The Share of Systematic Risk
in Bilateral Exchange Rates
- Supplementary Online Appendix -
NOT FOR PUBLICATION

This appendix first presents the general case of the model and the associated proofs (Appendix A), and then turns to robustness checks and extensions of the empirical results reported in the paper, notably on pairwise exchange rate regressions (Appendix B), on subsamples (pre-crisis and pre- and post-euro) and on rolling windows (Appendix C). Appendix D compares currency factors to principal components using pseudo-predictability tests. Appendix E studies other potential factors (like momentum), while Appendix F focuses on the dynamics of bid-ask spreads. Appendix G reports robustness checks on the length of the rolling windows used to build dollar-beta portfolios. Appendix H reports the correlation among the different currency factors, as well as among their volatilities. Appendix I reports the benchmark tests using different base currencies. Finally, I check that the carry and dollar factors are priced in country-level excess returns (Appendix J), and that the same shocks that drive exchange rate levels affect exchange rate volatilities (Appendix K).

Appendix A Model and Proofs

The model presented in the main text is a special case of the full model presented in this Appendix. I first present the full model and then define the parameter restriction that leads to the special case. For the Appendix to be self-contained, some elements already presented in the main text are mentioned again here.

Appendix A.1 General Case

Model In the model, the log nominal SDF in each country i evolves as:[22]

$$-m_{i,t+1} = \alpha_i + \chi_i \sigma_{i,t}^2 + \tau_i \sigma_{w,t}^2 + \gamma_i \sigma_{i,t} u_{i,t+1} + \sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}\, u_{w,t+1} + \sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}\, u_{g,t+1}, \quad (23)$$

where the shocks u^i, $u_{w,t+1}$, and $u_{w,t+1}$ are *i.i.d* Gaussian, with zero mean and unit variance. The country-specific and world state variables are governed by autoregressive Gamma processes:

$$\sigma_{i,t+1}^2 = \phi_i \sigma_{i,t}^2 + v_{i,t+1}, \quad (24)$$
$$\sigma_{w,t+1}^2 = \phi_w \sigma_{w,t}^2 + v_{w,t+1}, \quad (25)$$

[22] In Lustig et al. (2014), the SDF is a real variable, and inflation in each country is defined as $\pi_{t+1}^i = \pi_0 + \eta^w z_t^w + \sigma_\pi \epsilon_{t+1}^i$. Since inflation risk is not priced, the model can be as well defined in terms of nominal SDFs as above.

where the shocks $v_{i,t+1}$ and $v_{w,t+1}$ are drawn in a Gamma distribution, such that $E(v_i) = \theta_i^2(1-\phi_i)$, $var(V_i) = \sigma_i^2$, $E(v_w) = \theta_w^2(1-\phi_w)$, $var(V_w) = \sigma_w^2$. The unconditional mean of the country-specific and world state volatilities are thus $E(\sigma_i^2) = \theta_i^2$ and $E(\sigma_w^2) = \theta_w^2$. The Gamma distributions ensure that the volatilities remain positive. Each Gamma distribution is characterized by its shape, $k > 0$, and its scale, $\zeta > 0$. The parameters k_i and ζ_i that govern the shocks $v_{i,t+1}$ are equal to $k_i = \left[\theta_i^2(1-\phi_i)\right]^2 / \sigma_i^2$ and $\zeta_i = \sigma_i^2 / \left[\theta_i^2(1-\phi_i)\right]$. A similar choice defines the distribution of the $v_{w,t+1}$ shocks: $k_w = \left[\theta_w^2(1-\phi_w)\right]^2 / \sigma_w^2$ and $\zeta_w = \sigma_w^2 / \left[\theta_w^2(1-\phi_w)\right]$.

Interest Rates Since the shocks to the log SDF are Gaussian, the risk-free rate in country i is:

$$\begin{aligned} r_{i,t} &= -\log E_t\left(M_{i,t+1}\right) = -E_t\left(m_{i,t+1}\right) - \frac{1}{2} var_t\left(m_{i,t+1}\right), \\ &= \alpha_i + \chi_i \sigma_{i,t}^2 + \tau_i \sigma_{w,t}^2 - \frac{1}{2}\left(\gamma_i^2 \sigma_{i,t}^2 + \delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2 + \eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2\right), \\ &= \alpha_i + \left(\chi_i - \frac{1}{2}(\gamma_i^2 + \lambda_i^2 + \kappa_i^2)\right) \sigma_{i,t}^2 + \left(\tau_i - \frac{1}{2}(\delta_i^2 + \eta_i^2)\right) \sigma_{w,t}^2. \end{aligned} \tag{26}$$

