

Online Appendix

Cross-Country CIP Deviations

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Section A discusses alternative modeling approaches without mutual funds. It shows that both risky assets and constraints on safe asset holdings are needed for a hedging motive in the forward market. Section B derives the analytical results behind the Propositions in Section 5 of the paper. Section C discusses the goods market equilibrium.

A Alternative Modeling Approaches

It is clear that households in the model should not be given unconstrained access to all the assets as it would allow them to conduct CIP arbitrage themselves. But in this section we show that it is not enough to introduce frictions that limit CIP arbitrage by households if the objective is to account for the negative cross-country relationship between CIP deviations and interest rates. In the model in the paper, demand and supply of forward dollars come from CIP arbitrageurs, hedge funds, and households/mutual funds. In what follows, we keep the demand for forward dollars by CIP arbitrageurs and hedge funds the same as in the paper, but consider alternatives for households/mutual funds. In most of the analysis, we abstract from mutual funds. We discuss mutual funds only towards the end of this section.

A.1 Households hold no forward market positions

If we do not allow households to have forward market positions, directly or through mutual funds, the forward market clearing condition is $B_i^{CIP} + H_i = 0$, which implies

$$\Gamma(r_i + f_i - r_{\$}) + \Gamma_h f_i = 0 \tag{1}$$

Writing $cip_i = r_i + f_i - r_{\$}$ as the CIP deviation, we have $f_i = cip_i - r_i + r_{\$}$. Substituting, we have

$$cip_i = \frac{\Gamma_h}{\Gamma + \Gamma_h} r_i - \frac{\Gamma_h}{\Gamma + \Gamma_h} r_{\$} \tag{2}$$

This either implies that there is a counterfactual positive relationship between CIP deviations and interest rates (when $\Gamma_h > 0$) or there is no relationship (the CIP deviation is the same for all countries). The latter occurs when $\Gamma_h = 0$.

A.2 Frictions in the forward market

Now assume that households do take positions in the forward market. For simplicity we only model small country households. Adding US households makes no difference. In addition to the forward market, households also hold positions in the safe domestic and dollar asset. To prevent them from conducting perfect CIP arbitrage, assume that country i households face a quadratic cost $0.5\lambda\theta_i^2$ on a forward market position of θ_i . The portfolio return of households in country i is

$$R_{p,i} = 1 + \alpha_i \frac{R_{\$}}{S_{i,2}} + (1 - \alpha_i)R_i + \theta_i \left(\frac{1}{S_{i,2}} - \frac{1}{F_i} \right) - 0.5\lambda\theta_i^2 \quad (3)$$

Here θ_i are dollars bought forward. Log-linearized around returns and exchange rates equal to 1, we have

$$R_{p,i} = 1 + r_i + \alpha_i(r_{\$} - r_i - s_{i,2}) + \theta_i(f_i - s_{i,2}) - 0.5\lambda\theta_i^2 \quad (4)$$

Assume that households maximize $ER_{p,i} - 0.5\gamma var(R_{p,i})$. The expectation and variance of the exchange rate $s_{i,2}$ are 0 and σ^2 . Households then maximize

$$\alpha_i(r_{\$} - r_i) + \theta_i f_i - 0.5\gamma(\alpha_i + \theta_i)^2\sigma^2 - 0.5\lambda\theta_i^2 \quad (5)$$

Maximizing with respect to θ_i and α_i gives

$$\theta_i = \frac{r_i + f_i - r_{\$}}{\lambda} \quad (6)$$

$$\alpha_i = \left(\frac{1}{\lambda} + \frac{1}{\gamma\sigma^2} \right) (r_{\$} - r_i) - \frac{1}{\lambda}f_i \quad (7)$$

The forward market position θ_i is proportional to that of CIP arbitrageurs. This therefore changes nothing relative to the case where households do not hold any forward market position. We could introduce wealth heterogeneity, so that the forward market equilibrium is $\Gamma cip_i + cip_i W_i/\lambda + \Gamma_h f_i = 0$. But wealth heterogeneity would have a second-order effect on the CIP deviation. This is immediate if we start from an equilibrium where CIP deviations are zero and then introduce marginal wealth heterogeneity as in Section 5 of the paper.

A.3 Frictions in foreign bond market

Next assume that instead of the friction in the forward market, households face a cost $0.5\lambda\alpha_i^2$ associated with positions in the foreign bond market. They then maximize

$$\alpha_i(r_{\$} - r_i) + \theta_i f_i - 0.5\gamma(\alpha_i + \theta_i)^2\sigma^2 - 0.5\lambda\alpha_i^2 \quad (8)$$

The first-order conditions yield

$$\alpha_i = -\frac{cip_i}{\lambda} \quad (9)$$

$$\theta_i = \frac{cip_i}{\lambda} + \frac{f_i}{\gamma\sigma^2} \quad (10)$$

Introducing US households again does not change anything qualitatively. Forward market equilibrium is now

$$B_i^{CIP} + \theta_i W + H_i = 0 \quad (11)$$

where W is the wealth of households. This implies

$$\left(\Gamma + \frac{W}{\lambda}\right) cip_i + \left(\Gamma_h + \frac{W}{\gamma\sigma^2}\right) f_i = 0 \quad (12)$$

Substituting $f_i = cip_i - r_i + r_{\$}$, this again implies a positive relationship between CIP deviations and interest rates, in this case even when $\Gamma_h = 0$ as households adopt a speculative forward market position themselves. Notice that the case where the investors have no access to the foreign bond market corresponds to $\lambda = \infty$. We could introduce wealth heterogeneity across households, but it again has a second-order effect on the CIP deviation.

A.4 Corporate bonds

Go back to the case where households face a cost $0.5\lambda\theta_i^2$ in the forward market, but now allow households to hold both domestic and foreign safe assets and corporate bonds. The portfolio return is

$$R^{p,i} = (1 - \alpha_{i,1} - \alpha_{i,2} - \alpha_{i,3})R_i + \alpha_{i,1}\frac{R_{\$}}{S_{i,2}} + \alpha_{i,2}\tilde{R}_{i,c} + \alpha_{i,3}\frac{\tilde{R}_{\$,c}}{S_{i,2}} + \theta_i\left(\frac{1}{S_{i,2}} - \frac{1}{F_i}\right) - 0.5\lambda\theta_i^2 \quad (13)$$

Here $\alpha_{i,1}$ is the fraction invested in the dollar safe asset, $\alpha_{i,2}$ the fraction invested in the domestic corporate bond and $\alpha_{i,3}$ the fraction invested in the US corporate dollar bond. The rest is invested in the domestic safe asset.

