond returns in the data, using Bekaert and De Santis (2021).[20] In the model the standard deviation is $\sqrt{\pi(1-\pi)}$. We set $\tilde{\pi}_d = 0.01647$ and $\tilde{\pi} = 0.01898$ such that the average share invested abroad by the N countries, as well as the share invested abroad by the US, is $1 - h = 0.35$. Appendix D discusses this estimate.

Bekaert and De Santis (2021) report a currency-weighted mean of excess returns on corporate bonds of 0.0315. We set the rate of risk aversion γ such that the average of the corporate spreads $r_{i,c} - r_i$ across the N countries in the model matches the 0.0315 in the data. Given the parameterization discussed above, the corporate spread will be the same in the US as well. We set $\gamma_m = h\gamma$, such that the share invested in corporate bonds is the same for domestic and foreign assets.

[19] Without loss of generality, we set $d_1 = \Gamma_a = 0.5\rho$.

[20] Bekaert and De Santis (2021) report data on corporate bond returns from January 1998 to August 2018 from the perspective of a US investor. We use their results for hedged returns to avoid mixing in exchange rate volatility. They report results for the difference between the hedged return for a US investor and the T-bill rate, which can be written as the excess return $r_{i,c} - r_i$ plus the CIP deviation. In practice virtually all the volatility comes from the excess return or the corporate yield. They report annualized standard deviations of the return on corporate bonds denominated in US dollars, euros, yen, British pounds, Canadian dollars and Australian dollars. We use the BBB corporate bond numbers and take a weighted average of the standard deviations based on the reported market shares for the different currencies. This gives a standard deviation of 0.0493.

We set W_d to target an average CIP deviation of 14 basis points. We set the arbitrage capacity Γ of CIP arbitrageurs such that the difference between the highest and lowest CIP deviation corresponds to the 46 basis points for the 8 countries in the data. For now we set the arbitrage capacity Γ_h of hedge funds equal to zero. We will argue below that this fits well with the evidence reported by Hacioğlu-Hoke et al. (2024).

6.2 Baseline Results

Figure 3 shows the implications of the calibrated model for the relationship between the CIP deviation in countries 1 to N (vertical axis) and, respectively, the interest rate (chart A), the net foreign asset position (chart B), wealth (chart C) and hedging of US dollar assets held by households in the small countries through mutual funds (chart D).

These charts show that countries with a higher CIP deviation have a lower interest rate, a larger net foreign asset position, higher wealth and a larger hedging volume of exposure to dollar assets in the US. Charts A to C are similar to the corresponding data charts in Figures 1 and 2.[21] Chart D is qualitatively similar to Figure 8 in Du and Huber (2024).

We have already discussed why countries with higher wealth have a higher CIP deviation and lower interest rate. The relationship with the net foreign asset position follows from the discussion in Section 3.9. When $\Gamma_h = 0$, the net foreign asset position is equal to

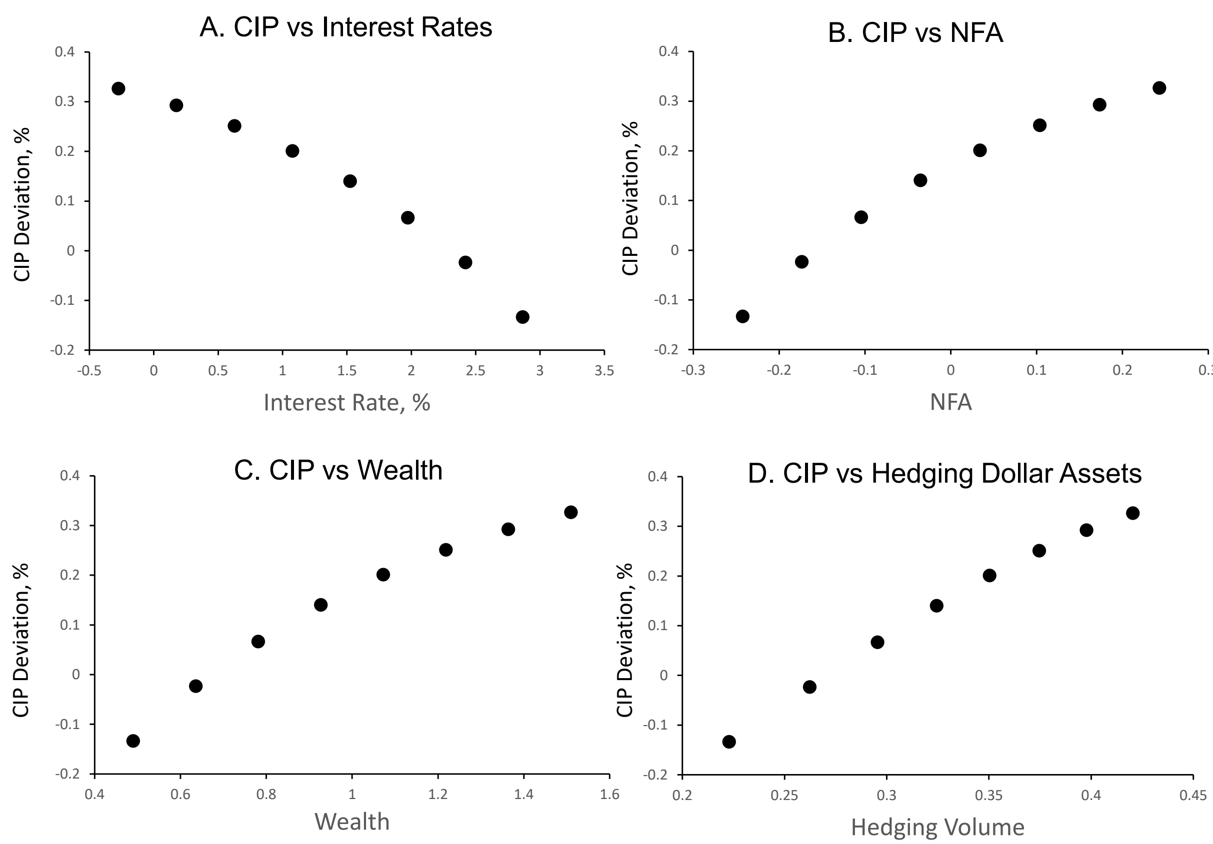
$$NFA_i = -B_i^{UIP} = -\Gamma_a(r_i - r_\$) \tag{44}$$