The average interest rate difference between the foreign and U.S. interest rates, also known as average forward discount, is:

$$\begin{aligned} AFD_t &= \frac{1}{N} \sum_i \left(r_{i,t} - r_t\right) = \overline{r_{i,t}} - r_t = \overline{\alpha_i} - \alpha + \overline{\left(\chi_i - \frac{1}{2}(\gamma_i^2 + \lambda_i^2 + \kappa_i^2)\right) \sigma_{i,t}^2} \\ &- \left(\chi - \frac{1}{2}(\gamma^2 + \lambda^2 + \kappa^2)\right) \sigma_t^2 + \left(\overline{\tau_i} - \tau - \frac{1}{2}\overline{(\delta_i^2 + \eta_i^2)} + \frac{1}{2}(\delta^2 + \eta^2)\right) \sigma_{w,t}^2. \end{aligned} \tag{27}$$

where a bar superscript ($\overline{x}$) denotes the average of any variable or parameter x across all countries. We drop the subscript $i = U.S.$ for any variable or parameter that corresponds to the home country.

Bilateral Exchange Rates The log change in bilateral exchange rates is the difference in log SDFs:

$$\begin{aligned} \Delta s_{i,t+1} &= m_{t+1} - m_{t+1}^i, \qquad (28) \\ &= \alpha_i - \alpha + \chi_i \sigma_{i,t}^2 - \chi \sigma_t^2 + (\tau_i - \tau)\sigma_{w,t}^2 \overbrace{+\gamma_i \sigma_{i,t} u_{i,t+1}}^{Country\ i-spec.shocks} - \overbrace{\gamma \sigma_t u_{t+1}}^{U.S.-spec.shocks} \\ &+ \underbrace{\left(\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2} - \sqrt{\delta^2 \sigma_{w,t}^2 + \lambda^2 \sigma_t^2}\right) u_{w,t+1} + \left(\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2} - \sqrt{\eta^2 \sigma_{w,t}^2 + \kappa^2 \sigma_t^2}\right) u_{g,t+1}}_{Global\ shocks}, \end{aligned}$$

where the second line presents the global components of exchange rates. If the parameters χ_i, χ, $\tau_i - \tau$ are all zero, then the exchange rate is a random walk and the U.I.P slope coefficient is zero.

The conditional variance of the exchange rate changes, $E_t\left(\Delta s^i_{t+1} - E_t(\Delta s^i_{t+1})\right)^2$, is:

$$
\begin{aligned}
Var_t\left(\Delta s^i_{t+1}\right) &= \gamma_i^2\sigma_{i,t}^2 + \gamma^2\sigma_t^2 + \left(\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)^2 \\
&+ \left(\sqrt{\eta_i^2\sigma_{w,t}^2 + \kappa_i^2\sigma_{i,t}^2} - \sqrt{\eta^2\sigma_{w,t}^2 + \kappa^2\sigma_t^2}\right)^2. \qquad (29)
\end{aligned}
$$

The exchange rate volatility is driven by three state variables, $\sigma^2_{i,t}$, σ^2_t, and $\sigma^2_{w,t}$. Exchange rate volatilities thus exhibit a common factor structure. Changes in exchange rate volatilities are described by the carry and dollar factors only if the shocks to the log SDF ($u_{i,t+1}$, u_{t+1}, $u_{w,t+1}$, and $u_{g,t+1}$) are correlated to the volatility shocks ($v_{i,t+1}$, v_{t+1}, and $v_{w,t+1}$).