Following the same procedure as in Appendix A of the paper, we can write the expectation and variance of the log-linearized portfolio return as

$$ER_{p,i} = 1 + r_i + \alpha_{i,1}(r_{\$} - r_i) + \alpha_{i,2}(r_{i,c} - r_i - \pi) + \alpha_{i,3}(r_{\$,c} - r_i - \tilde{\pi}) + \theta_i f_i - 0.5\lambda\theta_i^2$$

$$var(R_{p,i}) = (\alpha_{i,1} + \alpha_{i,3} + \theta_i)^2 \sigma^2 + v\alpha_{i,2}^2 + \frac{1}{N}\tilde{v}\alpha_{i,3}^2$$

Now assume that households maximize $ER_{p,i} - 0.5\gamma var(R_{p,i})$. The first-order conditions are

$$r_{\$} - r_i = \gamma(\alpha_{i,1} + \alpha_{i,3} + \theta_i)\sigma^2 \quad (14)$$

$$r_{i,c} - r_i - \pi = \gamma v\alpha_{i,2} \quad (15)$$

$$r_{\$,c} - r_i - \tilde{\pi} = \gamma\frac{1}{N}\tilde{v}\alpha_{i,3} + \gamma(\alpha_{i,1} + \alpha_{i,3} + \theta_i)\sigma^2 \quad (16)$$

$$f_i = \gamma(\alpha_{i,1} + \alpha_{i,3} + \theta_i)\sigma^2 + \lambda\theta_i \quad (17)$$

From the last equation we have

$$\theta_i = -\frac{\gamma\sigma^2}{\gamma\sigma^2 + \lambda}(\alpha_{i,1} + \alpha_{i,3}) + \frac{f_i}{\gamma\sigma^2 + \lambda} \quad (18)$$

This is the type of solution derived in the partial equilibrium literature that takes portfolio allocation as given. It appears at first that there is a hedge term (the first term) and a speculative term (second term). The hedge ratio is $\gamma\sigma^2/(\gamma\sigma^2 + \lambda)$. But this is misleading. The forward market position is in fact not at all driven by the hedging motive. After solving the portfolios from (29)-(31), we have

$$\theta_i = \frac{1}{\lambda}(r_i + f_i - r_{\$}) \quad (19)$$

$$\alpha_{i,2} = \frac{r_{i,c} - r_i - \pi}{\gamma v} \quad (20)$$

$$\alpha_{i,3} = \frac{r_{\$,c} - r_{\$} - \tilde{\pi}}{\gamma\tilde{v}/N} \quad (21)$$

$$\alpha_{i,1} = -\alpha_{i,3} - \theta_i + \frac{r_{\$} - r_i}{\gamma\sigma^2} \quad (22)$$

Notice that the forward market position θ_i remains a CIP arbitrage position, so that nothing changes relative to the case without corporate bonds. Also note that

the position in the safe dollar bond now has three parts. The first part perfectly hedges exchange rate risk associated with the corporate dollar bond. The second part is associated with the CIP arbitrage position. The third part is a standard UIP arbitrage position. This is quite different from what is happening in the paper, where the forward market position is chosen to hedge exchange rate risk associated with the dollar safe asset and the dollar corporate bond.

A.5 Restricted Access to Safe Assets

In order to introduce a genuine hedging motive, we need to restrict access to safe assets, whereby households from country i either cannot hold the dollar safe asset or the country i safe asset. First consider what happens when they cannot hold the dollar safe asset. We can do this by setting $\alpha_{i,1} = 0$. We then have

$$\begin{aligned} ER_{p,i} &= 1 + r_i + \alpha_{i,2}(r_{i,c} - r_i - \pi) + \alpha_{i,3}(r_{\$,c} - r_i - \tilde{\pi}) + \theta_i f_i - 0.5\lambda\theta_i^2 \\ \text{var}(R_{p,i}) &= (\alpha_{i,3} + \theta_i)^2 \sigma^2 + v\alpha_{i,2}^2 + \frac{1}{N}\tilde{v}\alpha_{i,3}^2 \end{aligned}$$

The first-order conditions are then

$$r_{i,c} - r_i - \pi = \gamma v \alpha_{i,2} \quad (23)$$

$$r_{\$,c} - r_i - \tilde{\pi} = \gamma \frac{1}{N} \tilde{v} \alpha_{i,3} + \gamma (\alpha_{i,3} + \theta_i) \sigma^2 \quad (24)$$

$$f_i = \gamma (\alpha_{i,3} + \theta_i) \sigma^2 + \lambda \theta_i \quad (25)$$

From the last equation we can write the position in the forward market as the sum of a hedge position and a speculative position:

$$\theta_i = -\frac{\gamma\sigma^2}{\gamma\sigma^2 + \lambda} \alpha_{i,3} + \frac{f_i}{\gamma\sigma^2 + \lambda} \quad (26)$$

Now this can no longer be rewritten as a CIP arbitrage position by substituting the solution for $\alpha_{i,3}$. The reason is that CIP arbitrage is no longer feasible without taking a position in the safe dollar asset. The solution for $\alpha_{i,3}$ is:

$$\alpha_{i,3} = \frac{-\gamma\sigma^2 f_i + (\lambda + \gamma\sigma^2)(r_{\$,c} - r_i - \tilde{\pi})}{\lambda\gamma\sigma^2 + \lambda\gamma\tilde{v}/N + \gamma^2\sigma^2\tilde{v}/N} \quad (27)$$

Clearly, substituting this back into (26) does not deliver a CIP arbitrage position. In this case the forward market position includes, in the first term of (26), a true

hedge position. The value of $\alpha_{i,3}$ will generally be positive because of a positive premium $r_{\$,c} - r_i - \tilde{\pi}$. This leads to negative value of θ_i to hedge it.

The forward market equilibrium condition then becomes

$$\Gamma_c p_i + \theta_i W_i + \Gamma_h f_i = 0 \quad (28)$$

Here we allow for wealth differences. Since $\alpha_{i,3}$ will generally be positive, θ_i will be negative. A country with high wealth will then have a high CIP deviation, as in the paper.

Now consider the alternative where households cannot hold the country i safe asset. Then $\alpha_{i,2} = 1 - \alpha_{i,1} - \alpha_{i,3}$. We have

$$\begin{aligned} ER_{p,i} &= 1 + \alpha_{i,1} r_{\$} + (1 - \alpha_{i,1} - \alpha_{i,3})(r_{i,c} - \pi) + \alpha_{i,3}(r_{\$,c} - \tilde{\pi}) + \theta_i f_i - 0.5\lambda\theta_i^2 \\ \text{var}(R_{p,i}) &= (\alpha_{i,1} + \alpha_{i,3} + \theta_i)^2 \sigma^2 + v(1 - \alpha_{i,1} - \alpha_{i,3})^2 + \frac{1}{N} \tilde{v} \alpha_{i,3}^2 \end{aligned}$$

The first-order conditions are

$$r_{\$} - r_{i,c} + \pi = \gamma(\alpha_{i,1} + \alpha_{i,3} + \theta_i) \sigma^2 - \gamma v(1 - \alpha_{i,1} - \alpha_{i,3}) \quad (29)$$

$$r_{\$,c} - r_{i,c} + \pi - \tilde{\pi} = \gamma \frac{1}{N} \tilde{v} \alpha_{i,3} + \gamma(\alpha_{i,1} + \alpha_{i,3} + \theta_i) \sigma^2 - \gamma v(1 - \alpha_{i,1} - \alpha_{i,3}) \quad (30)$$

$$f_i = \gamma(\alpha_{i,1} + \alpha_{i,3} + \theta_i) \sigma^2 + \lambda \theta_i \quad (31)$$

From the last equation

$$\theta_i = -\frac{\gamma \sigma^2}{\gamma \sigma^2 + \lambda} (\alpha_{i,1} + \alpha_{i,3}) + \frac{f_i}{\gamma \sigma^2 + \lambda} \quad (32)$$