Recall from Section 3.9 that the net foreign asset position associated with households is offset by CIP arbitrageurs under perfect hedging. The low interest rate in a high wealth country leads to net capital outflows by UIP arbitrageurs that implies a positive NFA. We revisit this below with partial hedging, where household external assets also affect the NFA.

The hedging volume in chart D corresponds to US dollar assets of country i held through mutual funds, which are fully hedged. It is equal to $\alpha_{i,m}W_i$. This is comparable to Du and Huber (2024), who define the hedging volume as the dollar hedging by foreign insurance companies, pension funds and mutual funds. Intuitively, a country with higher wealth will

[21] The interest rate chart is virtually identical to the one in Figure 1. NFA and wealth in the data are shown as a fraction of GDP. We do not do this in the model because the output-capital ratio is much too large in a two-period model due to the full depreciation of the capital stock in one period.

Figure 3: Baseline Model with Wealth Heterogeneity

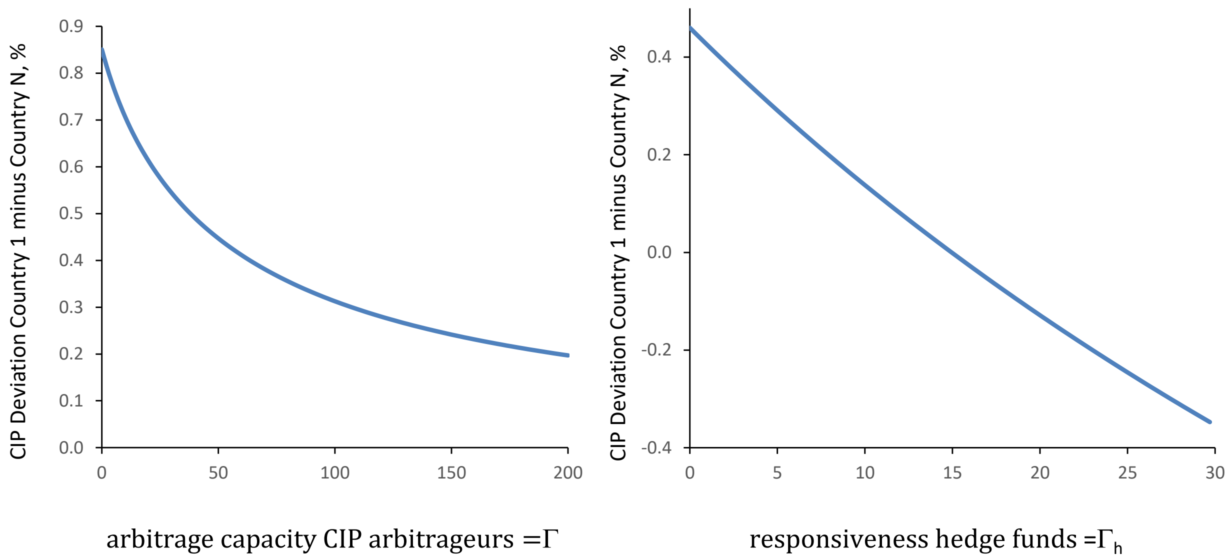


have higher investment in the US, which is perfectly hedged. It is exactly the larger hedging of dollar assets by such a country that leads to a larger supply of forward dollars that gives rise to a higher CIP deviation.

6.3 CIP Arbitrageurs and Hedge Funds

So far we have set $\Gamma = 46.75$ and $\Gamma_h = 0$. In Figure 4 we vary the arbitrage capacity Γ of CIP arbitrageurs from 0 to 200. We also vary the responsiveness Γ_h of hedge funds to expected profits from buying dollars forward from 0 to 30. In both cases, we keep the parameters otherwise the same as in Table 2, except that we vary d_0, $d_{\$,0}$ and ρ, such that the average interest rate and difference between the highest and lowest interest rate remains the same as in Figure 1.