Dollar Risk Factor The dollar risk factor is the average of all exchange rates defined in terms of U.S. dollars, and thus corresponds to:

$$
Dollar_{t+1} = \frac{1}{N}\sum_i \Delta s^i_{t+1}, \qquad (30)
$$

where N denotes the number of currencies in the sample. The Dollar factor is thus:

$$
\begin{aligned}
Dollar_{t+1} &= \overline{\alpha_i} - \alpha + \overline{\chi_i\sigma_{i,t}^2} - \chi\sigma_t^2 + \overline{\gamma_i\sigma_{i,t}u_{i,t+1}} - \gamma\sigma_t u_{t+1} \\
&+ \left(\overline{\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2}} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right) u_{w,t+1} \\
&+ \left(\overline{\sqrt{\eta_i^2\sigma_{w,t}^2 + \kappa_i^2\sigma_{i,t}^2}} - \sqrt{\eta^2\sigma_{w,t}^2 + \kappa^2\sigma_t^2}\right) u_{g,t+1}. \qquad (31)
\end{aligned}
$$

The volatility of the dollar factor is:

$$
\begin{aligned}
Var_t(Dollar_{t+1}) &= \overline{\gamma_i^2\sigma_{i,t}^2} - \gamma^2\sigma_t^2 + \left(\overline{\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2}} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)^2 \\
&+ \left(\overline{\sqrt{\eta_i^2\sigma_{w,t}^2 + \kappa_i^2\sigma_{i,t}^2}} - \sqrt{\eta^2\sigma_{w,t}^2 + \kappa^2\sigma_t^2}\right)^2. \qquad (32)
\end{aligned}
$$

The conditional slope coefficient on the dollar factor, or dollar beta, is equal to:

$$
\begin{aligned}
\beta^i_{Dollar,t} &= \frac{cov_t(\Delta s^i_{t+1}, Dollar_{t+1})}{var_t(Dollar_{t+1})} \\
&= \frac{cov_t(\gamma_i u^i_{t+1}, \overline{\gamma_i\sigma_{i,t}u_{i,t+1}})}{var_t(Dollar_{t+1})} \\
&+ \frac{\gamma^2\sigma_t^2 + \left(\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)\left(\overline{\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2}} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)}{var_t(Dollar_{t+1})} \\
&+ \frac{\left(\sqrt{\eta_i^2\sigma_{w,t}^2 + \kappa_i^2\sigma_{i,t}^2} - \sqrt{\eta^2\sigma_{w,t}^2 + \kappa^2\sigma_t^2}\right)\left(\overline{\sqrt{\eta_i^2\sigma_{w,t}^2 + \kappa_i^2\sigma_{i,t}^2}} - \sqrt{\eta^2\sigma_{w,t}^2 + \kappa^2\sigma_t^2}\right)}{var_t(Dollar_{t+1})}. \qquad (33)
\end{aligned}
$$

Carry Risk Factor The carry risk factor is the average exchange rate of high- versus low-interest rate currencies:

$$Carry_{t+1} = \frac{1}{N_H}\sum_{i\in H}\Delta s^i_{t+1} - \frac{1}{N_L}\sum_{i\in L}\Delta s^i_{t+1}, \tag{34}$$

where N_H (N_L) denotes the number of high (low) interest rate currencies in the sample. The Carry factor is thus:

$$\begin{aligned} Carry_{t+1} &= \overline{\alpha_i}^H - \overline{\alpha_i}^L + \overline{\chi_i\sigma^2_{i,t}}^H - \overline{\chi_i\sigma^2_{i,t}}^L + \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^H - \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^L \\ &+ \left(\overline{\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}}}^H - \overline{\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}}}^L\right) u_{w,t+1} \\ &+ \left(\overline{\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}}}^H - \overline{\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}}}^L\right) u_{g,t+1} \end{aligned} \tag{35}$$

where $\overline{x^i}^H$ and $\overline{x^i}^L$ denote the average of any variable inside each portfolio ($\overline{x^i}^H = \frac{1}{N_H}\sum_{i\in H} x^i$, $\overline{x^i}^L = \frac{1}{N_L}\sum_{i\in L} x^i$). The volatility of the Carry factor is then:

$$\begin{aligned} Var_t(Carry_{t+1}) &= \overline{\gamma_i^2\sigma^2_{i,t}}^H - \overline{\gamma_i^2\sigma^2_{i,t}}^L + \left(\overline{\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}}}^H - \overline{\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}}}^L\right)^2 \\ &+ \left(\overline{\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}}}^H - \overline{\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}}}^L\right)^2. \end{aligned} \tag{36}$$