This is the sum of a hedge portfolio and a speculative portfolio. This again cannot be written as including a CIP arbitrage position after substituting the solution for $\alpha_{i,1} + \alpha_{i,3}$. This is again because CIP arbitrage is not possible without access to the country i safe asset. We have

$$\alpha_{i,1} + \alpha_{i,3} = \frac{-\gamma \sigma^2 f_i + (\lambda + \gamma \sigma^2)(\gamma v + r_{\$} - r_{i,c} + \pi)}{\lambda \gamma \sigma^2 + \lambda \gamma v + \gamma \sigma^2 \gamma v} \quad (33)$$

A.6 Mutual Funds

A.6.1 Optimal Hedging

In the paper, we assumed that mutual funds either perfectly hedge their foreign currency exposure or they adopt a given hedge ratio of less than 1. To see how

this could follow from an optimal forward market position by hedge funds, consider first the country i hedge fund that invest in the US. Assume that it sells θ_i dollars forward. Also, allow for a quadratic cost $0.5\lambda\theta_i^2$ in the forward market. The portfolio return of the mutual fund is then

$$R_{m,i} = (1 - \mu_{i,m})R_{\$}\frac{1}{S_{i,2}} + \mu_{i,m}\tilde{R}_{\$,c}\frac{1}{S_{i,2}} + \theta_i\left(\frac{1}{F_i} - \frac{1}{S_{i,2}}\right) - 0.5\lambda\theta_i^2 \quad (34)$$

Following the procedure in Appendix A of the paper, we have

$$ER_{m,i} = 1 + (1 - \mu_{i,m})r_{\$} + \mu_{i,m}(r_{\$,c} - \pi) - \theta_i f_i - 0.5\lambda\theta_i^2 \quad (35)$$

$$var(R_{m,i}) = (1 - \theta_i)^2\sigma^2 + \mu_{i,m}^2 v \quad (36)$$

With the mean-variance objective $E(R_{m,i}) - 0.5\gamma_m var(R_{m,i})$, the optimal portfolio share μ_{im} remains the same as in the paper. The optimal forward market position becomes

$$\theta_i = \frac{\gamma_m\sigma^2}{\gamma_m\sigma^2 + \lambda} - \frac{1}{\gamma_m\sigma^2 + \lambda}f_i \quad (37)$$

The last term is a speculative position. This is analogous to the speculative position of hedge funds, which is also proportional to f_i . As discussed in the paper, we simplify by allocating all the speculative positions to the hedge funds. The first term is equal to 1 when $\lambda = 0$. This is the baseline case in the paper, with perfect hedging. When $\lambda > 0$, this term is less than 1. This motivates the partial hedge ratio θ in Section 7 of the paper. The hedge ratio is $\gamma_m\sigma^2/(\gamma_m\sigma^2 + \lambda)$.

Next consider the mutual fund used by US households to invest in country i . Assuming that the fund buys κ_i dollars forward, its portfolio return (in dollars) is

$$R_{m,d,i} = (1 - \phi_{i,m})R_i S_{i,2} + \phi_{i,m}\tilde{R}_{\$,i,c} + \kappa_i\left(1 - \frac{S_{i,2}}{F_i}\right) - 0.5\lambda\kappa_i^2 \quad (38)$$

Again following Appendix A of the paper, we can write the expectation and variance of the return as

$$ER_{m,d,i} = 1 + (1 - \phi_{i,m})r_i + \phi_{i,m}(r_{\$,i,c} - \pi) + \kappa_i f_i - 0.5\lambda\kappa_i^2$$

$$var(R_{m,d,i}) = \phi_{i,m}^2 v + (1 - \phi_{i,m} - \kappa_i)^2\sigma^2$$

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 κ_i is

$$\kappa_i = \frac{\gamma_m\sigma^2}{\gamma_m\sigma^2 + \lambda}(1 - \phi_{i,m}) + \frac{1}{\gamma_m\sigma^2 + \lambda}f_i \quad (39)$$

We again abstract from the speculative second term. The hedge ratio implied by the first term is again $\gamma_m \sigma^2 / (\gamma_m \sigma^2 + \lambda)$. It is again 1 when λ is zero and less than 1 when $\lambda > 0$.

A.6.2 Alternative mutual fund assumptions

The paper assumes that mutual funds invest in the foreign safe asset and corporate bond. We could alternatively introduce mutual funds that only invest in the safe foreign asset, while hedging exchange rate risk. This clearly does not work as households in country i could then take a position in the safe domestic asset and hedged safe dollar asset. They would be able to conduct perfect CIP arbitrage. It is therefore important that the mutual funds in the paper also invest in a risky asset.

As alluded to in the text, what also does not work is to have a single mutual fund that US households can invest in, which holds a diversified portfolio of all assets in all of the N countries. The hedged return in dollars is then $r_i + f_i$ when investing in country i . The mutual fund could arbitrage these hedged returns across the N countries, so that $r_i + f_i$ is the same for all i . But that means that the CIP deviation $cip_i = f_i + r_i - r_{\$}$ is also the same for all i , which goes against the objective of the paper to understand differences in CIP deviations. More generally, there must be some friction to prevent such perfect cross-currency CIP arbitrage.

B Analytical Results Section 4

In this section, we derive the analytical results discussed in Section 4 of the paper. In Section B.1 we first linearize the three market clearing conditions for each of the N countries (safe asset market equilibrium, corporate bond market equilibrium and forward market equilibrium). In Sections B.2 to B.4, we use these to derive the impact of the three types of cross-country heterogeneity on the CIP deviation, safe interest rate and corporate spread for each country. In doing so we assume that the US variables are unaffected by the heterogeneity. Section B.5 confirms that this is indeed the case.

B.1 Linearization

We will simultaneously consider asymmetries across countries in wealth, productivity and safe asset supply:

$$W_i = W + \epsilon_{i,w} \quad (40)$$

$$A_i = A + \epsilon_{i,a} \quad (41)$$

$$d_{0,i} = d_0 + \epsilon_{i,d} \quad (42)$$

We assume that $\sum_{i=1}^N \epsilon_{i,w} = 0$, $\sum_{i=1}^N \epsilon_{i,a} = 0$ and $\sum_{i=1}^N \epsilon_{i,d} = 0$. In Section B.5 we will verify that under these assumptions there will be no change to US variables for marginal heterogeneity (taking derivatives with respect to these epsilons). Changes in the small countries relative to the symmetric case will cancel each other out. So $\hat{r}_s = \hat{r}_{s,c} = \hat{K}_d = 0$.