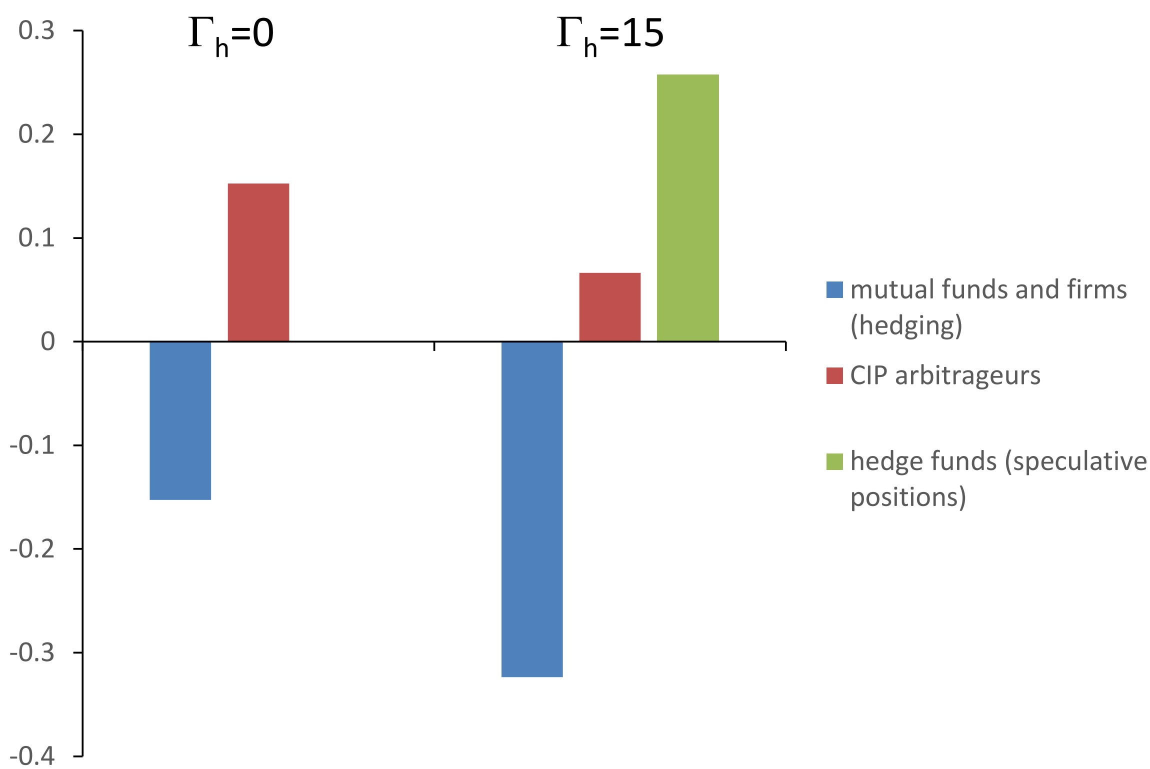
Figure 4: CIP Deviations vs Libor Interest Rates and Net Foreign Assets



As we vary Γ and Γ_h, we report the difference between the CIP deviation in country 1 (highest wealth) and country N (lowest wealth). In our baseline case, this difference was 0.46 percentage points based on the countries in Figure 1. Not surprising, as we increase the arbitrage capacity Γ of CIP arbitrageurs, they are better able to absorb excess demand or supply of forward dollars and equilibrium CIP deviations are smaller. The difference between the CIP deviations in countries 1 and N then shrinks. This tells us that limited CIP arbitrage is a key ingredient in the model. At the same time, as we further lower the CIP arbitrage capacity we see that the difference in CIP deviations becomes even larger.

As we increase Γ_h, the difference between the CIP deviation of the highest and lowest wealth countries not only shrinks, but eventually even changes sign as we raise Γ_h sufficiently. This illustrates Proposition 1. In order to account for the evidence in the data, Γ_h should be zero or very small. To make the case that this is a plausible assumption, in Figure 5 we report the net forward market positions of CIP arbitrageurs, hedgers (mutual funds, firms) and speculators (hedge funds) for the high wealth country 1, both for the baseline case of $\Gamma_h = 0$ and for $\Gamma_h = 15$.[22] A positive value represents a net demand of forward dollars, while a negative value represents a net supply of forward dollars.

Figure 5: Forward Market Positions High Wealth Country



*This is the net demand for forward dollars (negative numbers are a net supply of forward dollars).

Figure 5 shows that when $\Gamma_h = 0$, CIP arbitrageurs take the opposite position of hedgers.

[22]The net forward market position is positive when buying dollars forward and negative when selling dollars forward. The position associated with hedging is the net of the positions associated with external liabilities and assets, $\omega_{i,m} W_d - \alpha_{i,m} W_i$. This differs from the hedging volume in Figure 3D, which only captures hedging of external dollar assets, so $\alpha_{i,m} W_i$. We report that hedging volume only for comparability to Du and Huber (2024).

By contrast, when $\Gamma_h = 15$, it is mostly hedge funds that take the other side of the hedgers. This is the result of aggressively buying dollars forward when the forward rate rises. At the same time, this reduces the equilibrium forward rate and CIP deviation and therefore shrinks the position of CIP arbitrageurs and their demand for forward dollars.[23]

The evidence reported by Hacioğlu-Hoke et al. (2024) is consistent with the case of $\Gamma_h = 0$. They show that dealer banks take the opposite position of hedgers (asset managers, insurers, pensions funds and investment funds). They find that hedge funds have positions that are on average zero. Hedge fund positions are positive or negative for short periods of time to exploit short term profit opportunities. Since our focus is on cross-sectional evidence, which is related to persistent positions in the forward market, hedge funds are best modeled as being inactive. Their positions may matter more in a model focused on the time series response to shocks.

7 Partial Hedging

While full exchange rate hedging is a useful benchmark, the evidence points to partial hedging. To see the impact of limited hedging, we now assume that mutual funds and firms have a hedge ratio of θ. As shown in the Online Appendix, this can be formalized by introducing a quadratic cost associated with using the forward market. Mutual funds still decide how to allocate between risk-free foreign assets and corporate bonds. But since their hedging is limited, households take into account exchange rate risk associated with investment abroad through mutual funds. The new portfolios of mutual funds and households are discussed in Appendix C. The forward market equilibrium condition now becomes

$$B_i^{CIP} + \theta\omega_{i,m}W_d - \theta\alpha_{i,m}W_i + H_i = 0 \quad i = 1, .., \mathrm{N} \tag{45}$$

We illustrate the results for a hedge ratio of $\theta = 0.6$. For the other parameters, we follow the same calibration approach as discussed in Section 6.1 for the baseline case with complete hedging. The parameters are shown in Table 2.

One key difference is related to the fractions invested abroad. As shown in Appendix C,

[23] The fact that hedgers have a much larger position when $\Gamma_h = 10$ is a result of the lower cost of hedging dollar positions due to the lower CIP deviation.

the fraction that households from country i invest in the US depends on

$$-\theta cip_i - (1-\theta)(r_i - r_\$)$$

As a result of partial hedging, this gives less weight to the CIP deviation and more weight to the interest differential. Households now care about both the hedged return differential cip_i and the unhedged return differential $r_i - r_\$$.

