Cross-Country CIP Deviations*

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Abstract

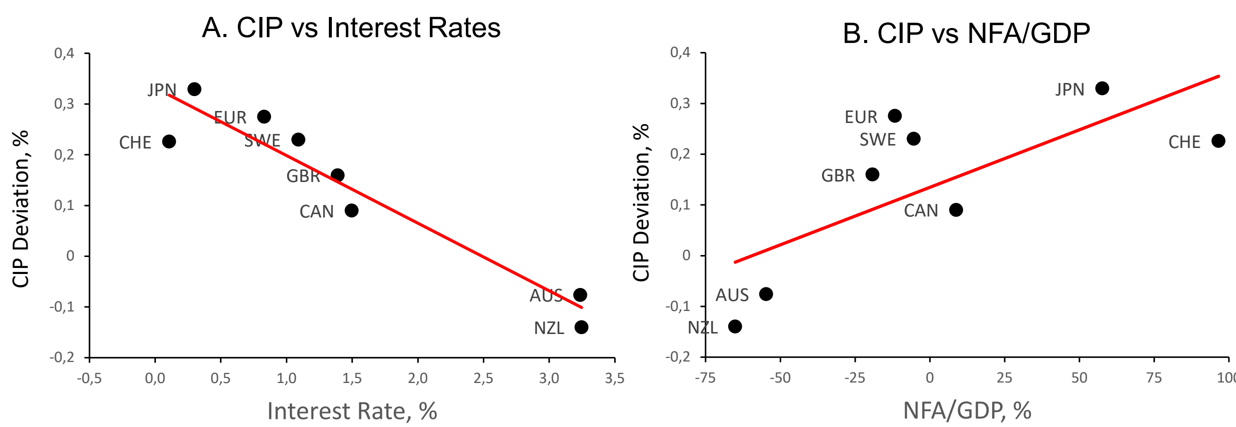
to be written

*PRELIMINARY AND INCOMPLETE

1 Introduction

Since the Global Financial Crisis we have seen deviations from Covered Interest Rate Parity (CIP) that can be explained by limited arbitrage implied by tighter regulations of potential arbitrageurs. These CIP deviations vary significantly across countries and in a way that is related to cross-country differences in several other variables. First, CIP deviations with respect to the US dollar tend to be 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 the recent literature on CIP deviations has documented these features, it has not developed a macroeconomic model that can explain them. The objective of this paper is to

[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.

propose a macroeconomic model with country asymmetries that can explain cross-country differences in CIP deviations and their link to interest rate levels and net external positions. Equilibrium in the FX forward market is key to understanding CIP deviations. However, the literature on international portfolio choice generally ignores the forward market as it is redundant without CIP arbitrage frictions. Moreover, 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.

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 all three of these motives. We will show that a hedging motive of forward market positions is key if we want to account for a negative relationship between the interest rate and CIP deviation. The CIP arbitrage and speculative motives alone imply a positive relationship between the interest rate and CIP deviation.

What matters is the overall net supply of forward dollars associated with FX hedging. This includes the supply of forward dollars when foreign investors hedge their US dollar assets. But we need to subtract the demand of forward dollars associated with US investors hedging foreign currency assets and foreign firms hedging dollar borrowing. With a limited CIP arbitrage capacity, a country with a large net supply of forward dollars associated with hedging will have a relatively high CIP deviation. 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 will occur in the model we develop is through saving and wealth. A country with a relatively high saving rate will have a low interest rate. But at the same time, high saving and wealth also lead to a large demand for dollar assets that need to be hedged by selling dollars forward, raising the CIP deviation. We will also show that a country with low productivity will have 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 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. But the interest rate 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. We will show that this will be 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. The countries are 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. The mutual funds function like the hedgers in Hacioğlu-Hoke et al. (2024).

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 three types of heterogeneity for the CIP deviation, interest rate and corporate spread. 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. We find that 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. However, we find that 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. We find that the model can account well for the empirical evidence in the data related to the cross-country relationship between the CIP deviation on one hand and the interest rate, net foreign asset position, wealth and hedging volume on the other hand.

We find that the model continues to perform well once we allow for partial hedging by mutual funds and firms. At the same time, it leads to a new mechanism linking CIP deviations and interest rates. Under partial hedging, investment abroad will also be affected by unhedged return differentials (UIP deviation). As a result, low interest rate countries invest more in the US. Since this is partially hedged, it raises the supply of forward dollars and, therefore, the CIP deviation.

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, Gourinchas, and Itskhoki (2025). Our focus will be on total NFA, as shown in Figure 1.[2]

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 relationship between CIP deviations and the estimated hedging volume to GDP ratio They use the cross-currency basis, not what we define as the CIP deviation.. We will also look at this correlation. Nenova, Schrimpf, and Shin (2025) find that the volume of FX forwards and swaps is positively correlated both with holdings of foreign debt assets and with the CIP deviation. We do not model volumes of FX transactions.

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) report higher hedging ratios of international investors, but they focus on a subset of investors active in the FX market. 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 our numerical analysis, we also consider partial hedging.

From a theoretical perspective, the literature has shown that the demand for FX forwards or swaps can be decomposed into a pure hedging motive and a pure speculative motive. Glen 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, Keller, and Zou (2025), Hacioğlu-Hoke et al. (2024), Bräuer and Hau (2024), and Bacchetta, Davis, and Van Wincoop (2024). In our benchmark analysis, we assume that mutual funds and firms only have a pure hedging demand and that the pure speculative demand comes from hedge funds.

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, Benhima, and Berthold (2023), Dao and Gourinchas (2025) and Dao et al. (2025). Some papers only consider CIP arbitrage, either by assumption as Moskowitz, Ross, Ross, and Vasudevan (2026) or because financial intermediaries are risk neutral or there is no exchange

[2] 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.

rate uncertainty (either by assumption or due to linearization), e.g., Gabaix and Maggiori (2015), Fanelli and Straub (2021), Amador, Bianchi, Bocola, and Perri (2020) or Basu, Boz, Gopinath, Roch, and Unsal (2020). In our specification, financial intermediaries face exchange risk with UIP trades, but they also face regulatory cost with CIP trades.

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

2 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. The 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 will also consider partially hedged mutual funds in Section 4.