We will focus on a particular country i in what follows. There are 5 variables for country i that we need to solve: \hat{r}_i , $\hat{r}_{i,c}$, $\hat{r}_{s,i,c}$, \hat{f}_i and \hat{K}_i . Two of these can be immediately solved as a function of the others. First, from firm arbitrage we have

$$\hat{r}_{s,i,c} = \hat{r}_{i,c} + \hat{f}_i \quad (43)$$

Second, linearizing the firm first-order condition

$$A_i \nu K_i^{\nu-1} = 1 + r_{i,c} \quad (44)$$

and evaluating at the symmetric equilibrium, we have

$$A\nu(\nu-1)\bar{K}^{\nu-2}\hat{K}_i + \nu\bar{K}^{\nu-1}\hat{A}_i = \hat{r}_{i,c} \quad (45)$$

Therefore

$$\hat{K}_i = k_1 \epsilon_{i,a} - k_2 \hat{r}_{i,c} \quad (46)$$

where

$$k_1 = \frac{\bar{K}}{(1-\nu)A} \quad (47)$$

$$k_2 = \frac{1}{A\nu(1-\nu)\bar{K}^{\nu-2}} \quad (48)$$

Here $\bar{K} = cW$ is the capital stock in the symmetric equilibrium.

This leaves us with the three market equilibrium conditions, the safe asset market equilibrium, the corporate bond market equilibrium and the forward market equilibrium. These equilibrium conditions are

$$(1 - \alpha_{i,c} - \alpha_{i,m})W_i + \omega_{i,m}(1 - \phi_{i,m})W_d + B_i^{CIP} + B_i^{UIP} = D_i \quad (49)$$

$$K_i = \alpha_{i,c}W_i + \phi_{i,m}\omega_{i,m}W_d \quad (50)$$

$$B_i^{CIP} + \omega_{i,m}W_d - \alpha_{i,m}W_i + H_i = 0 \quad (51)$$

We replace the safe asset market equilibrium condition with an aggregate asset market equilibrium condition that we get by adding the first two equations and subtracting the last one. This gives

$$W_i - D_i - K_i = H_i - B_i^{UIP} \quad (52)$$

Replacing the safe asset market clearing condition with (52), and using $D_i = d_{i,0} - d_1 r_i$, $H_i = \Gamma_h f_i$, the system of equations becomes

$$W_i - K_i = d_0 + \epsilon_{i,d} - d_1 r_i + \Gamma_h f_i - B_i^{UIP} \quad (53)$$

$$K_i = \alpha_{i,c}W_i + \phi_{i,m}\omega_{i,m}W_d \quad (54)$$

$$B_i^{CIP} + \omega_{i,m}W_d - \alpha_{i,m}W_i + \Gamma_h f_i = 0 \quad (55)$$

We need to linearize (54)-(55). (53) is already in linear form.

It is useful to make two substitutions. The first one is $\hat{f}_i = \hat{c}i p_i - \hat{r}_i$, as we are ultimately interested in the CIP deviation. The second substitution is meant to focus on the corporate spread $\hat{\delta}_i = \hat{r}_{i,c} - \hat{r}_i$ as opposed to the corporate yield itself. To that end we make the substitution $\hat{r}_{i,c} = \hat{\delta}_i + \hat{r}_i$. We can then solve for $\hat{c}i p_i$, \hat{r}_i and $\hat{\delta}_i$.

(53) implies

$$\hat{r}_i = a_0 \epsilon_{i,a} - a_1 \epsilon_{i,w} + a_1 \epsilon_{i,d} - a_2 \hat{\delta}_i + a_3 \hat{c}i p_i \quad (56)$$

where $a_0 = k_1/\bar{a}$, $a_1 = 1/\bar{a}$, $a_2 = k_2/\bar{a}$ and $a_3 = \Gamma_h/\bar{a}$, with

$$\bar{a} = \rho + \Gamma_h + k_2 \quad (57)$$

Here $\rho = d_1 + \Gamma_a$. All a_i are positive.

Before making the two substitutions, linearizing (54)-(55) gives

$$k_1 \epsilon_{i,a} - k_2 \hat{r}_{i,c} = \hat{\alpha}_{i,c} W + h c \epsilon_{i,w} + \left(c \hat{\omega}_{i,m} + \frac{1}{N} (1-h) \hat{\phi}_{i,m} \right) NW \quad (58)$$

$$\Gamma(\hat{r}_i + \hat{f}_i) + \hat{\omega}_{i,m} NW - \hat{\alpha}_{i,m} W - (1-h) \epsilon_{i,w} + \Gamma_h \hat{f}_i = 0 \quad (59)$$

With the substitutions, these become

$$k_1\epsilon_{i,a} - k_2\hat{\delta}_i - k_2\hat{r}_i = \hat{\alpha}_{i,c}W + hc\epsilon_{i,w} + \left(c\hat{\omega}_{i,m} + \frac{1}{N}(1-h)\hat{\phi}_{i,m} \right) NW \quad (60)$$

$$\Gamma c\hat{p}_i + \hat{\omega}_{i,m}NW - \hat{\alpha}_{i,m}W - (1-h)\epsilon_{i,w} + \Gamma_h c\hat{p}_i - \Gamma_h \hat{r}_i = 0 \quad (61)$$

This involves changes in four portfolio shares. Substitute $\hat{r}^{s,i,c} = \hat{r}_{i,c} + \hat{f}_i$, $\hat{f}_i = c\hat{p}_i - \hat{r}_i$ and $\hat{r}_{i,c} = \hat{\delta}_i + \hat{r}_i$ into the portfolio shares. Differentiating the portfolio shares, using that $\tilde{v}_d = \tilde{v}$ then delivers

$$\hat{\alpha}_{i,c} = \frac{\hat{\delta}_i}{\gamma v} \quad (62)$$

$$\hat{\alpha}_{i,m} = -\frac{N}{\gamma c^2 \tilde{v}} c\hat{p}_i \quad (63)$$

$$\hat{\omega}_{i,m} = \frac{1}{\gamma \tilde{v} c^2} \left(c\hat{\delta}_i + c\hat{p}_i \right) - \frac{1-h}{Nc\gamma_m v} \hat{\delta}_i \quad (64)$$

$$\hat{\phi}_{i,m} = \frac{\hat{\delta}_i}{\gamma_m v} \quad (65)$$

Then (60) becomes

$$\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) \hat{\delta}_i + \frac{NW}{\gamma \tilde{v} c} c\hat{p}_i + hc\epsilon_{i,w} + k_2\hat{\delta}_i + k_2\hat{r}_i - k_1\epsilon_{i,a} = 0 \quad (66)$$

This implies

$$\hat{r}_i = b_0\epsilon_{i,a} - b_1\epsilon_{i,w} - b_2\hat{\delta}_i - b_3c\hat{p}_i \quad (67)$$

where

$$b_0 = \frac{k_1}{k_2} \quad (68)$$

$$b_1 = \frac{hc}{k_2} \quad (69)$$

$$b_2 = \frac{1}{k_2} \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) \quad (70)$$

$$b_3 = \frac{NW}{\gamma \tilde{v} c k_2} \quad (71)$$

Finally, (61) gives

$$\Gamma c\hat{p}_i + \frac{NW}{\gamma \tilde{v} c^2} \left(c\hat{\delta}_i + c\hat{p}_i \right) - \frac{(1-h)W}{c\gamma_m v} \hat{\delta}_i + \frac{NW}{\gamma \tilde{v} c^2} c\hat{p}_i - (1-h)\epsilon_{i,w} + \Gamma_h c\hat{p}_i - \Gamma_h \hat{r}_i = 0 \quad (72)$$