Consider the high wealth country 1. Its positive CIP deviation implies a higher hedged return of investing in country 1 relative to the US. Reducing the hedge ratio θ reduces the weight attached to this return advantage, which leads to a larger fraction invested in the US. Less weight is given to the CIP deviation as hedging is incomplete. In addition, more weight is given to the interest differential. Country 1 has a relatively low interest rate, leading to larger investment in the US. The same argument implies that as a result of partial hedging the low wealth country N invests a smaller fraction in the US.

These portfolio changes have implications for the calibrated parameters shown in Table 2, which we discuss in Appendix C. Here we focus on the main implications. Figure 6 reports the relevant charts, which can be compared to Figure 3 for the baseline case. The main results are very similar to the baseline case.

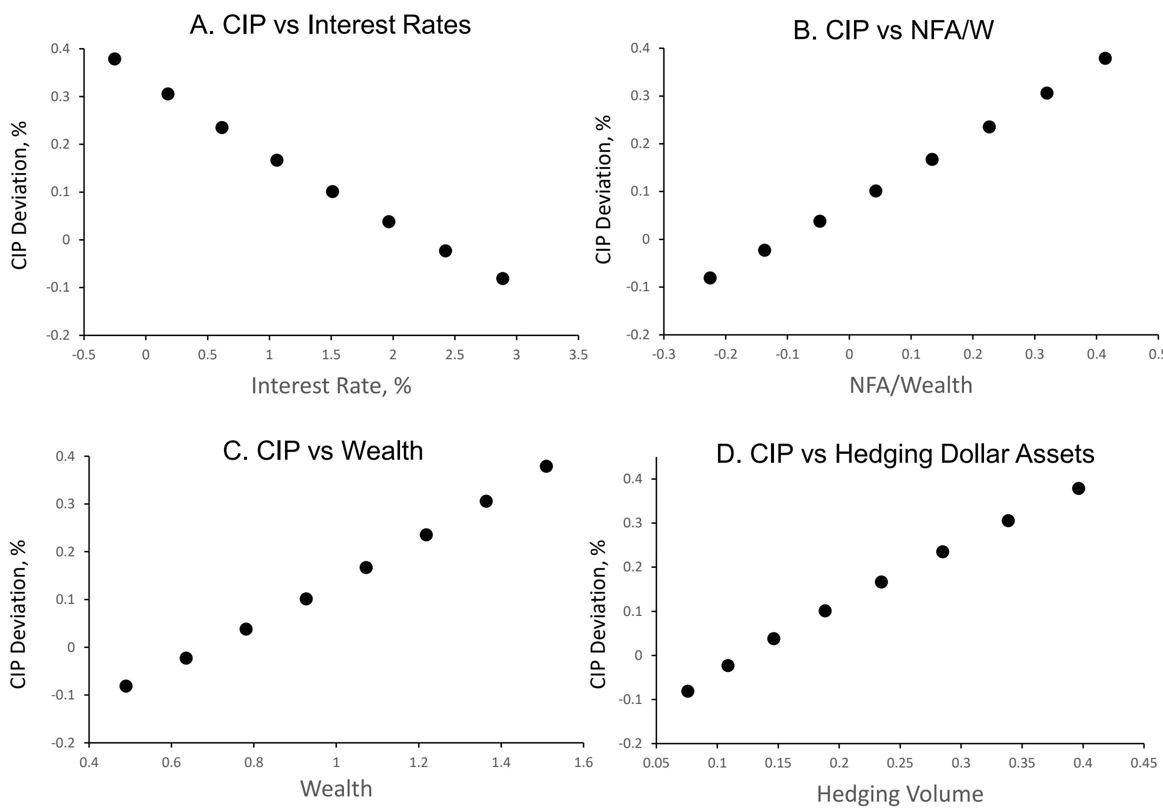
Panels A and C, which show the CIP deviation versus respectively the interest rate and wealth, are virtually identical to the baseline case. However, the forward market equilibrium that drives the relationship between the CIP deviation and interest rate has changed a bit. We saw in (42)-(43) that when linearizing around the symmetric equilibrium, and assuming $\Gamma_h = 0$, the forward market equilibrium took the form $a_1\widehat{cip}_i + a_2\hat{\delta}_i - (1-h)\epsilon_{i,w} = 0$, with all $a_i > 0$. Under partial hedging this is generalized to

$$a_1\widehat{cip}_i + a_2\hat{\delta}_i + a_3\hat{r}_i - (1-h)\epsilon_{i,w} = 0$$

with $a_3 > 0$ as well.

Since hedging is partial, portfolio allocation does not just depend on the CIP deviation and corporate spread, but also on interest rates. The high wealth country 1 has a relatively low interest rate. Under partial hedging this makes it more attractive for country 1 to invest in the US and less attractive for the US to invest in country 1. Since a fraction θ of these

Figure 6: Partial Hedging with Wealth Heterogeneity



cross-border investments are hedged, this raises the net supply of forward dollars, which increases the CIP deviation.

This is an additional channel that contributes to a negative relationship between the interest rate and CIP deviation. This carry-trade channel has been suggested in the literature, e.g., Du et al. (2018), Du and Schreger (2022), and Dao et al. (2025). It plays no role in the baseline model with perfect hedging. There the relationship between the CIP deviation and interest rate is mainly the result of wealth separately impacting demand for forward dollars (and therefore the CIP deviation) and demand for safe assets (and therefore the safe interest rate). Under partial hedging this remains the case, but the lower interest rate in a high wealth country feeds back to demand for forward dollars by affecting cross-border positions. While this additional channel does not cause the negative relationship between the CIP deviation and interest rate, it can amplify it.The difference in the CIP deviation between the highest and lowest wealth countries in Figure 6 remains the same as in Figure 3 only because the calibration now leads to a higher arbitrage capacity of CIP arbitrageurs.