There are also firms, hedge funds, financial institutions 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. UIP and CIP arbitrageurs have limited capacity to arbitrage respectively UIP and CIP deviations 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 both periods and that endowments and output are in units of the domestic consumption index. In the Online Appendix we show that these assumptions can be consistent with goods market equilibrium when there are appropriate shocks to the composition of goods that make up the endowments and output in each country.

2.1 Assets

In each country, there is a safe asset denominated in the currency of that country. The gross dollar interest rate of the US safe asset is $R_\$$. We denote small countries with the subscript $i = 1, .., N$. The gross interest rate of country i safe asset is R_i. These are returns from period 1 to period 2. The period 2 exchange rate for country i is S_i, which is dollars per unit of country i currency.

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 default outcome for domestic firms of $v = \pi(1 - \pi)$ (evaluated at bond yields of 1). We assume that mutual funds are just as informed as domestic households of the country in which they invest, and therefore also consider this to be the expectation and variance of the default outcome in that country.

In contrast, US households perceive the expected probability of default of firms in each small country to be $\tilde{\pi}$, with $\tilde{\pi} > \pi$, and the corresponding variance as $\tilde{v} = \tilde{\pi}(1-\tilde{\pi})$. Similarly, households in each small country perceive the expected probability of default of US firms to be $\tilde{\pi}_d$. We assume that the perceived variance is $\tilde{v}_d/N$ 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 are 0 and σ^2. This implies that the expected change in the (log) exchange rate is zero. 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 Mutual Funds

It is useful to discuss the need to introduce mutual funds in the first place. We need to restrict somehow the portfolio of assets that households have access to. Otherwise, households could conduct perfect CIP arbitrage themselves. Some papers assume that foreign investors simply cannot hold a position in the safe dollar bond (e.g., Du and Huber, 2024) or cannot short the safe dollar bond (e.g., Kubitza, Sigaux, and Vandeweyer, 2025). But we know that foreign investors hold a lot of safe dollar assets.[3]

Therefore, we introduce mutual funds that only invest in foreign assets and do not conduct CIP arbitrage.[4] Consider a European mutual fund, held by European households, that invests in US dollar assets. European households cannot conduct any CIP arbitrage as the US safe asset and the risky US corporate dollar bond are bundled within the mutual fund. Moreover, they will hold positive amounts of both dollar corporate bonds and safe assets, as we observe in the data. The fund hedges the exchange rate risk associated with its portfolio of dollar assets.

In what follows, we first assume that mutual funds fully hedge exchange rate risk, while in Section 5 we assume that they adopt an exogenous partial hedge ratio. In addition, we do not allow households themselves to choose a forward market position. We assume that only hedge funds speculate in the forward market. These assumptions are made to connect more closely to the data. Hacioğlu-Hoke et al. (2024) provide a comprehensive view of the London FX derivatives market, which includes all FX derivatives transactions (forwards, futures, swaps) that have a UK counter party. They provide evidence on the motivation for these

[3] In the Online Appendix we illustrate that simply imposing frictions that limit CIP arbitrage by households is not enough. In order to account for the cross-sectional relationship between CIP deviations and interest rates, we need a setup where forward market positions are at least partially chosen to hedge exchange rate risk associated with foreign investment.

[4] The returns of the mutual funds go to the households that invest in them. The funds do not charge fees.

FX derivatives positions. They find that speculative positions are mostly taken by hedge funds. Hedging positions are taken by mutual funds, pension funds, insurance companies and corporations. Finally, dealer-banks are global banks that provide liquidity to speculators and hedgers.

In our framework, the mutual funds and firms are indeed the hedgers. We separately introduce hedge funds that take speculative positions. Finally, CIP arbitrageurs in the model can be thought of as the dealer-banks that take the opposite position to the hedgers and speculators. They demand a price for this, which is the CIP deviation.

We find that for expositional clarity it is easiest to first assume complete hedging. The exogenous partial hedge ratios that we consider in Section 5 may capture that some funds do not hedge at all or that they invest in equity rather than fixed income assets. What is key to the analysis is that FX derivatives markets are used to hedge foreign currency investment, not that this hedging is perfect.

One final point needs to be made regarding the modeling of mutual funds. We introduce a separate mutual fund for each foreign country that US households invest in. If there were one global mutual fund that invest in the assets of all N foreign countries, this fund could conduct perfect cross-currency CIP arbitrage. It could take unlimited positions to equate the hedged returns on safe assets of all N countries. In this case, CIP deviations relative to the dollar would be the same for all N currencies. To avoid such cross-currency arbitrage, we assume that there are separate funds that invest in each of the N countries. US households then need to allocate their portfolio across these N funds, as well as the domestic US assets.

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. 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

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

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:

$$E(R_{i,m}) - 0.5\gamma_m var(R_{i,m}) \tag{1}$$

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

$$\mu_{i,m} = \frac{r_{\$,c} - \pi - r_{\$}}{\gamma_m v} \tag{2}$$

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 $r_{\$}$.

US households are allowed to invest in N mutual funds, each investing in one of the small countries. The mutual fund for country i invests in the safe asset of country i and the corporate dollar bond issued by firms of country i. 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 the Appendix A, after log-linearization the expectation and variance of the return of the mutual fund can be written as

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

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

$$\phi_{i,m} = \frac{r_{\$,i,c} - \pi - r_i - f_i}{\gamma_m v} \tag{3}$$

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

2.3 Households

2.3.1 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

$$ln(C_{1,i}) + \beta_i ln\left[E\left(C_{2,i}\right)^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{4}$$

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

$$W_i = \frac{\beta_i}{1+\beta_i}Z \tag{5}$$

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[5]

$$E(R_{p,i}) - 0.5\gamma var(R_{p,i}) \tag{6}$$

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

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

[5] 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 (6).

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 $\tilde{v}_d/N$ for US bonds. The last term in the expectation is the expected hedged excess return on the portfolio of US assets that the mutual fund invests in.

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

$$\alpha_{i,c} = \frac{r_{i,c} - \pi - r_i}{\gamma v} \tag{7}$$

$$\alpha_{i,m} = \frac{r_\$ - r_i - f_i + \mu_{i,m}\left(r_{\$,c} - \tilde{\pi}_d - r_\$\right)}{\gamma \mu_{i,m}^2 \frac{\tilde{v}_d}{N}} \tag{8}$$

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 expected excess return on the US versus the domestic currency safe asset when fully hedged. It is the CIP deviation with the sign reversed. 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.