We can write this as

$$\left(\Gamma + 2\frac{NW}{\gamma\tilde{v}c^2} + \Gamma_h\right)\hat{c}ip_i + \frac{W}{\gamma c}\left(\frac{N}{\tilde{v}} - \frac{1-h}{h}\frac{1}{v}\right)\hat{\delta}_i - (1-h)\epsilon_{i,w} - \Gamma_h\hat{r}_i = 0 \quad (73)$$

To summarize, we have a system of three equations in the variables \hat{r}_i , $\hat{\delta}_i$ and $\hat{c}ip_i$:

$$\hat{r}_i = a_0\epsilon_{i,a} - a_1\epsilon_{i,w} + a_1\epsilon_{i,d} - a_2\hat{\delta}_i + a_3\hat{c}ip_i \quad (74)$$

$$\hat{r}_i = b_0\epsilon_{i,a} - b_1\epsilon_{i,w} - b_2\hat{\delta}_i - b_3\hat{c}ip_i \quad (75)$$

$$\left(\Gamma + 2\frac{NW}{\gamma c^2\tilde{v}} + \Gamma_h\right)\hat{c}ip_i + \frac{W}{\gamma c}\left(\frac{N}{\tilde{v}} - \frac{1-h}{h}\frac{1}{v}\right)\hat{\delta}_i - (1-h)\epsilon_{i,w} - \Gamma_h\hat{r}_i = 0 \quad (76)$$

We can solve all three variables by inverting a three by three matrix. Instead we follow the approach of first solving the first two equations and then substituting the result into (76). We will first solve for the CIP deviation this way, then the safe interest rate and then the corporate spread.

Before applying this, it is useful to point out that

$$\frac{N}{\tilde{v}} - \frac{1-h}{h}\frac{1}{v} > 0 \quad (77)$$

To see that, use that in the symmetric equilibrium in Section 3.1 of the paper we impose

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

From here it follows immediately that (77) holds as long as $\tilde{\pi} > \pi$. This implies that there is a larger perceived default risk of foreign than domestic firms, which we will assume.

B.2 Solving CIP deviation

First solve \hat{r}_i and $\hat{\delta}_i$ from (74)-(75). The solution is

$$\begin{pmatrix} \hat{r}_i \\ \hat{\delta}_i \end{pmatrix} = \frac{1}{b_2 - a_2} \begin{pmatrix} -a_1b_2 + b_1a_2 & a_0b_2 - b_0a_2 & a_1b_2 & b_2a_3 + a_2b_3 \\ a_1 - b_1 & -a_0 + b_0 & -a_1 & -(b_3 + a_3) \end{pmatrix} \begin{pmatrix} \epsilon_{i,w} \\ \epsilon_{i,a} \\ \epsilon_{i,d} \\ \hat{c}ip_i \end{pmatrix} \quad (78)$$

We can substitute this back into (76). This then becomes

$$z_1 \hat{c}i p_i + z_2 \epsilon_{i,w} - z_3 \epsilon_{i,a} + z_4 \epsilon_{i,d} = 0 \quad (79)$$

where

$$z_1 = \Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{a_3 + b_3}{b_2 - a_2} - \Gamma_h \frac{b_2 a_3 + a_2 b_3}{b_2 - a_2} \quad (80)$$

$$z_2 = -(1-h) + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{a_1 - b_1}{b_2 - a_2} - \Gamma_h \frac{-a_1 b_2 + b_1 a_2}{b_2 - a_2} \quad (81)$$

$$z_3 = \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{a_0 - b_0}{b_2 - a_2} - \Gamma_h \frac{-a_0 b_2 + b_0 a_2}{b_2 - a_2} \quad (82)$$

$$z_4 = -\frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{a_1}{b_2 - a_2} - \frac{\Gamma_h a_1 b_2}{b_2 - a_2} \quad (83)$$

It follows that

$$\hat{c}i p_i = -\frac{z_2}{z_1} \epsilon_{i,w} + \frac{z_3}{z_1} \epsilon_{i,a} - \frac{z_4}{z_1} \epsilon_{i,d} \quad (84)$$

It is immediate that $z_4 < 0$. For the others, redefine z_i after multiplying them by $(b_2 - a_2)k_2 \bar{a} > 0$. (79) then still holds. We have

$$\begin{aligned} z_1 &= (b_2 - a_2)k_2 \bar{a} \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_2 \bar{a} (a_3 + b_3) \\ &\quad - \Gamma_h k_2 \bar{a} (b_2 a_3 + a_2 b_3) \end{aligned} \quad (85)$$

$$\begin{aligned} z_2 &= -(1-h)(b_2 - a_2)k_2 \bar{a} + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_2 \bar{a} (a_1 - b_1) \\ &\quad + \Gamma_h k_2 \bar{a} (a_1 b_2 - b_1 a_2) \end{aligned} \quad (86)$$

$$z_3 = \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_2 \bar{a} (a_0 - b_0) + \Gamma_h k_2 \bar{a} (a_0 b_2 - b_0 a_2) \quad (87)$$

We now need to substitute the a_i , b_i and \bar{a} terms. This gives

$$\begin{aligned} z_1 &= \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) (\rho + \Gamma_h + k_2) \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) \\ &\quad - k_2^2 \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_2 \Gamma_h \\ &\quad - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{NW}{\gamma \tilde{v} c} (\rho + \Gamma_h + k_2) \\ &\quad - \Gamma_h^2 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) - \Gamma_h k_2 \frac{NW}{\gamma \tilde{v} c} \end{aligned}$$

It is easy to check that $z_1 > 0$. The easiest way to do this is first checking that $z_1 > 0$ when $\Gamma_h = 0$ and then checking that the sum of the terms multiplying Γ_h is positive as well. Since $z_4 < 0$, it is immediate that a country with a low supply of the safe asset ($\epsilon_{i,d}$ is low) has a relatively low CIP deviation.

Next, consider z_2 . After substituting the expressions for a_i , b_i and \bar{a} , we have

$$\begin{aligned} z_2 = & -(1-h) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) (\rho + \Gamma_h + k_2) + (1-h)k_2^2 \\ & + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_2 - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) hc (\rho + \Gamma_h + k_2) \\ & + \Gamma_h \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) - \Gamma_h k_2 hc \end{aligned}$$

First extract the terms that depend on Γ_h . The coefficient on Γ_h of these terms is equal to

$$\begin{aligned} & -(1-h) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) hc \\ & + \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) - k_2 hc \end{aligned}$$

Collecting terms, this is equal to

$$\frac{W}{\gamma v} + hk_2(1-c) \quad (88)$$

This is clearly positive. We can conclude that when Γ_h becomes very large, z_2 will definitely be positive, so the the CIP deviation is lower in a country with high household wealth.