Notice that the carry-trade channel may also change the impact of heterogeneity of safe asset supply studied in Section 5.4. A country with a low interest rate due to a low safe asset supply can have a high CIP deviation as the low interest rate leads to more investment in the US that is partially hedged. However, as discussed in Section 5.5, the empirical evidence shows a negative relationship between the safe asset supply and interest rate.

Panel B of Figure 6 shows the CIP deviation versus the net foreign asset position. It is again similar to the baseline case. The net foreign asset position now varies a bit more across countries than before. Under partial hedging the net foreign asset position is

$$NFA_i = \alpha_{i,m} W_i - \omega_{i,m} W_d - B_i^{UIP} - B_i^{CIP} = -B_i^{UIP} + (1-\theta)\left(\alpha_{i,m} W_i - \omega_{i,m} W_d\right) \quad (46)$$

The second equality substitutes the forward market equilibrium condition (45) with $H_i = 0$. In contrast to the case of perfect hedging ($\theta = 1$), the net foreign asset position is now also higher the higher investment by country i households in the US minus US households in country i. Country 1 household investment in the US is high both as a result of high wealth and the higher interest rate in the US than in country 1.

Panel D, which shows the CIP deviation against the hedging volume of investment in the US by individual countries, is similar as well. But the hedging volume now varies more across countries. This may seem counterintuitive as the hedge ratio is lower. But it is again the result of the high wealth country 1 investing a larger share in the US and the low wealth country N investing a smaller share in the US as a result of interest differentials. Since investment in the US now varies more across countries, the hedging volume also varies more across countries, notwithstanding the lower hedge ratio.

8 Conclusion

We set out to develop a model to account for the cross-country relationship between CIP deviations and both the interest rate and net foreign asset position. We found that to be even able to address this question requires making various assumptions about the available assets and the access to these assets by various agents. We derived a set of analytical results which show that the cross-country relationship between CIP deviations and interest rates is complex, depending on a variety of model assumptions and the nature of the heterogeneity.

We found that the data are most supportive of an explanation associated with cross-country wealth heterogeneity. High wealth countries tend to have a high CIP deviation and low interest rate. Other explanations, associated with cross-country heterogeneity in productivity and safe asset supply, are not consistent with the data.

After a calibration of the model, we show that the model is indeed consistent with an explanation of the stylized facts based on cross country wealth heterogeneity. The model can account for the cross-country relationship between the CIP deviation on the one hand and the interest rate, net foreign asset position and wealth on the other hand. It can also account for the relationship between hedging volume of US dollar assets and the CIP deviation. Moreover, the model is guided by evidence related to the major players in the FX derivatives market and their motives.

Future work can consider several directions. One direction is to consider a dynamic model that considers both cross sectional and time series features of the data. CIP deviations are driven by both persistent dollar shortages that we have investigated here and more temporary dollar funding shocks that operate in the time series domain. Another direction is to consider evidence for a broader set of countries, specifically developing countries.

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Appendix

A Expectation and variance of log-linearized portfolio returns

We derive the expectation and variance of log-linearized portfolio returns that give rise to the optimal portfolios of mutual funds and households in Section 3.2 and 3.3. Starting with the mutual fund used by country i households to invest in the US, the return in terms of the country i currency is

$$R_{m,i} = (1-\mu_{i,m})R_{\$}\frac{1}{S_i} + \mu_{i,m}\tilde{R}_{\$,c}\frac{1}{S_i} + \left(\frac{1}{F_i} - \frac{1}{S_i}\right) \tag{A.1}$$

Here $\mu_{i,m}$ is the fraction invested in US corporate bonds, with the remainder invested in the safe dollar asset. The return on the corporate bond is $\tilde{R}_{\$,c}$, which is the yield $R_{\$,c}$ with probability $1-\pi$ and 0 with probability π (from the perspective of the mutual fund). To hedge the exchange rate risk, the fund sells dollars forward, captured by the last term.

Log-linearizing around $R_{\$} = \tilde{R}_{\$,c} = S_i = F_i = 1$, we have

$$R_{m,i} = 1 + (1-\mu_{i,m})r_{\$} + \mu_{i,m}\left(\tilde{R}_{\$,c} - 1\right) - f_i \tag{A.2}$$

where $\tilde{R}_{\$,c} - 1 = R_{\$,c} - 1$ with probability $1-\pi$, which is log-linearized as $r_{\$,c}$. $\tilde{R}_{\$,c} - 1$ is -1 with probability π. The expectation of $\tilde{R}_{\$,c} - 1$ is then $(1-\pi)r_{\$,c} - \pi$. Since $\pi r_{\$,c}$ is a second-order term, we approximate this as $r_{\$,c} - \pi$. The variance of $\tilde{R}_{\$,c} - 1$ is $(1-\pi)r_{\$,c}^2 + \pi - (r_{\$,c} - \pi)^2$. Again, omitting second-order terms in the form of quadratic returns and the product of returns and π, this is equal to $v = \pi(1-\pi)$. The expressions for $E(R_{i,m})$ and $var(R_{i,m})$ in the text follow immediately.

Next consider the mutual fund that the US uses to invest in country i. The return in dollars is

$$R_{m,d,i} = (1-\phi_{i,m})R_i S_i + \phi_{i,m}\tilde{R}_{\$,i,c} + (1-\phi_{i,m})\left(1 - \frac{S_i}{F_i}\right) \tag{A.3}$$

Here $\phi_{i,m}$ is the fraction invested in the country i corporate dollar bond, with the remainder invested in the country i safe asset. The return on the corporate bond is $\tilde{R}_{\$,i,c}$, which is $R_{\$,i,c}$ with probability $1-\pi$ and 0 with probability π. To hedge the exchange rate risk associated with investment in the safe country i asset, the fund buys $1-\phi_{i,m}$ dollars forward, reflected in the last term.