2.3.2 US Households

Now consider US households. They start period 1 with a real endowment of $Z_d = NZ$, 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

$$W_d = \frac{\beta_d}{1+\beta_d} Z_d \tag{9}$$

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 the country i mutual fund with dollar return $R_{m,d,i}$. After log-linearization, the expectation and variance of the portfolio return are As shown in Appendix A, the expectation and variance can be written as

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

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

The optimal portfolios are then

$$\omega_{d,c} = \frac{r_{\$,c} - \pi - r_\$}{\gamma v} \tag{10}$$

$$\omega_{i,m} = \frac{r_i + f_i - r_\$ + \phi_{i,m}(r_{\$,i,c} - \tilde{\pi} - r_i - f_i)}{\gamma \tilde{v} \phi_{i,m}^2} \tag{11}$$

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. 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.

2.4 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

$$Y_i = A_i K_i^{\nu} \tag{12}$$

Assume that the price of capital is 1.[6] A fraction η_i of capital is financed through dollar bonds. The firm fully hedges currency risk associated with issuing dollar bonds through the forward market.

[6] 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.

Log-linearized profits are

$$\Pi_i = A_i K_i^\nu - K_i \left[1 + \eta_i (r_{\$,i,c} - f_i) + (1-\eta_i) r_{i,c}\right] \tag{13}$$

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

$$r_{\$,i,c} - r_{i,c} - f_i = 0 \tag{14}$$

$$A_i \nu K_i^{\nu-1} = 1 + r_{i,c} \tag{15}$$

Equation (C.30) 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 ($r_i + f_i - r_\$$). (C.31) 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

$$A_d \nu K_d^{\nu-1} = 1 + r_{\$,c} \tag{16}$$

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

2.5 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 bond. 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

$$\Pi_i^a = \psi_i \left(r_i + s_i - r_\$\right) + \lambda_i \left(f_i - s_i\right) = B_i^{CIP}(r_i + f_i - r_\$) + B_i^{UIP}(r_i + s_i - r_\$) \tag{17}$$

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

$$E\left(\Pi_i^a\right) - 0.5\gamma_a var\left(\Pi_i^a\right) - 0.5\frac{1}{\Gamma}\left(B_i^{CIP}\right)^2 \tag{18}$$

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

$$B_i^{CIP} = \Gamma\left(r_i + f_i - r_\$\right) \tag{19}$$

$$B_i^{UIP} = \Gamma_a\left(r_i - r_\$\right) \tag{20}$$

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 $r_i + f_i - r_\$$.

2.6 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

$$\Pi_h = h_i(f_i - s_i) \tag{21}$$

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

$$h_i = \frac{f_i}{\gamma_h \sigma^2} \tag{22}$$

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

$$H_i = \Gamma_h f_i \tag{23}$$

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.

2.7 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. One can think of these as governments and central banks. But they could also include highly rated financial institutions. They only take a position in the safe asset of a particular country. In equilibrium this position will be negative, so that they supply the safe asset. The equilibrium supply is assumed to be interest rate sensitive.

We simply model the period 1 supply of safe assets in country i as

$$D_i = d_0 - d_1 r_i \tag{24}$$

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

$$D_d = d_{\$,0} - N d_1 r_\$ \tag{25}$$

2.8 Market Clearing

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

$$(1-\alpha_{i,c}-\alpha_{i,m})W_i+\omega_{i,m}(1-\phi_{i,m})W_d+B_i^{CIP}+B_i^{UIP}=D_i \tag{26}$$

The first two terms are demands for country i safe assets by households, either directly for domestic households or through a mutual fund for US households. 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:

$$\left(\frac{A_i\nu}{1+r_{i,c}}\right)^{\frac{1}{1-\nu}}=\alpha_{i,c}W_i+\phi_{i,m}\omega_{i,m}W_d \tag{27}$$

The left hand side is the supply of capital K_i from (C.31). 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:

$$B_i^{CIP}+\omega_{i,m}W_d-\alpha_{i,m}W_i+H_i=0 \quad i=1,..,N \tag{28}$$

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 represents a 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:

$$\left(1-\omega_{d,c}-\sum_{i=1}^{N}\omega_{i,m}\right)W_d+\sum_{i=1}^{N}\alpha_{i,m}(1-\mu_{i,m})W_i-\sum_{i=1}^{N}B_i^{CIP}-\sum_{i=1}^{N}B_i^{UIP}=D_d \tag{29}$$

$$\left(\frac{A_d\nu}{1+r_{\$,c}}\right)^{\frac{1}{1-\nu}}=\sum_{i=1}^{N}\alpha_{i,m}\mu_{i,m}W_i+\omega_{d,c}W_d \tag{30}$$

These $3N+2$ 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 (C.30).

3 Solution

We first describe some 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 4. The analytical solution is obtained by considering marginal cross-country asymmetries when starting from the symmetric equilibrium. In Section 5 we consider a calibrated version of the model that is solved numerically and allows for large cross-country heterogeneity.

3.1 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 the CIP deviations are all zero.

To this end, assume that the N countries have the same household wealth, productivity and safe asset supply: $W_i=W$, $A_i=A$ and $d_{i,0}=d_0$.[7] We also assume that the US is the same size as the sum of the N small countries, so that $d_{\$,0}=Nd_0$, $W_d=NW$ and in equilibrium output and the capital stock are N times that in each small county. The latter is accomplished by setting $A_d=AN^{1-\nu}$.

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

In addition, we set parameters such that all countries invest a 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). This also implies that in equilibrium $D_i = D = (1-c)W$ and $K_i = K = cW$.

To achieve this equilibrium, we first set $\tilde{\pi}_d = \tilde{\pi}$.[8] We next set $\gamma_m = h\gamma$. This implies that the share c invested in corporate bonds is the same for domestic as foreign assets. In addition we solve $\tilde{\pi}$ from the quadratic

$$\tilde{\pi} - \pi + \frac{1}{N}(1-h)c\gamma\tilde{\pi}(1-\tilde{\pi}) = \gamma v h c$$

This implies that the fraction invested in domestic corporate bonds ($\alpha_{i,c}$ and $\omega_{d,c}$) is hc when substituting the expression for excess returns below. Finally, we set productivity A such that in equilibrium the marginal product of capital is 1 plus the corporate yield, as in (C.31), when the capital stock is $K = cW$.