Now consider the terms of z_2 that do not depend on Γ_h . These are

$$\begin{aligned} & -(1-h) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) (\rho + k_2) + (1-h)k_2^2 \\ & + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_2 - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) hc (\rho + k_2) \end{aligned}$$

Collecting terms, this is

$$-(1-h)k_2\rho - \frac{W}{\gamma} \left(\rho \frac{N}{\tilde{v}} + \frac{(1-h)k_2}{chv} \right) + \frac{W}{\gamma} \frac{N}{\tilde{v}} \left(\frac{1}{c} - 1 \right) k_2 \quad (89)$$

This can be positive or negative as the first two terms are negative, while the last term is positive. Multiplying by $c\gamma/(Wk_2)$, we can write this as

$$-(1-h) \frac{\gamma}{W} c\rho - c\rho \frac{1}{k_2} \frac{N}{\tilde{v}} - \frac{(1-h)}{hv} + \frac{N}{\tilde{v}} (1-c) \quad (90)$$

This is negative when c is sufficiently large. Other factors contributing to this being negative are a large ρ and small k_2 . When the overall term is negative, a country with high household wealth has a high CIP deviation. A low value of c , especially in combination with a low value of ρ and a large value of k_2 , can make this term positive. In that case, a country with high household wealth has a low CIP deviation.

Next, consider z_3 . We have

$$z_3 = \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_1 k_2 - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_1 (\rho + \Gamma_h + k_2) + \Gamma_h k_1 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) - \Gamma_h k_1 k_2$$

This is equal to

$$z_3 = -\frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_1 (\rho + \Gamma_h) + \Gamma_h k_1 \frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) \quad (91)$$

When we set $\Gamma_h = 0$, so abstracting from speculative forward demand, this becomes

$$z_3 = -\frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_1 \rho \quad (92)$$

This is negative. So without speculative forward demand, a country with low productivity will have a high CIP deviation.

To see how this conclusion may be modified with speculative forward demand, the terms in the expression for z_3 that are proportional to Γ_h are

$$-\frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_1 + k_1 \frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) \quad (93)$$

The first term is negative, while the second term is positive. When c is sufficiently small, the first term will dominate. In that case, speculative forward demand only amplifies the increase in the CIP deviation. When c is sufficiently large, the second term will dominate. In that case, the CIP deviation will be negative in a low productivity country with very strong speculative forward demand.

B.3 Solving safe interest rate

First, solve $\hat{\delta}_i$ and $\hat{c}ip_i$ from (74)-(75). The solution is

$$\begin{pmatrix} \hat{\delta}_i \\ \hat{c}ip_i \end{pmatrix} = \frac{-1}{a_2b_3 + b_2a_3} \begin{pmatrix} b_3a_1 + a_3b_1 & -b_3a_0 - a_3b_0 & -b_3a_1 & b_3 + a_3 \\ -b_2a_1 + a_2b_1 & b_2a_0 - a_2b_0 & b_2a_1 & a_2 - b_2 \end{pmatrix} \begin{pmatrix} \epsilon_{i,w} \\ \epsilon_{i,a} \\ \epsilon_{i,d} \\ \hat{r}_i \end{pmatrix} \quad (94)$$

Now substitute this result into

$$\left(\Gamma + 2\frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) \hat{c}ip_i + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \hat{\delta}_i - (1-h)\epsilon_{i,w} - \Gamma_h \hat{r}_i = 0 \quad (95)$$

and multiply by $-(a_2b_3 + b_2a_3)$. This gives

$$m_1 \hat{r}_i + m_2 \epsilon_{i,w} - m_3 \epsilon_{i,a} + m_4 \epsilon_{i,d} = 0 \quad (96)$$

where

$$\begin{aligned} m_1 &= \left(\Gamma + 2\frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (a_2 - b_2) + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) (b_3 + a_3) + \Gamma_h (a_2b_3 + b_2a_3) \\ m_2 &= \left(\Gamma + 2\frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (-b_2a_1 + a_2b_1) + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) (b_3a_1 + a_3b_1) + (1-h)(a_2b_3 + b_2a_3) \\ m_3 &= \left(\Gamma + 2\frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (-b_2a_0 + a_2b_0) + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) (b_3a_0 + a_3b_0) \\ m_4 &= -\frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) b_3a_1 + \left(\Gamma + \frac{2NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) b_2a_1 \end{aligned}$$

We have

$$\hat{r}_i = -\frac{m_2}{m_1} \epsilon_{i,w} + \frac{m_3}{m_1} \epsilon_{i,a} - \frac{m_4}{m_1} \epsilon_{i,d} \quad (97)$$

It is easy to quickly check that $m_4 > 0$. For the others, rescale m_i by multiplying each of them by $k_2 \bar{a}$. For m_1 this gives

$$\begin{aligned} m_1 &= \left(\Gamma + 2\frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_2^2 \\ &\quad - \left(\Gamma + 2\frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) (\rho + \Gamma_h + k_2) \\ &\quad + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{NW}{\gamma \tilde{v} c} (\rho + \Gamma_h + k_2) + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \Gamma_h k_2 \\ &\quad + \Gamma_h k_2 \frac{NW}{\gamma \tilde{v} c} + \Gamma_h^2 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) \end{aligned}$$

It is easy to check that $m_1 < 0$. The easiest way to do this is first checking that $m_1 < 0$ when $\Gamma_h = 0$ and then checking that the sum of the terms multiplying Γ_h is negative as well. It follows that a country with a low safe asset supply ($\epsilon_{i,d} < 0$) has a low safe rate.

After mutiplying by $k_2\bar{a}$, m_2 becomes

$$\begin{aligned} m_2 = & - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) + \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_2 hc \\ & + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{NW}{\gamma \tilde{v} c} + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \Gamma_h hc \\ & + (1-h) k_2 \frac{NW}{\gamma \tilde{v} c} + (1-h) \Gamma_h \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) \end{aligned}$$

First, consider the terms that do not depend on Γ_h . These are

$$\begin{aligned} & - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) + \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) k_2 hc \\ & + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{NW}{\gamma \tilde{v} c} + (1-h) k_2 \frac{NW}{\gamma \tilde{v} c} \end{aligned}$$

It is easy to check that this is negative. This means that in the absence of speculative forward demand for dollars, the safe interest rate will be lower in countries with high household wealth.

Now consider the terms that depend on Γ_h . The coefficient on Γ_h is

$$\begin{aligned} & - \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) + k_2 hc + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) hc \\ & + (1-h) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) \end{aligned}$$

This is equal to

$$-h(1-c)k_2 - \frac{W}{\gamma v} \quad (98)$$

This is also negative. Therefore, the safe interest rate will always be lower in countries with high household wealth.

After mutiplying by $k_2\bar{a}$, m_3 becomes

$$\begin{aligned} m_3 = & - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_1 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) + \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_1 k_2 \\ & + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{k_1 NW}{\gamma \tilde{v} c} + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \Gamma_h k_1 \end{aligned}$$

The terms not involving Γ_h are

$$\begin{aligned} & - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) k_1 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) + \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) k_1 k_2 \\ & + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \frac{k_1 NW}{\gamma \tilde{v} c} \end{aligned}$$

This is equal to

$$- \Gamma \frac{k_1 W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) - \frac{k_1 NW^2}{\gamma^2 c^2 \tilde{v}} \left(\frac{N}{\tilde{v}} + \frac{1+h}{h} \frac{1}{v} \right) \quad (99)$$

This is negative, so that a country with low productivity has a low interest rate in the absence of speculative forward positions.