Formally, the conditional slope coefficient on the carry factor or beta is equal to:

$$\begin{aligned} \beta^i_{Carry,t} &= \frac{cov_t(\Delta s^i_{t+1}, Carry_{t+1})}{var_t(Carry_{t+1})} \qquad (37) \\ &= \frac{cov_t(\gamma_i\sigma_{i,t}u_{i,t+1}, \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^H - \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^L)}{var_t(Carry_{t+1})} \\ &+ \frac{\left(\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}} - \sqrt{\delta^2\sigma^2_{w,t} + \lambda^2\sigma^2_t}\right)\left(\overline{\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}}}^H - \overline{\sqrt{\delta_i^2\sigma^2_{w,t} + \lambda_i^2\sigma^2_{i,t}}}^L\right)}{var_t(Carry_{t+1})} \\ &+ \frac{\left(\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}} - \sqrt{\eta^2\sigma^2_{w,t} + \kappa^2\sigma^2_t}\right)\left(\overline{\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}}}^H - \overline{\sqrt{\eta_i^2\sigma^2_{w,t} + \kappa_i^2\sigma^2_{i,t}}}^L\right)}{var_t(Carry_{t+1})}. \end{aligned}$$

Global component of the dollar factor A measure of the global component of the dollar factor can be obtained by going long in a set of high dollar-beta-currencies and short in a set of low dollar-beta-currencies:

$$Dollar\ Global_{t+1} = \frac{1}{N_H\beta}\sum_{i\in H\beta}\Delta s^i_{t+1} - \frac{1}{N_L\beta}\sum_{i\in L\beta}\Delta s^i_{t+1}, \tag{38}$$

where $N_{H\beta}$ and $N_{L\beta}$ denote the number of currencies in the high ($H\beta$) and low ($L\beta$) dollar beta portfolios. The global component of the dollar factor is thus:

$$\begin{aligned} Dollar\ Global_{t+1} &= \overline{\alpha_i}^{H\beta} - \overline{\alpha_i}^{L\beta} + \overline{\chi_i \sigma_{i,t}^2}^{H\beta} - \overline{\chi_i \sigma_{i,t}^2}^{L\beta} + \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^{H\beta} - \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^{L\beta} \\ &+ \left(\overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{H\beta} - \overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{L\beta} \right) u_{w,t+1} \\ &+ \left(\overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{H\beta} - \overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{L\beta} \right) u_{g,t+1}, \end{aligned} \tag{39}$$

where $\overline{x^i}^{H\beta} = \frac{1}{N_{H\beta}} \sum_{i \in H\beta} x^i$, $\overline{x^i}^{L\beta} = \frac{1}{N_{L\beta}} \sum_{i \in L\beta} x^i$. The conditional covariance between the global component of the dollar factor and the carry factor is:

$$\begin{aligned} cov_t \quad & (Dollar\ Global_{t+1}, Carry_{t+1}) = cov_t \left(\overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^{H} - \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^{L}, \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^{H\beta} - \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^{L\beta} \right) \\ + & \left(\overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{H\beta} - \overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{L\beta} \right) \left(\overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{H} - \overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{L} \right) \\ + & \left(\overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{H\beta} - \overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{L\beta} \right) \left(\overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{H} - \overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{L} \right). \end{aligned} \tag{40}$$

The volatility of the global component of the dollar factor is:

$$\begin{aligned} Var_t \left(Dollar\ Global_{t+1} \right) &= \overline{\gamma_i^2 \sigma_{i,t}^2}^{H\beta} - \overline{\gamma_i^2 \sigma_{i,t}^2}^{L\beta} + \left(\overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{H\beta} - \overline{\sqrt{\delta_i^2 \sigma_{w,t}^2 + \lambda_i^2 \sigma_{i,t}^2}}^{L\beta} \right)^2 \\ &+ \left(\overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{H\beta} - \overline{\sqrt{\eta_i^2 \sigma_{w,t}^2 + \kappa_i^2 \sigma_{i,t}^2}}^{L\beta} \right)^2. \end{aligned} \tag{41}$$

Appendix A.2 Special Case

The main text focuses on the case of orthogonal risk factors. In the data, the correlation between the Carry and the Dollar is not statistically significant, so this is a natural starting point. The special case presented in the main text corresponds to the following parameter restrictions of the full model: (i) $\chi_i = \frac{1}{2}(\gamma_i^2 + \lambda_i^2 + \kappa_i^2)$ in all countries except the U.S., where $\chi < \frac{1}{2}(\gamma^2 + \lambda^2 + \kappa^2)$; (ii) $\overline{\delta_i} = \delta$; and (iii) $\eta_i = 0$ and $\lambda_i = 0$. The first restriction implies that foreign risk-free rates do not depend on the foreign country-specific volatilities while precautionary savings dominate in the U.S. The second restriction assumes that the U.S. SDF loads on the world shocks as the average country in the sample. The third restriction introduces a clear asymmetry between the two global shocks and thus simplifies a lot the exposition: their volatilities depend either on global or on country-specific shocks. As shown in the main text, these three restrictions imply that the factors are orthogonal.