It can then be checked that there is a solution where

$$\begin{aligned} f_i &= 0 \\ r_i &= r_\$ = \left(d_0 - (1-c)W\right)/d_1 \\ r_{i,c} &= r_{\$,c} = r_i + \tilde{\pi} + \frac{1}{N}(1-h)c\gamma\tilde{v} \end{aligned}$$

The CIP deviation $r_i + f_i - r_\$$ is zero in all countries in this symmetric equilibrium.

3.2 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

[8] The assumption $\tilde{\pi}_d = \tilde{\pi}$ implies that the perceived default probability of foreign firms is $\tilde{\pi}$ for US investors in the small countries, but $\tilde{\pi}/N$ for small country investors in Europe. We justify this by considering the US as an aggregate of N regions with uncorrelated shocks. This may seem inconsistent with the assumption that US households perceive the variance to be v for domestic firms, rather than v/N. But since we do not allow small countries to invest in other small countries, this assumption gives rise to a nice symmetric equilibrium and one where the share invested abroad is identical in all countries (small countries and the US).

the form

$$W_i = W + \epsilon_{i,w} \tag{31}$$

$$A_i = A + \epsilon_{i,a} \tag{32}$$

$$d_{i,0} = d_0 + \epsilon_{i,d} \tag{33}$$

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 4, 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 $\hat{cip}_i = \hat{r}_i + \hat{f}_i$.

3.3 Key Parameters

The results based on the analytical derivatives depend on four key parameters that affect demand and supply of forward dollars. The first is the supply elasticity of corporate capital. Linearizing (C.31), we can write the supply of corporate capital as

$$\hat{K}_i = k_1 \epsilon_{i,a} - k_2 \hat{r}^{i,c} \tag{34}$$

where $k_1 = \bar{K}/[(1-\nu)A]$ and $k_2 = 1/[A\nu(1-\nu)\bar{K}^{\nu-2}]$. Higher productivity raises the supply of corporate capital, while a higher cost of capital lowers the supply of corporate capital. Our first key parameter is k_2, which captures the sensitivity of the supply of corporate capital to the corporate yield. It can become very high in the limiting case where the production function is close to linear (ν close to 1).

The second key parameter is Γ_h. A higher value of Γ_h implies that demand for forward dollars by hedge funds is more sensitive to the forward rate. The third key parameter is $\rho = d_1 + \Gamma_a$. It captures 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.

4 Analytical Results

In the Online Appendix we go through the full algebra associated with solving for $\left[\hat{r}_i, \hat{\delta}_i, \hat{cip}_i\right]$ that gives rise to the results discussed in this Section. We first consider household wealth heterogeneity, followed by productivity heterogeneity and finally safe asset supply heterogeneity. Since $\epsilon_{i,w}$, $\epsilon_{i,a}$ and $\epsilon_{i,d}$ average to zero across the N countries, we show in the Online Appendix that US variables and averages of the endogenous small country variables remain unchanged. The aim of this section is to obtain an analytical understanding of the forces at play, while in the next section we provide a quantitative analysis.

4.1 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 high (low), with a low (high) interest rate elasticity ρ of the safe asset demand and a high (low) supply elasticity k_2 of capital.*

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 through the portfolio growth channel, which lowers the interest rate.

Next consider the impact on the corporate spread. Higher household wealth impacts the equilibrium corporate spread through both the demand and supply of corporate capital.

On the demand side, portfolio growth associated with 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 particularly when the capital share ν is high (production function more linear). The supply channel is also strengthened when the safe rate drops 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 the linearized equilibrium in the market for forward dollars, which is

$$\left(\frac{1}{\Gamma} + 2\frac{N\tilde{W}}{\gamma\tilde{v}c^2}\right)\hat{cip}_i + \frac{\tilde{W}}{\gamma c}\left(\frac{N}{\tilde{v}} - \frac{1-h}{h}\frac{1}{v}\right)\hat{\delta}_i - (1-h)\epsilon_{i,w} + \Gamma_h\hat{f}_i = 0 \tag{35}$$

The left hand side is the demand for forward dollars. The second term in brackets can be shown to be positive.

The demand for forward dollars depends positively on the CIP deviation. A higher CIP deviation in country i implies a higher return on country i safe assets relative to dollar safe assets when fully hedged. This implies reduced demand for the dollar safe asset by country i and increased demand for country i safe asset by the US. To hedge the resulting changes in currency exposure, there is increased demand for forward dollars. For a given corporate spread, the same applies to corporate bonds. Finally, CIP arbitrageurs also increase demand for forward dollars when the CIP deviation rises. They borrow more safe dollars in the US, invest in country i safe asset and buy dollars forward.

The other key term in (35) is the one associated with the asymmetry in household wealth, $-(1-h)\epsilon_{i,w}$. 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, which raises demand for forward dollars, is then needed to clear the market. This is consistent with the cross-country evidence on interest rates and CIP deviations. A country with high (low) wealth has both a low (high) safe interest rate and a high (low) CIP deviation.

But (35) shows that 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, holding speculative forward demand zero ($\Gamma_h = 0$). When it drops, it reduces US demand for corporate dollar bonds from the small country, which reduces the need of the country's firms to hedge by buying dollars forward. The reduced demand for forward dollars 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 can more than offset the increase in the CIP deviation due to increased holdings of US dollar assets that are hedged.

The theory is also inconsistent with the cross-sectional evidence for the CIP deviation and safe rate when speculative forward demand is large enough as captured by a sufficiently large Γ_h. 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 raises the profits from buying dollars forward by hedge funds. When Γ_h is large enough, a lower CIP deviation may be required to clear the market. This is most intuitive when we consider the limit of Γ_h to infinity. It follows from the last term of (35) that then $\hat{f}_i = 0$. Otherwise, there would be infinite speculative forward positions. But in that case we have $\hat{cip}_i = \hat{r}_i < 0$.

4.2 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 corporate spread and a lower capital stock. 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 for forward dollars 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 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 lowers the supply of corporate capital. A drop in the corporate spread is needed to clear the market.[9]

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 that issue corporate dollar bonds. The lower demand for forward dollars raises the CIP deviation.

For a given safe interest rate, a lower corporate spread implies a lower corporate yield. This leads to a portfolio reallocation towards the safe asset, which reduces the safe rate. The safe rate is also reduced by the positive CIP deviation, which increases the return on safe assets of the small country relative to the US when fully hedged. It therefore raises demand for the small country safe asset, lowering its safe rate.