Log-linearizing around $R_i = \tilde{R}_{\$,i,c} = S_i = F_i = 1$, we have

$$R_{m,d,i} = 1 + (1-\phi_{i,m})(r_i + f_i) + \phi_{i,m}\left(\tilde{R}_{\$,i,c} - 1\right) \tag{A.4}$$

where $\tilde{R}_{\$,i,c} - 1 = R_{\$,i,c} - 1$ with probability $1-\pi$, which is log-linearized as $r_{\$,i,c}$. $\tilde{R}_{\$,i,c} - 1$ is -1 with probability π. The expectation of $\tilde{R}_{\$,i,c} - 1$ is then $(1-\pi)r_{\$,i,c} - \pi$. Since $\pi r_{\$,i,c}$ is a second-order term, we approximate this as $r_{\$,i,c} - \pi$. The variance of $\tilde{R}_{\$,i,c} - 1$ is $(1-\pi)r^2_{\$,i,c} + \pi - (r_{\$,i,c} - \pi)^2$. Again omitting second-order terms as before, this is equal to $v = \pi(1-\pi)$. The expressions for $E(R_{i,m,d})$ and $var(R_{i,m,d})$ in the text follow immediately.

Next consider country i households. Their portfolio return is

$$R_{p,i} = \alpha_{i,c}\tilde{R}_{i,c} + \alpha_{i,m}R_{m,i} + (1-\alpha_{i,c}-\alpha_{i,m})R_i \tag{A.5}$$

where $\alpha_{i,c}$ is the fraction invested in the domestic corporate bond and $\tilde{R}_{i,c}$ is the return of the country i corporate bond in the country i currency. It is equal to $R_{i,c}$ with probability π and 0 with probability $1-\pi$. Log-linearizing around $R_i = 1$, we have

$$R_{p,i} = 1 + \alpha_{i,c}\left(\tilde{R}_{i,c} - 1\right) + \alpha_{i,m}\left(R_{m,i} - 1\right) + (1-\alpha_{i,c}-\alpha_{i,m})r_i \tag{A.6}$$

Since we assume that returns on corporate bonds are uncorrelated across countries, we have

$$ER_{p,i} = 1 + \alpha_{i,c}E\left(\tilde{R}_{i,c} - 1\right) + \alpha_{i,m}E\left(R_{m,i} - 1\right) + (1-\alpha_{i,c}-\alpha_{i,m})r_i \tag{A.7}$$

$$var(R_{p,i}) = \alpha^2_{i,c}var\left(\tilde{R}_{i,c} - 1\right) + \alpha^2_{i,m}var(R_{m,i} - 1) \tag{A.8}$$

Following the same approach as above, we have $E\left(\tilde{R}_{i,c} - 1\right) = r_{i,c} - \pi$ and $var\left(\tilde{R}_{i,c} - 1\right) = v$. In the expressions for $E\left(R_{m,i} - 1\right)$ and $var(R_{m,i} - 1)$ in the text we need to replace π and v with $\tilde{\pi}_d$ and $\tilde{v}_d/\text{N}$, where $\tilde{v}_d = \tilde{\pi}_d(1-\tilde{\pi}_d)$. This gives the expressions for $ER_{p,i}$ and

$var(R_{p,i})$ in the text. Note that from the perspective of country i we could write $\tilde{R}_{\$,c}$ as the average of the return in N regions of the US that have the same probability of default, but uncorrelated default outcomes. This gives rise to a variance of $\tilde{R}_{\$,c}$ of $\tilde{v}_d/\text{N}$.

Finally, the portfolio return of US households is

$$R_{p,US} = \omega_{d,c}\tilde{R}_{\$,c} + \sum_{i=1}^{\text{N}} \omega_{i,m} R_{m,d,i} + \left(1 - \omega_{d,c} - \sum_{i=1}^{\text{N}} \omega_{i,m}\right) R_{\$} \tag{A.9}$$

where $\omega_{d,c}$ is the fraction invested in the domestic corporate dollar bond and $\tilde{R}_{\$,c}$ is the return on the domestic corporate dollar bond. Linearizing around $R_{\$} = 1$, we can write this as

$$R_{p,US} = 1 + \omega_{d,c}\left(\tilde{R}_{\$,c} - 1\right) + \sum_{i=1}^{\text{N}} \omega_{i,m}\left(R_{m,d,i} - 1\right) + \left(1 - \omega_{d,c} - \sum_{i=1}^{\text{N}} \omega_{i,m}\right) r_{\$} \tag{A.10}$$

Again using that corporate bond returns are uncorrelated across countries, we have

$$ER_{p,US} = 1 + \omega_{d,c}E\left(\tilde{R}_{\$,c} - 1\right) + \sum_{i=1}^{\text{N}} \omega_{i,m}E\left(R_{m,d,i} - 1\right) + \left(1 - \omega_{d,c} - \sum_{i=1}^{\text{N}} \omega_{i,m}\right) r_{\$} \tag{A.11}$$

$$var(R_{p,US}) = \omega_{d,c}^2 var\left(\tilde{R}_{\$,c} - 1\right) + \sum_{i=1}^{\text{N}} \omega_{i,m}^2 var(R_{m,d,i} - 1) \tag{A.12}$$

We have $E\left(\tilde{R}_{\$,c} - 1\right) = r_{\$,c} - \pi$ and $var\left(\tilde{R}_{\$,c} - 1\right) = v$. Substituting the expressions for $E\left(R_{m,d,i} - 1\right)$ and $var(R_{m,d,i} - 1)$ in the text, replacing π and v with $\tilde{\pi}$ and $\tilde{v}$, we obtain the expressions for $ER_{p,US}$ and $var(R_{p,US})$ in the text.