Appendix A.3 Proofs

Conditional Carry Risk Premium I show here that in the general version of the model, the assumption that carry betas are constant leads to counterfactual implications on the volatility of the dollar and carry factors.

For the reader's convenience, I repeat here the conditional slope coefficient on the carry factor or carry beta presented in Equation (37):

$$\begin{aligned}
\beta^i_{Carry,t} &= \frac{cov_t(\Delta s^i_{t+1}, Carry_{t+1})}{var_t(Carry_{t+1})} \qquad (42)\\
&= \frac{cov_t(\gamma_i u_{i,t+1}, \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^H - \overline{\gamma_i \sigma_{i,t} u_{i,t+1}}^L)}{var_t(Carry_{t+1})} \\
&+ \frac{\left(\sqrt{\delta_i^2 \sigma^2_{w,t} + \lambda_i^2 \sigma^2_{i,t}} - \sqrt{\delta^2 \sigma^2_{w,t} + \lambda^2 \sigma^2_t}\right)\left(\overline{\sqrt{\delta_i^2 \sigma^2_{w,t} + \lambda_i^2 \sigma^2_{i,t}}}^H - \overline{\sqrt{\delta_i^2 \sigma^2_{w,t} + \lambda_i^2 \sigma^2_{i,t}}}^L\right)}{var_t(Carry_{t+1})} \\
&+ \frac{\left(\sqrt{\eta_i^2 \sigma^2_{w,t} + \kappa_i^2 \sigma^2_{i,t}} - \sqrt{\eta^2 \sigma^2_{w,t} + \kappa^2 \sigma^2_t}\right)\left(\overline{\sqrt{\eta_i^2 \sigma^2_{w,t} + \kappa_i^2 \sigma^2_{i,t}}}^H - \overline{\sqrt{\eta_i^2 \sigma^2_{w,t} + \kappa_i^2 \sigma^2_{i,t}}}^L\right)}{var_t(Carry_{t+1})}.
\end{aligned}$$

The first term is nonzero only if the beta is estimated for a currency that belongs to either the high or low interest rate portfolio. The second and third terms are time-varying and depend on the same state variables that drive the interest rates. Their time-variation justifies using a conditional version of the carry factor. When describing bilateral exchange rates, I use the carry factor and the same carry factor multiplied by the difference between the foreign and domestic interest rate because the state variables are unknown. The interest rate is only an approximation of the true conditioning variable in the model.

Ignoring the first term, the carry betas are constant only when three restrictions are satisfied: $\overline{\gamma_i^2 \sigma^2_{i,t}}^H = \overline{\gamma_i^2 \sigma^2_{i,t}}^L$, $\lambda_i = 0$ and either $\kappa_i = 0$ or $\eta_i = 0$. The case of $\eta_i = 0$ corresponds to the one developed in the main text, which leads to constant betas as shown in Equation (37).

I start here with the case of $\kappa_i = 0$. In this case, the volatility of the carry factor is proportional to $\sigma^2_{w,t}$, and so is the covariance between the exchange rate and the carry factor. The carry beta is thus constant. The first restriction ($\overline{\gamma_i^2 \sigma^2_{i,t}}^H = \overline{\gamma_i^2 \sigma^2_{i,t}}^L$) appears in line with the data; I did not find evidence that portfolios of high and low interest rate countries differ in their country-specific volatilities. Going back to the law of motion of the log SDF, the last two restrictions ($\lambda_i = 0$ and $\kappa_i = 0$) imply that the volatilities of the global shocks are driven by the same state variable, $\sigma_{w,t}$. In this case, the log SDF is:

$$-m_{i,t+1} = \alpha_i + \chi_i \sigma^2_{i,t} + \tau_i \sigma^2_{w,t} + \gamma_i \sigma_{i,t} u_{i,t+1} + \delta_i \sigma_{w,t} u_{w,t+1} + \eta_i \sigma_{w,t} u_{g,t+1},$$

As we shall see, it implies that the volatility of the carry factor is perfectly correlated to the volatility of the global component of the dollar factor.