When speculative forward demand is strong enough, it is no longer the case that countries with a low safe rate have a high CIP deviation. 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 $\Gamma_h \to \infty$. As before, we must then have $\hat{f}_i = 0$, so that $\hat{cip}_i = \hat{r}_i$. 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.

4.3 Safe Asset Supply Asymmetry

Now consider a safe asset supply asymmetry. The safe asset supply $D_i = d_0 + \epsilon_{i,d} - d_1 r_i$ can also be thought 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

[9] As before, a lower safe rate implies a lower corporate yield if we keep the corporate spread unchanged. This by itself raises the supply of corporate capital. But this effect is always outweighed by the negative supply effect coming from the lower productivity.

buys government bonds and therefore removes safe assets from the market. One naturally expects the safe interest rate to drop. This experiment is close to introducing an exogenous drop in the safe rate.

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

Proposition 3 *A country with lower 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 as we discussed, the differential in hedged returns is determined by the CIP deviation itself, not the interest rate differential. UIP arbitrageurs respond to a differential in safe returns, but since they do not hedge they do not impact the equilibrium CIP deviation.

The drop in the safe rate naturally raises the corporate spread. As discussed, for a given corporate spread it implies a lower corporate yield. This raises the supply of corporate capital, which raises the equilibrium corporate spread.

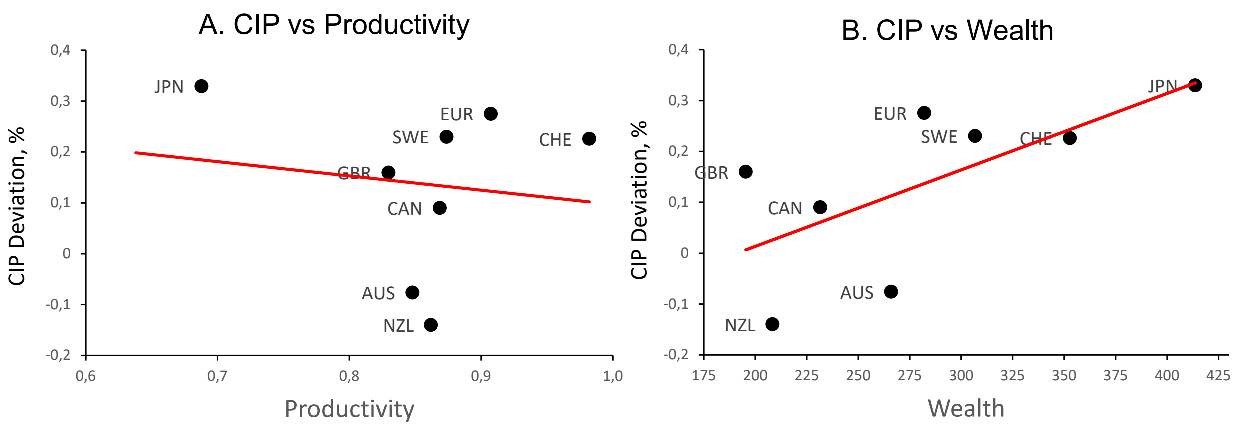
The lower CIP deviation in the country with a lower safe rate can be explained as follows. First, the higher corporate spread raises demand for corporate dollar bonds by the US. This raises demand by the country's firms for forward dollars, which lowers the equilibrium CIP deviation. Second, for a given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

A key difference with high saving by households is that those households invest abroad and therefore will also hold more dollar assets. Hedging of those positions raises the CIP deviation. Agents that only hold safe assets, or governments that only issue safe assets, do not hold US dollar assets. A change in their saving, while affecting the equilibrium safe rate, therefore does not impact the forward market through increased hedging of dollar assets.

4.4 Evaluating Asymmetries

The previous subsections showed that cross-country differences in safe asset supplies cannot explain CIP and interest rate differentials. However, differences in productivity or household wealth can potentially explain these features. To verify whether these are empirically plausible explanations, we examine the relationship between CIP deviations and productivity or household wealth. These relationships are shown in Figure 2.

Figure 2: CIP Deviations vs Productivity and Wealth



We measure productivity as TFP relative to that in the US, using data from the World Penn Table for 2007-2019. For household wealth W, we use the sum of fixed assets and net foreign assets, $W = K + NFA$, as a fraction of GDP. Fixed assets (for the total economy) come from the OECD Annual balance sheet for non-financial assets.[10] NFA is OECD net financial worth from Annual financial balance sheets.

Figure 2 shows that there is a weak relationship between productivity and the CIP deviation. In contrast, wealth and CIP deviations are clearly correlated. We conclude that only asymmetries in household wealth can explain the empirical evidence on cross-country CIP deviation. We further explore this source of asymmetry in the next section and show that a calibrated version of our model is quantitatively consistent with empirical evidence.

[10]For New Zealand, we use the average over 2007-2017 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 taken from the OECD.

5 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 explain that countries with a higher CIP deviation have a lower interest rate and a higher net foreign asset position and more FX hedging of dollar exposure (Du and Huber (2024) and Borio et al. (2018)).

There are three differences relative to the analytical solution discussed in Section 3. First, we now consider large cross-country heterogeneity. Second, we do not linearize the model, solving the $3N + 2$ 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.

5.1 Calibration

Table 1 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 $N = 8$.[11] We introduce wealth heterogeneity $W_i = W + \epsilon_{i,w}$ with $\epsilon_{i,w} = W\epsilon(N+1-2i)/(N-1)$ for $i = 1, .., N$. This means that wealth varies from $W(1 + \epsilon)$ for country $i = 1$ to $W(1 - \epsilon)$ for country $i = N$. We set ϵ to match the ratio of the highest to the lowest wealth of 2.12 across the 8 countries in Figure 2. This implies $\epsilon = 0.36$. We normalize the average wealth as $W = 1$.

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 $\nu = 0.4$.[12]

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 remaining set of parameters is set jointly to target all the moments.

We set the intercept d_0 of the supply of safe assets of the N countries such that the

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

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

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.[13]

We set productivity $A_i = A$ for $i = 1, .., N$ 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).[14] In the model the standard deviation is $\sqrt{\pi(1-\pi)}$. We set $\tilde{\pi}_d = 0.01647$ and $\tilde{\pi} = 0.01894$ such that the average share invested abroad by the N countries, as well as the share invested abroad by the US, is $1 - h = 0.35$. See the Online Appendix for the construction of this latter 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.