The terms proportional to Γ_h are

$$-k_1 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) + k_1 k_2 + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) k_1 \quad (100)$$

This is equal to

$$- \frac{k_1 W}{\gamma v} \left(1 + \frac{1-h}{h} \frac{1}{c} \right) + \frac{k_1 W N}{\gamma \tilde{v}} \left(\frac{1}{c} - 1 \right) \quad (101)$$

The first term is negative, while the second term is positive. When c is large enough, the first term will dominate and the interest rate will be lower in low productivity countries, no matter the degree of speculative forward trade. But when c is small enough, the second term will dominate. In that case, the interest rate will be higher in a low productivity country for sufficiently large speculative forward trade.

B.4 Solving corporate spread

First solve \hat{r}_i and $\hat{c}ip_i$ from (74)-(75). The solution is

$$\begin{pmatrix} \hat{r}_i \\ \hat{c}ip_i \end{pmatrix} = \frac{-1}{a_3 + b_3} \begin{pmatrix} b_3 a_1 + a_3 b_1 & -b_3 a_0 - a_3 b_0 & -b_3 a_1 & b_3 a_2 + a_3 b_2 \\ b_1 - a_1 & a_0 - b_0 & a_1 & b_2 - a_2 \end{pmatrix} \begin{pmatrix} \epsilon_{i,w} \\ \epsilon_{i,a} \\ \epsilon_{i,d} \\ \hat{\delta}_i \end{pmatrix} \quad (102)$$

Now substitute this result into

$$\left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) \hat{c}ip_i + \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \hat{\delta}_i - (1-h)\epsilon_{i,w} - \Gamma_h \hat{r}_i = 0 \quad (103)$$

and multiply by $-(a_3 + b_3)$. This gives

$$h_1 \hat{\delta}_i + h_2 \epsilon_{i,w} - h_3 \epsilon_{i,a} + h_4 \epsilon_{i,d} = 0 \quad (104)$$

where

$$\begin{aligned} h_1 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (b_2 - a_2) - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) (a_3 + b_3) - \Gamma_h (b_3 a_2 + b_2 a_3) \\ h_2 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (b_1 - a_1) + (1-h)(a_3 + b_3) - \Gamma_h (b_3 a_1 + a_3 b_1) \\ h_3 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (b_0 - a_0) - \Gamma_h (b_3 a_0 + a_3 b_0) \\ h_4 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) a_1 + \Gamma_h b_3 a_1 \end{aligned}$$

It follows that

$$\hat{\delta}_i = -\frac{h_2}{h_1} \epsilon_{i,w} + \frac{h_3}{h_1} \epsilon_{i,a} - \frac{h_4}{h_1} \epsilon_{i,d} \quad (105)$$

It is immediate that $h_4 > 0$. For the others, rescale all h_i by multiplying each of them by $k_2 \bar{a}$. For h_1 this gives

$$\begin{aligned} h_1 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (\rho + \Gamma_h + k_2) \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) \\ &\quad - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_2^2 - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) \Gamma_h k_2 \\ &\quad - \frac{W}{\gamma c} \left(\frac{N}{\tilde{v}} - \frac{1-h}{h} \frac{1}{v} \right) (\rho + \Gamma_h + k_2) \frac{NW}{\gamma \tilde{v} c} \\ &\quad - \Gamma_h k_2 \frac{NW}{\gamma \tilde{v} c} - \Gamma_h^2 \left(\frac{W}{\gamma} \left(\frac{1}{v} + \frac{N}{\tilde{v}} \right) + k_2 \right) \end{aligned}$$

Collecting terms, it is easy to show that $h_1 > 0$ by first setting $\Gamma_h = 0$ and then focusing on the terms in Γ_h . Since $h_4 > 0$, it follows that a country with a low safe asset supply ($\epsilon_{i,d} < 0$) has a high corporate spread.

After mutiplying by $k_2 \bar{a}$, h_2 becomes

$$\begin{aligned} h_2 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (\rho + \Gamma_h + k_2) hc - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_2 \\ &\quad + (1-h) \Gamma_h k_2 + (1-h) \frac{NW}{\gamma \tilde{v} c} (\rho + \Gamma_h + k_2) - \Gamma_h \frac{NW}{\gamma \tilde{v} c} - \Gamma_h^2 hc \end{aligned}$$

When $\Gamma_h = 0$, this becomes

$$\begin{aligned} & \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) (\rho + k_2) hc - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) k_2 \\ & + (1 - h) \frac{NW}{\gamma \tilde{v} c} (\rho + k_2) \end{aligned}$$

This is equal to

$$- \left((1 - hc)\Gamma + \frac{NW}{\gamma c^2 \tilde{v}} (2 - hc - c) \right) k_2 + \rho \left(hc\Gamma + \frac{NW}{\gamma c \tilde{v}} (h + 1) \right) \quad (106)$$

The first term is negative, while the second term is positive. Overall, this term is negative when k_2 is large and ρ is small. In that case the corporate spread is higher in a country with high household wealth. The corporate spread is lower in a country with high household wealth when k_2 is small, c is large and ρ is large.

The coefficient on Γ_h in the expression for h_2 add up to

$$hc \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} \right) + hc(\rho + k_2) - k_2 + (1 - h)k_2 + (1 - h) \frac{NW}{\gamma \tilde{v} c} - \frac{NW}{\gamma \tilde{v} c} \quad (107)$$

This is equal to

$$hc \left(\rho + \Gamma + \frac{NW}{\gamma \tilde{v} c^2} \right) - h(1 - c)k_2 \quad (108)$$

The first term is positive, while the second term is negative. The same conclusion applies as when $\Gamma_h = 0$. Overall this term is negative when k_2 is large and ρ is small. The term is positive when k_2 is small and ρ is large.

After multiplying by $k_2 \bar{a}$, h_3 becomes

$$\begin{aligned} h_3 &= \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) (\rho + \Gamma_h + k_2) k_1 - \left(\Gamma + 2 \frac{NW}{\gamma c^2 \tilde{v}} + \Gamma_h \right) k_1 k_2 \\ & \quad - \frac{NW}{\gamma \tilde{v} c} \Gamma_h k_1 - \Gamma_h^2 k_1 \end{aligned}$$

It is easy to check that this is always positive. It follows that the corporate spread is lower in a country with low productivity.

B.5 US Variables

It remains to be shown that US interest rates do not change as a result of the heterogeneity among small countries, so that $\hat{r}_s = \hat{r}_{s,c} = 0$. To this end, we need

to differentiate the two market clearing conditions for the US:

$$\begin{aligned} & \left(1 - \omega_{d,c} - \sum_{i=1}^N \omega_{i,m}\right) W_d + \sum_{i=1}^N \alpha_{i,m} (1 - \mu_{i,m}) W_i - \sum_{i=1}^N B_i^{CIP} - \sum_{i=1}^N B_i^{UIP} = D_d \quad (109) \\ & \left(\frac{A_d \nu}{1 + r_{\$,c}}\right)^{\frac{1}{1-\nu}} = \sum_{i=1}^N \alpha_{i,m} \mu_{i,m} W_i + \omega_{d,c} W_d \quad (110) \end{aligned}$$

We assumed that $\sum_{i=1}^N \epsilon_{i,w} = 0$, $\sum_{i=1}^N \epsilon_{i,a} = 0$ and $\sum_{i=1}^N \epsilon_{i,d} = 0$. It immediately follows that $\sum_{i=1}^N \hat{c}i p_i = \sum_{i=1}^N \hat{r}_i = \sum_{i=1}^N \hat{\delta}_i = 0$. From this it is also immediate that $\sum_{i=1}^N \hat{\alpha}_{i,m} = \sum_{i=1}^N \hat{\omega}_{i,m} = 0$. It is then easy to check that the two market equilibrium conditions can be written as two linear expressions in $\hat{r}_{\$}$ and $\hat{r}_{\$,c}$ that are both zero. It follows that $\hat{r}_{\$} = \hat{r}_{\$,c} = 0$.