In the special case where $\lambda_i = 0$ and $\kappa_i = 0$, the high and low dollar beta portfolios do not differ in their amounts of country-specific volatilities because sorting countries by their dollar betas only recovers differences in δ_i and η_i, as can be seen in Equation (33). These parameters do not govern the amount of country-specific volatilities. The volatility of the global component of the dollar is thus in this case:

$$Var_t\left(Dollar\ Global_{t+1}\right) = \left(\overline{\delta_i}^{H\beta} - \overline{\delta_i}^{L\beta}\right)^2 \sigma^2_{w,t} + \left(\overline{\eta_i}^{H\beta} - \overline{\eta_i}^{L\beta}\right)^2 \sigma^2_{w,t}. \tag{43}$$

In the special case where $\overline{\gamma_i^2\sigma_{i,t}^2}^H = \overline{\gamma_i^2\sigma_{i,t}^2}^L$, $\lambda_i = 0$ and $\kappa_i = 0$, the volatility of the carry factor is then:

$$Var_t(Carry_{t+1}) = \left(\overline{\delta_i}^{H} - \overline{\delta_i}^{L}\right)^2 \sigma^2_{w,t} + \left(\overline{\eta_i}^{H} - \overline{\eta_i}^{L}\right)^2 \sigma^2_{w,t}. \tag{44}$$

The volatilities of the global component of the dollar factor is thus perfectly correlated with the volatility of the carry factor. This is not the case in the data.

Let us now go to the second potential case: $\overline{\gamma_i^2\sigma_{i,t}^2}^H = \overline{\gamma_i^2\sigma_{i,t}^2}^L$, $\lambda_i = 0$ and $\eta_i = 0$. In this case, the currency factors are:

$$\begin{aligned} Carry_{t+1} &= \overline{\alpha_i}^H - \overline{\alpha_i}^L + \overline{\chi_i\sigma_{i,t}^2}^H - \overline{\chi_i\sigma_{i,t}^2}^L + \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^H - \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^L \\ &+ \left(\overline{\delta_i}^H - \overline{\delta_i}^L\right)\sigma_{w,t}u_{w,t+1} + \left(\overline{\kappa_i\sigma_{i,t}}^H - \overline{\kappa_i\sigma_{i,t}}^L\right)u_{g,t+1} \end{aligned} \tag{45}$$

$$\begin{aligned} Dollar_{t+1} &= \overline{\alpha_i} - \alpha + \overline{\chi_i\sigma_{i,t}^2} - \chi\sigma_t^2 + \overline{\gamma_i\sigma_{i,t}u_{i,t+1}} - \gamma\sigma_t u_{t+1} \\ &+ \left(\overline{\delta_i} - \delta\right)\sigma_{w,t}u_{w,t+1} + \left(\overline{\kappa_i\sigma_{i,t}} - \kappa\sigma_t\right)u_{g,t+1}, \end{aligned} \tag{46}$$

$$\begin{aligned} Dollar\ Global_{t+1} &= \overline{\alpha_i}^{H\beta} - \overline{\alpha_i}^{L\beta} + \overline{\chi_i\sigma_{i,t}^2}^{H\beta} - \overline{\chi_i\sigma_{i,t}^2}^{L\beta} + \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^{H\beta} - \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^{L\beta} \\ &+ \left(\overline{\delta_i}^{H\beta} - \overline{\delta_i}^{L\beta}\right)\sigma_{w,t}u_{w,t+1} + \left(\overline{\kappa_i\sigma_{i,t}}^{H\beta} - \overline{\kappa_i\sigma_{i,t}}^{L\beta}\right)u_{g,t+1}, \end{aligned} \tag{47}$$

The volatility of the carry factor and the volatility of the global component of the dollar factor are:

$$Var_t(Carry_{t+1}) = \overline{\gamma_i^2\sigma_{i,t}^2}^H - \overline{\gamma_i^2\sigma_{i,t}^2}^L + \left(\overline{\delta_i}^H - \overline{\delta_i}^L\right)^2\sigma^2_{w,t} + \left(\overline{\kappa_i\sigma_{i,t}}^H - \overline{\kappa_i\sigma_{i,t}}^L\right)^2, \tag{48}$$

$$Var_t\left(Dollar\ Global_{t+1}\right) = \overline{\gamma_i^2\sigma_{i,t}^2}^{H\beta} - \overline{\gamma_i^2\sigma_{i,t}^2}^{L\beta} + \left(\overline{\delta_i}^{H\beta} - \overline{\delta_i}^{L\beta}\right)^2\sigma^2_{w,t} + \left(\overline{\kappa_i\sigma_{i,t}}^{H\beta} - \overline{\kappa_i\sigma_{i,t}}^{L\beta}\right)^2. \tag{49}$$