We set W_d to target an average CIP deviation of 14 basis points. We set the arbitrage

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

[14] 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.

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 evidence reported by Hacioğlu-Hoke et al. (2024).

5.2 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, interest rates (chart A), the net foreign asset position as a share of wealth (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-C are quite similar to the corresponding data charts in Figures 1 and 2, both in terms of the direction of the relationships and the quantitative magnitudes. Chart D is qualitatively similar to Figure 8 in Du and Huber (2024).

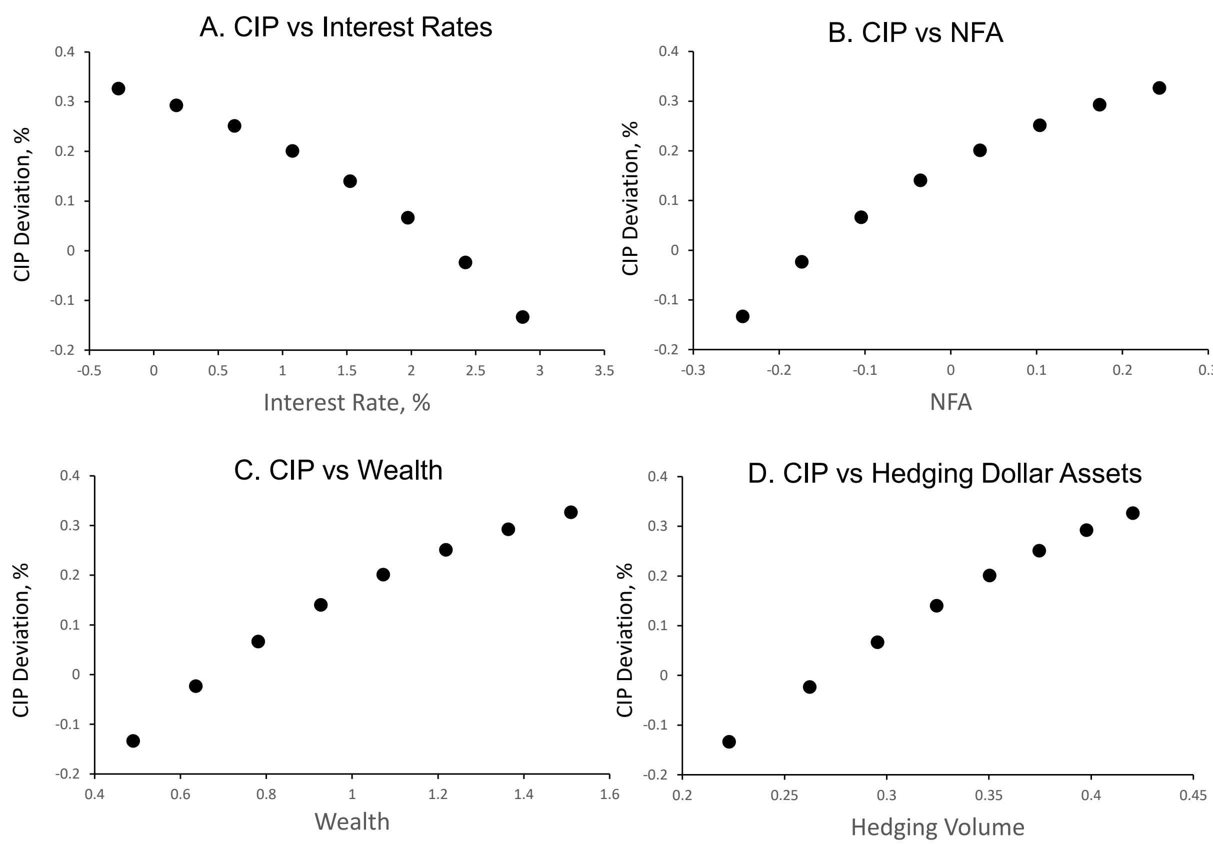
We have already discussed why countries with higher wealth have a higher CIP deviation and lower interest rate. The relationship with the net foreign asset position can be understood as follows. The net foreign asset position is equal to

$$NFA_i = \alpha_{i,m} W_i - \omega_{i,m} W_d - B_i^{UIP} - B_i^{CIP} = -B_i^{UIP} = -\Gamma_a (r_i - r_\$) \tag{36}$$

The second equality substitutes the forward market equilibrium (35), assuming $\Gamma_h = 0$. A higher wealth country has a higher CIP deviation and a lower interest rate. The low interest rate leads to net capital outflows by UIP arbitrageurs and therefore a positive NFA. The external assets and liabilities through external household portfolios do not affect the net foreign asset position here as a result of perfect hedging. We revisit this below with partial hedging.

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 insurance companies, pension funds and mutual funds. Intuitively, consider again a country with relatively high wealth and therefore a relatively high CIP deviation. This country will have a relative high

Figure 3: Baseline Model with Wealth Heterogeneity

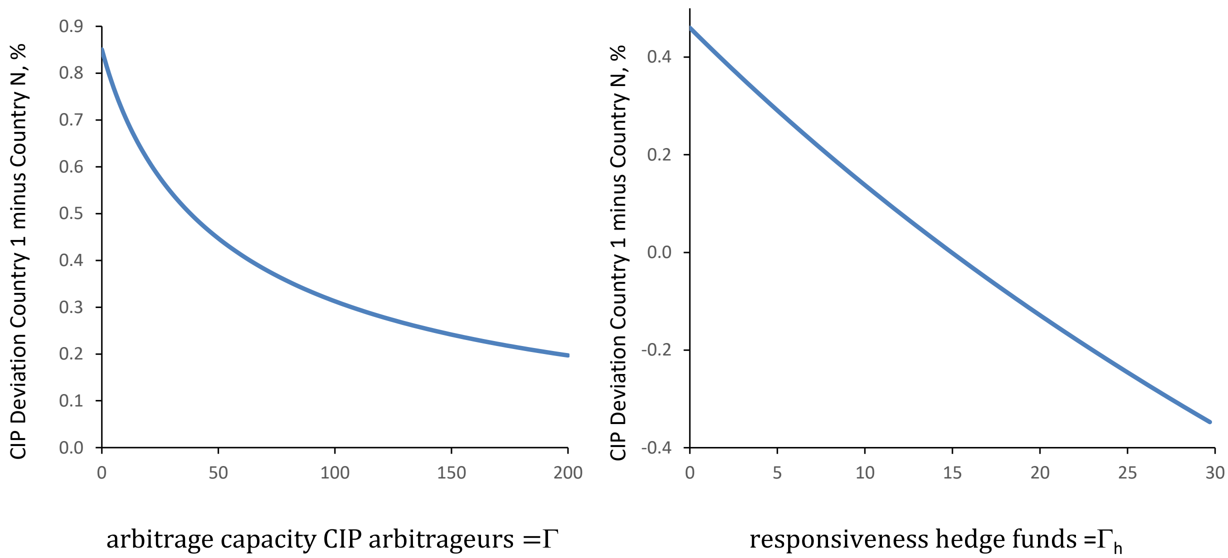


investment in the US, which is perfectly hedged. It is exactly the larger hedging of dollar assets by such a country that leads to a larger supply of forward dollars that gives rise to a higher CIP deviation.