B Safe Asset Supply

Assume the following utility of safe asset suppliers in country i:

$$\frac{C_{i,1}^{1-\chi}}{1-\chi} + aC_{i,2} \tag{B.13}$$

Let D_i be period 1 debt, R_i the gross interest rate and Y a period 2 endowment. Assume that there is no period 1 endowment and debt. Then

$$C_{i,1} = D_i \tag{B.14}$$

$$C_{i,2} = Y - R_i D_i \tag{B.15}$$

The first-order condition implies

$$D_i = (aR_i)^{-1/\chi} \tag{B.16}$$

We can linearize this as

$$D_i = d_0 - d_1 r_i \tag{B.17}$$

with $d_0 = a^{-1/\chi}$ and $d_1 = a^{-1/\chi}/\chi$. There are always values of a and χ corresponding to any values of d_0 and d_1: $\chi = d_0/d_1$, $a = d_0^{-d_0/d_1}$. Also note that while Y does not enter the solution, it needs to be big enough to make sure that $C_{i,2} > 0$.

C Partial Hedging

Here we derive the portfolios of mutual funds and households, as well as first-order conditions for firms, under an assumed hedge ratio of θ.

C.1 Mutual Funds

With a hedge ratio of θ, (A.1) becomes

$$R_{m,i} = (1 - \mu_{i,m}) R_{\$} \frac{1}{S_i} + \mu_{i,m} \tilde{R}_{\$,c} \frac{1}{S_i} + \theta \left(\frac{1}{F_i} - \frac{1}{S_i} \right) \tag{C.18}$$

Following the procedure in Appendix A, we have

$$ER_{m,i} = 1 + (1 - \mu_{i,m}) r_{\$} + \mu_{i,m} \left(r_{\$,c} - \pi \right) - \theta f_i \tag{C.19}$$

$$var(R_{m,i}) = (1 - \theta)^2 \sigma^2 + \mu_{i,m}^2 v \tag{C.20}$$

With the same mean-variance objective $E(R_{m,i}) - 0.5\gamma_m var(R_{m,i})$ as before, the optimal portfolio share μ_{im} remains as in (5).

The mutual fund used by US households to invest in country i allocates a share $1 - \phi_{i,m}$ to the safe country i asset and a share $\phi_{i,m}$ to the country i corporate dollar bond. Assume again a hedge ratio of θ. This implies a demand for forward dollars of $\theta(1 - \phi_{i,m})$ for each dollar invested in the mutual fund. The period 2 dollar return of the mutual fund is then

$$R_{m,d,i} = (1 - \phi_{i,m})R_i S_i + \phi_{i,m}\tilde{R}_{\$,i,c} + \theta(1 - \phi_{i,m})\left(1 - \frac{S_i}{F_i}\right) \tag{C.21}$$

Following Appendix A, we can write the expectation and variance of the return as

$$ER_{m,d,i} = 1 + (1 - \phi_{i,m})r_i + \phi_{i,m}(r_{\$,i,c} - \pi) + \theta(1 - \phi_{i,m})f_i$$
$$var(R_{m,d,i}) = \phi_{i,m}^2 v + (1 - \phi_{i,m})^2(1 - \theta)^2\sigma^2$$

The fund maximizes the mean variance objective $ER_{m,d,i} - 0.5\gamma_m var(R_{m,d,i})$. The first-order condition with respect to $\phi_{i,m}$ implies

$$\phi_{i,m} = \frac{(1 - \theta)^2\sigma^2}{(1 - \theta)^2\sigma^2 + v} + \frac{r_{\$,i,c} - \pi - r_i - \theta f_i}{\gamma_m((1 - \theta)^2\sigma^2 + v)} \tag{C.22}$$

C.2 Households

Substituting the expressions above for $ER_{m,i}$ and $var(R_{m,i})$ into (A.7)-(A.8), with π and v replaced by $\tilde{\pi}_d$ and $\tilde{v}_d/\text{N}$, we have

$$ER_{p,i} = 1 + r_i + \alpha_{i,c}\left(r_{i,c} - \pi - r_i\right) + \alpha_{i,m}\left((1 - \mu_{i,m})r_\$ + \mu_{i,m}\left(r_{\$,c} - \tilde{\pi}_d\right) - r_i - \theta f_i\right)$$
$$var(R_{p,i}) = \alpha_{i,c}^2 v + (\alpha_{i,m}\mu_{i,m})^2\frac{\tilde{v}_d}{\text{N}} + \alpha_{i,m}^2(1 - \theta)^2\sigma^2$$

The first-order conditions of maximizing $E(R_{p,i}) - \gamma var(R_{p,i})$ with respect to $\alpha_{i,c}$ and

$\alpha_{i,m}$ imply

$$\alpha_{i,c} = \frac{r_{i,c} - \pi - r_i}{\gamma v} \tag{C.23}$$

$$\alpha_{i,m} = \frac{r_\$ - r_i + \mu_{i,m}\left(r_{\$,c} - \tilde{\pi}_d - r_\$\right) - \theta f_i}{\gamma \mu_{i,m}^2 \frac{\tilde{v}_d}{\mathrm{N}} + (1-\theta)^2 \gamma \sigma^2} \tag{C.24}$$