For the carry and global component of the dollar factor to be orthogonal, only two cases are possible: (i) $\overline{\delta_i}^{H\beta} = \overline{\delta_i}^{L\beta}$ and $\overline{\kappa_i\sigma_{i,t}}^H = \overline{\kappa_i\sigma_{i,t}}^L$, or (ii) $\overline{\delta_i}^H = \overline{\delta_i}^L$ and $\overline{\kappa_i\sigma_{i,t}}^{H\beta} = \overline{\kappa_i\sigma_{i,t}}^{L\beta}$. In the first case, the carry factor depends on the global shocks $u_{w,t+1}$, while the global component of the dollar factor depends on the global shocks $u_{g,t+1}$. In the second case, it is the opposite. In each case, these restrictions imply that the volatilities of the carry factor and the volatility of the global component of the dollar factor are orthogonal, which is counterfactual. In the first case, these volatilities are:

$$Var_t(Carry_{t+1}) = \left(\overline{\delta_i}^H - \overline{\delta_i}^L\right)^2\sigma^2_{w,t}, \tag{50}$$

$$Var_t\left(Dollar\ Global_{t+1}\right) = \overline{\gamma_i^2\sigma_{i,t}^2}^{H\beta} - \overline{\gamma_i^2\sigma_{i,t}^2}^{L\beta} + \left(\overline{\kappa_i\sigma_{i,t}}^{H\beta} - \overline{\kappa_i\sigma_{i,t}}^{L\beta}\right)^2. \tag{51}$$

These volatilities are then uncorrelated. In the second case, these volatilities are:

$$Var_t(Carry_{t+1}) = \left(\overline{\kappa_i\sigma_{i,t}}^H - \overline{\kappa_i\sigma_{i,t}}^L\right)^2, \tag{52}$$

$$Var_t\left(Dollar\ Global_{t+1}\right) = \overline{\gamma_i^2\sigma_{i,t}^2}^{H\beta} - \overline{\gamma_i^2\sigma_{i,t}^2}^{L\beta} + \left(\overline{\delta_i}^{H\beta} - \overline{\delta_i}^{L\beta}\right)^2 \sigma_{w,t}^2 \tag{53}$$

In this case, since $\overline{\kappa_i\sigma_{i,t}}^{H\beta} = \overline{\kappa_i\sigma_{i,t}}^{L\beta}$, it must be that sorting by dollar betas recovers only differences in δ_i. Thus dollar beta portfolios do not differ in their amounts of country-specific volatilities: $\overline{\gamma_i^2\sigma_{i,t}^2}^{H\beta} = \overline{\gamma_i^2\sigma_{i,t}^2}^{L\beta}$. Again the volatilities of the carry factor and the volatility of the global component of the dollar factor are orthogonal.

To summarize, assuming that the carry betas are constant and taking into account that the high-minus-low risk factors are orthogonal always leads to counterfactual implications on the volatilities of the high-minus-low risk factors in this model.

Number of Global Shocks I show here that the absence of a second global shock leads to counterfactual implications on the interest rate-sorted and dollar beta-sorted portfolios.

Let us assume that the second set of global shocks does not exist ($u_{g,t+1} = 0$. In this case, the dollar betas differ across countries because of differences in γ_i, δ_i, and λ_i across countries:

$$\begin{aligned} \beta^i_{Dollar,t} &= \frac{cov_t(\gamma_i u^i_{t+1}, \overline{\gamma_i\sigma_{i,t}u_{i,t+1}})}{var_t(Dollar_{t+1})} \\ &+ \frac{\gamma^2\sigma_t^2 + \left(\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)\left(\overline{\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2}} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)}{var_t(Dollar_{t+1})}, \end{aligned} \tag{54}$$

$$\begin{aligned} \beta^i_{Carry,t} &= \frac{cov_t(\gamma_i\sigma_{i,t}u_{i,t+1}, \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^H - \overline{\gamma_i\sigma_{i,t}u_{i,t+1}}^L)}{var_t(Carry_{t+1})} \\ &+ \frac{\left(\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2} - \sqrt{\delta^2\sigma_{w,t}^2 + \lambda^2\sigma_t^2}\right)\left(\overline{\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2}}^H - \overline{\sqrt{\delta_i^2\sigma_{w,t}^2 + \lambda_i^2\sigma_{i,t}^2}}^L\right)}{var_t(Carry_{t+1})} \end{aligned} \tag{55}$$