5.3 CIP Arbitrageurs and Hedge Funds

So far we have set $\Gamma = 14.194$ 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 20. In both cases, we keep the parameters otherwise the same as in Table 1, 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.

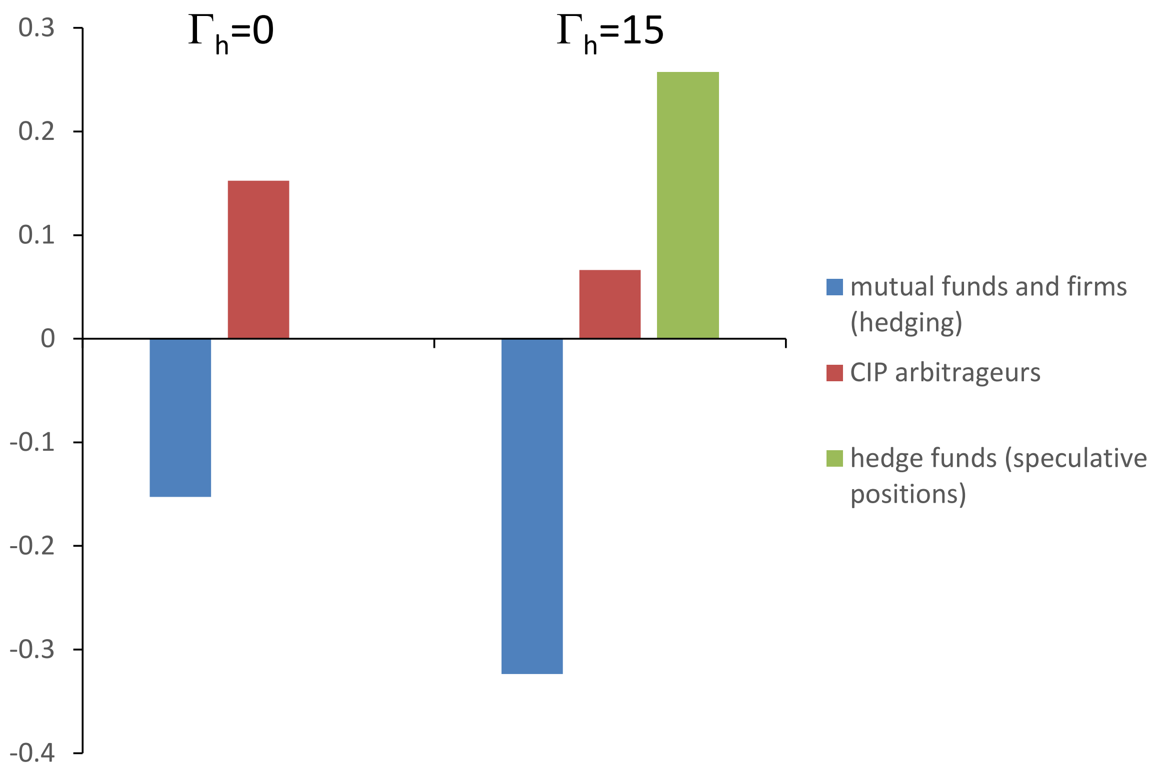
Figure 4: CIP Deviations vs Libor Interest Rates and Net Foreign Assets



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 will be 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.

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 $\Gamma_h = 10$. 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. By contrast, when $\Gamma_h = 10$, 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.[15]

[15] The fact that hedgers have a much larger position when $\Gamma_h = 10$ is a result of the lower cost of hedging

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 (e.g. asset managers, insurers, pensions funds and investment funds). They find that hedge funds have positions that are on average zero. Their 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 matter more in a model focused on the time series response to shocks.

5.4 Partial Hedging

While full exchange rate hedging is a useful benchmark, the evidence points to partial hedging. However, the precise degree of hedging is not known. Cheema-Fox and Greenwood (2024) find that fixed income funds almost always hedge and have a hedge ratio close to 1. They consider funds that have been active in the foreign exchange market over the past 12 months. Du and Huber (2024) find that hedge ratios are more limited for mutual funds, pension funds, and insurance companies. There may be various explanations for this difference. Cheema-Fox and Greenwood (2024) find that hedge ratios are smaller for equity positions. Moreover, it is possible that some of the institutions in Du and Huber (2024) do not hedge at all. The sample in Cheema-Fox and Greenwood (2024) is more biased towards funds that do hedge.

To see the impact of limited hedging, we now assume that mutual funds and firms have a hedge ratio of θ. 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 the Appendix. The forward market equilibrium condition now becomes

$$B_i^{CIP} + \theta\omega_{i,m}W_d - \theta\alpha_{i,m}W_i + H_i = 0 \quad i = 1, .., N \tag{37}$$

We illustrate the results for a hedge ratio of $\theta = 0.6$. For the other parameters, we follow

dollar positions due to the lower CIP deviation.

the same calibration approach as discussed in Section 5.1 for the baseline case with complete hedging. The parameters are shown in Table 1.

One key difference is related to the fractions invested abroad. 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 reduces this return advantage of investing in country 1. This raises investment by country 1 in the US, while lowering investment by the US in country 1. Even though the hedge ratio θ is lower, this raises the net supply of dollars associated with hedging, $\theta\alpha_{1,m}W_1 - \theta\omega_{1,m}W_d$. This raises the forward rate and CIP deviation of country 1.