For US households, substitute the expressions above for $ER_{m,d,i}$ and $var(R_{m,d,i})$ into (A.11)-(A.12), with π and v replaced by $\tilde{\pi}$ and $\tilde{v}$. This gives

$$ER_{p,US} = 1 + r_\$ + \omega_{d,c}(r_{\$,c} - \pi - r_\$) + \sum_{i=1}^{\mathrm{N}} \omega_{i,m}\left((1-\phi_{i,m})(r_i - r_\$) + \phi_{i,m}(r_{\$,i,c} - \tilde{\pi} - r_\$) + \theta(1-\phi_{i,m})f_i\right)$$

$$var(R_{p,US}) = \sigma^2 \sum_{i=1}^{\mathrm{N}} \omega_{i,m}^2 (1-\phi_{i,m})^2 (1-\theta)^2 + \tilde{v} \sum_{i=1}^{\mathrm{N}} (\omega_{i,m}\phi_{i,m})^2 + \omega_{d,c}^2 v$$

Maximizing $E(R_{p,US}) - \gamma var(R_{p,US})$, the optimal portfolios are then

$$\omega_{d,c} = \frac{r_{\$,c} - \pi - r_\$}{\gamma v} \tag{C.25}$$

$$\omega_{i,m} = \frac{r_i - r_\$ + \phi_{i,m}(r_{\$,i,c} - \tilde{\pi} - r_i) + (1-\phi_{i,m})\theta f_i}{\gamma \tilde{v} \phi_{i,m}^2 + \gamma \sigma^2 (1-\phi_{i,m})^2 (1-\theta)^2} \tag{C.26}$$

C.3 Firms

For country i firms capital is financed by selling dollar and country i currency bonds. A fraction η_i is financed through dollar bonds. Assume that a fraction θ of dollar bonds are hedged. Then the profit of the firm in period 2 is

$$\Pi_i = A_i K_i^\nu - K_i\left(\eta_i R_{\$,i,c}\frac{1}{S_i} + (1-\eta_i)R_{i,c}\right) + \theta \eta_i K_i \left(\frac{1}{S_i} - \frac{1}{F_i}\right)$$

The last term is dollars bought forward. After log-linearizing returns, this is

$$\Pi_i = A_i K_i^\nu - K_i\left[1 + \eta_i(r_{\$,i,c} - s_i) + (1-\eta_i)r_{i,c} - \theta\eta_i(f_i - s_i)\right] \tag{C.27}$$

Assume that the firm maximizes

$$K_i \left(E\frac{\Pi_i}{K_i} - 0.5\gamma var\left(\frac{\Pi_i}{K_i}\right)\right) \tag{C.28}$$

This is equal to the capital stock times the risk-adjusted profit per unit of capital. It corresponds to

$$A_i K_i^{\nu} - K_i \left[1 + \eta_i r_{\$,i,c} + (1-\eta_i) r_{i,c} - \theta\eta_i f_i + 0.5\gamma\sigma^2\eta_i^2(1-\theta)^2\right] \tag{C.29}$$

The first-order conditions with respect to η_i and K_i imply

$$r_{\$,i,c} - r_{i,c} - \theta f_i + \gamma\sigma^2(1-\theta)^2\eta_i = 0 \tag{C.30}$$

$$A_i \nu K_i^{\nu-1} = 1 + r_{i,c} \tag{C.31}$$

Here we have abstracted from a second-order term on the right hand side of (C.31) equal to $-0.5\gamma\sigma^2\eta_i^2(1-\theta)^2$.

C.4 Implications for Calibration

As can be seen from Table 2, partial hedging changes some of the calibrated parameters. Specifically, Γ increases from 47 to 98 and W_d drops from 6.1 to 3.2. Here we briefly describe what is behind these changes.

As discussed in Section 7, partial hedging increases investment in the US by country 1 and lowers investment in the US by country N as now investment is also affected by the low interest rate in country 1 and high interest rate in country N. Similarly, partial hedging reduces investment by the US in country 1 and increases investment by the US in country N. Even though the hedge ratio θ is lower, this raises the net supply of dollars associated with hedging in country 1, $\theta\alpha_{1,m}W_1 - \theta\omega_{1,m}W_d$, while lowering it in country N.

The impact is that for unchanged parameters the CIP deviation varies more across countries. The CIP deviation increases in country 1 and drops even further in country N (becoming more negative). To offset this, and keep the difference in CIP deviations equal to 46 basis points in the data, the arbitrage capacity Γ of CIP arbitrageurs is increased from 47 to 98.

The other substantial parameter change in Table 2 is a reduction in the wealth W_d of the US. For a given W_d, the higher arbitrage capacity of CIP arbitrageurs lowers the average CIP deviation. To keep it unchanged at 14 basis points as in the data, W_d is lowered. This decreases demand for small country assets and therefore demand for forward dollars through hedging, raising the average CIP deviation back to 14 basis points. An alternative that leads to the same result is to lower the hedge ratio of the US relative to that of the small countries.

D Calibration: Proportion of Assets Invested Abroad

To estimate the share $1 - h$ invested abroad, we use

$$\frac{\text{External equity and bond assets}}{\text{Domestic equity and bond capitalization} + (\text{External equity and bond assets - liabilities})}$$

For External equity and bond assets and liabilities, we use OECD International investment position for portfolio investment. For bond capitalization, we use OECD Debt securities from (non-consolidated) Annual Financial Balance Sheets. For Australia, which does not have OECD non-consolidated data, we use BIS Debt Securities data at market value.[24] For equity capitalization, we use World Bank market capitalization of listed domestic companies (current US dollars).

The sample is 2007-2020. Unfortunately, data are not available for Finland and Sweden and are partial for various countries: Italy, UK: 2007-2014; Belgium, France, Portugal: 2007-2018. We take the average over the available data. For the Eurozone, we take the GDP-weighted average over 10 countries, not including Ireland.

[24]Comparing OECD and BIS data for other countries, there are differences in the numbers, but they are not substantial. We cannot use BIS data because for some countries debt is in nominal value and for other countries at market value.