C Goods Market Equilibrium

In the paper, we make some assumptions about exchange rates without specifying the goods market equilibrium in the model. Here, we show that these exchange rate assumptions can be justified with the right assumptions regarding the goods market. For period 1 we assume that the bilateral exchange rate of the N currencies relative to the dollar are all 1, while for period 2 we assume that the log exchange rates $s_{i,2}$ have a mean 0 and variance σ^2 .

The description of the goods market that follows can be applied to both periods 1 and 2. Let $S_{i,t}$ be the exchange rate in period $t = 1, 2$ (dollars per unit of currency i). Output and endowments in the paper are defined in terms of the domestic consumption index, which is a composite basket of $N + 1$ goods. We will refer to these goods as each being associated with an individual country, although one needs to keep in mind that country i produces a basket of goods, not just country i goods.

The consumption index is defined the same for all agents within a country. For respectively small country i and the US, these indices are

$$C_{i,t} = \left((1 - \bar{\omega})^{1/\theta} C_{ii,t}^{(\theta-1)/\theta} + \bar{\omega}^{1/\theta} C_{id,t}^{(\theta-1)/\theta} \right)^{\theta/(\theta-1)} \quad (111)$$

$$C_{d,t} = \left((1 - \omega)^{1/\theta} C_{dd,t}^{(\theta-1)/\theta} + \sum_{i=1}^N (\omega/N)^{1/\theta} C_{di,t}^{(\theta-1)/\theta} \right)^{\theta/(\theta-1)} \quad (112)$$

Here $C_{ii,t}$ is consumption of the country i good by country i agents. Similarly, $C_{dd,t}$ is consumption of the US good by US agents. $C_{id,t}$ is consumption of the US good by country i agents and $C_{di,t}$ is consumption of the country i good by US agents. The same indices apply to investment K_i and K_d in period 1.

Central banks target a price index of 1 in each country during both periods. $C_{i,t}$ is then total consumption spending as well. For simplicity, we will think of $C_{i,t}$ as aggregate spending by all agents in country i , including investment spending by firms in period 1 as well. $C_{i,t}$ follows from the solution described in the paper, which depends on exchange rates as well. We will take $C_{i,t}$ as given.

The supply of goods is associated with endowments and production. Households and safe asset suppliers receive endowments. Firms produce output in period 2, which generally varies across countries as productivity differs. Let $Z_{i,t}$ and $Z_{d,t}$ be the real value of all endowments plus production in country i and the US. These are also the nominal values in terms of the currencies of these countries as central banks target a price index of 1 in each country. Let $p_{i,t}$ be the price of the good of country i in the country i currency and $p_{d,t}$ the price of the US good in dollars. $Z_{i,t}$ is a bundle that consists of $Z_{ii,t}$ country i goods and $Z_{id,t}$ US goods. Similarly, $Z_{d,t}$ is a bundle that consists of $Z_{dd,t}$ US goods and $Z_{di,t}$ country i goods of each of the N small countries. We then have

$$Z_{i,t} = p_{i,t}Z_{ii,t} + \frac{p_{d,t}}{S_{i,t}}Z_{id,t} \quad (113)$$

$$Z_{d,t} = p_{d,t}Z_{dd,t} + \sum_{i=1}^N p_{i,t}S_{i,t}Z_{di,t} \quad (114)$$

The goods market equilibrium for the small country i good is

$$C_{ii,t} + C_{di,t} = Z_{ii,t} + Z_{di,t} \quad (115)$$

We can ignore the goods market equilibrium for the US good by Walras' Law.

The price indices for agents in country i and the US can be written as

$$P_{i,t} = \left((1 - \bar{\omega})p_{i,t}^{1-\theta} + \bar{\omega}p_{d,t}^{1-\theta}S_{i,t}^{\theta-1} \right)^{1/(1-\theta)} \quad (116)$$

$$P_{d,t} = \left((1 - \omega)p_{d,t}^{1-\theta} + \sum_{i=1}^N (\omega/N)p_{i,t}^{1-\theta}S_{i,t}^{1-\theta} \right)^{1/(1-\theta)} \quad (117)$$

Since central banks target these price indices to be 1, we can use them to solve for prices $p_{i,t}$ and $p_{d,t}$ as a function of the exchange rates.

Country i agents allocate total spending across country i and US goods as follows:

$$C_{ii,t} = (1 - \bar{\omega})p_{i,t}^{-\theta}C_{i,t} \quad (118)$$

$$C_{id,t} = \bar{\omega}(p_{d,t}/S_{i,t})^{-\theta}C_{i,t} \quad (119)$$

This uses that the overall price index is 1. Similarly, for US agents

$$C_{dd,t} = (1 - \omega)p_{d,t}^{-\theta}C_{d,t} \quad (120)$$

$$C_{di,t} = (\omega/N)(p_{i,t}S_{i,t})^{-\theta}C_{d,t} \quad (121)$$

After substituting these into the goods market equilibrium for country i goods, we have

$$(1 - \bar{\omega})p_{i,t}^{-\theta}C_{i,t} + (\omega/N)(p_{i,t}S_{i,t})^{-\theta}C_{d,t} = Z_{ii,t} + Z_{di,t} \quad (122)$$

Combine this with (113)-(114), which are repeated below for convenience

$$Z_{i,t} = p_{i,t}Z_{ii,t} + \frac{p_{d,t}}{S_{i,t}}Z_{id,t} \quad (123)$$

$$Z_{d,t} = p_{d,t}Z_{dd,t} + \sum_{i=1}^N p_{i,t}S_{i,t}Z_{di,t} \quad (124)$$

Now consider given values of $S_{i,t}$, either 1 for period 1 or based on draws from the exogenous distribution for the log exchange rates in period 2. We have seen that these values of $S_{i,t}$ also determine $p_{i,t}$ and $p_{d,t}$. Normally, we would solve for the N exchange rates from the N goods market equilibrium conditions (124), taking $Z_{ii,t}$, $Z_{id,t}$, $Z_{dd,t}$ and $Z_{di,t}$ as given. But here we reverse engineer. (122)-(124) give us $2N + 1$ equations. For given values of the exchange rates, we pick the $3N + 1$ values of $Z_{ii,t}$, $Z_{id,t}$, $Z_{dd,t}$ and $Z_{di,t}$ such that the $2N + 1$ equations (122)-(124) are satisfied. We even have N degrees of freedom to achieve this. The point is that for any set of exchange rates (and therefore goods prices), we can always decompose output and production of each country into bundles of the right amount of goods of each country such that goods market equilibrium is satisfied and the nominal and real values of output plus production corresponds to $Z_{i,t}$ in country i and $Z_{d,t}$ in the US.