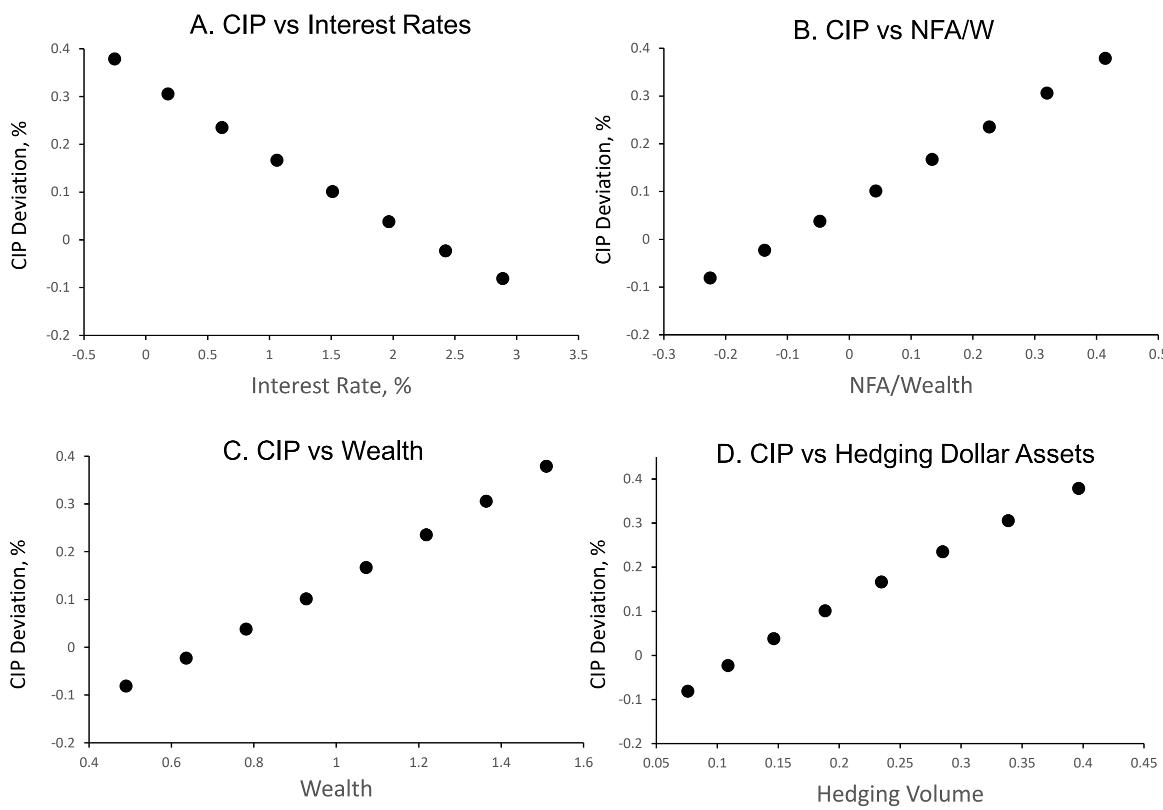
The exact opposite happens for the low wealth country N. Its negative CIP deviation implies a lower hedged return of investing in country N relative to the US. Reducing the hedge ratio reduces this relative return advantage of the US compared to country N. This reduces investment by country N in the US, while increasing investment by the US in country N. The net demand for forward dollars increases, the forward rate drops, and the CIP deviation becomes even more negative in country N.

The impact is that for unchanged parameters the CIP deviation will vary more across countries. The gap between the CIP deviation in country 1 relative to that in country N will increase. To offset this, and keep this difference equal to 46 basis points as in the data, the arbitrage capacity Γ of CIP arbitrageurs is increased from 14 to 83. The other substantial parameter change in Table 1 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.[16]

With the newly calibrated parameters, the main results are very similar to the baseline case. The results are shown in Figure 6. Panels A and C, which show the CIP deviation versus respectively the interest rate and wealth, are virtually identical to those in Figure 3 for the baseline case. Panel B shows the CIP deviation versus the net foreign asset position. It is again quite similar to the baseline case. The net foreign asset position now varies a bit

[16] The evidence from Cheema-Fox and Greenwood (2024) and Sialm and Zhu (2024) shows that US mutual funds have a lower hedging ratio than US funds.

Figure 6: Partial Hedging with Wealth Heterogeneity



more across countries than before. Under partial hedging the net foreign asset position is

$$NFA_i = \alpha_{i,m} W_i - \omega_{i,m} W_d - B_i^{UIP} - B_i^{CIP} = -B_i^{UIP} + (1-\theta)\left(\alpha_{i,m} W_i - \omega_{i,m} W_d\right) \quad (38)$$

The second equality substitutes the forward market equilibrium condition (37) 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. The net foreign asset position, scaled by wealth, is 0.46 higher in country 1 than in country N, of which 0.21 is associated with UIP arbitrageurs and 0.25 with households. Country 1 household investment in the US is high both as a result of high wealth and, as discussed above, a higher portfolio share invested in the US due to the partial hedging.

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. Since investment in the US now varies more across countries, the hedging volume also varies more across countries, notwithstanding the lower hedge ratio.

6 Conclusion

Table 1: Calibrated Parameters

Parameter	Baseline	Partial Hedging	Description
N	8	8	number of countries
ϵ	0.36	0.36	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	0.4789	0.4519	constant term safe asset supply small countries
$d_{\$,0}$	3.1761	1.4121	constant term safe asset supply US
ρ	21.44	13.64	interest rate sensitivity safe asset supply
A_i	2.0353	1.8423	productivity of the N countries
A_d	7.007	5.8248	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
$\tilde{\pi}$	0.01894	0.01239	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	7.2416	3.8913	US wealth
Γ	14.194	82.980	arbitrage capacity CIP arbitrageurs
Γ_h	0	0	arbitrage capacity hedge funds

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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 2.2 and 2.3. 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

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

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 $\tilde{v}_d/N$, 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 $\tilde{v}_d/N$.

Finally, the portfolio return of US households is

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

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

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

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

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

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

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 the period 1 debt, R_i the gross interest rate and Y period 2 income. Assume that there is no period 1 income 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

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

The exchange rate is assumed to be uncorrelated with the default outcome. Following the procedure in Appendix A, we have

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

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

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 (2).

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 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 $\tilde{v}_d/N$, we have

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

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

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

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

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

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

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

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 $-0.5\gamma\sigma^2\eta_i^2(1-\theta)^2$.