In the data, sorting by carry betas and sorting by dollar betas deliver two different cross-sections of average currency excess returns with zero correlation between their respective high-minus-low exchange rates. But in the absence of a second global shock, the implied sorts by carry or dollar betas are the same because they both recover cross-country differences in δ_i and λ_i. The two cross-sections differ if sorting by dollar betas is the same as sorting countries by their γ_i parameters. Yet, differences in γ_i cannot produce differences in average excess returns because the associated shocks are uncorrelated to the U.S. SDF:

$$E_t\left(r^f_{i,t} - r^f_t - \Delta s_{t+1}\right) + \frac{1}{2}Var_t\left(\Delta s_{t+1}\right) = -cov_t\left(m_{t+1}, \gamma_i\sigma_{i,t}u^i_{t+1}\right) = 0. \tag{56}$$

There is thus no way to build two independent cross-section of currency risk premia in the absence of a second global shock.

Appendix B Pairwise R^2s

The large R^2s of the factor regressions can be favorably compared to those of simple pairwise currency regressions. For each currency i, I regress it on a constant and each currency j available in the sample ($i \neq j$):

$$\Delta s^i_{t+1} = \alpha + \beta \Delta s^j_{t+1} + \varepsilon^{i,j}_{t+1}.$$

Each regression delivers a pair-specific R^2, denoted $R^{2^{i,j}}$. This is the R^2 equivalent to the OptionMetrics correlation coefficient that many practitioners use. Some currencies are highly correlated, and thus lead to high R^2s: the Australian and New Zealand dollars offer one such example. But without knowing ex ante the intrinsic correlation matrix, one would expect, for each currency i, an R^2 that corresponds to the mean of all the estimates that involve currency i. For each currency i, the standard deviation of all the estimates $R^{2^{i,j}}$ gives a measure of the uncertainty around its mean R^2.

Figure 3 summarizes the findings, comparing R^2s obtained with the carry and dollar factors (vertical axis) to those obtained from random univariate regressions (horizontal axis). If the carry and dollar factors are of any help in capturing exchange rate variation, all points in Figure 3 should be above the 45-degree line, which is clearly the case. It turns out that the factors' R^2s are, for all developed countries, at least one-standard deviation above the mean R^2 estimated from the pairwise univariate regressions above. The same is true for all developing countries, except three: Saudi Arabia and the United Arab Emirates, which are unsurprising outliers since they have pegged their currencies to the U.S dollar, and Indonesia, which has few observations. For developed currencies, one can always handpick another developed currency that is highly correlated with the currency under study, and thus will lead to a high R^2. But there is no currency that delivers this feature for all exchange rates. Conversely, the dollar and the carry factor have the same economic interpretation for all currencies.[23] They deliver R^2s that are large, not only compared to those of UIP tests (arguably, a low bar) and macroeconomic variables, but also to those of bivariate exchange rate regressions.

[Figure 3 about here.]

Appendix C Sub-Samples and Rolling Windows

I study different sub-samples (pre-crisis and pre- vs. post-euro) before turning to rolling window estimates.

Results obtained on a sample that ends in December 2007 are very similar to those reported in the paper. Regressions of bilateral exchange rates on the carry and dollar factors on a pre-crisis sample

[23] The carry and dollar factors only differ across currencies because of the exclusion of the currency under study. But simple carry and dollar factors that use the whole sample produce similar results.

lead to similar results as on the full sample. Out of the 13 currencies reported in Table 1, only two countries exhibit a significantly lower R^2 over the pre-crisis sample (Australia and Canada). For all the other countries, the R^2s obtained on the two samples are less than one standard deviation away from each other. Figure 4 presents the time-series of the carry and dollar factors; there is no clear difference between the pre- and post-crisis samples.

[Figure 4 about here.]

Table 8 reports regression results on a sample that ends in December 1998, while Table 9 reports similar results on a sample that starts in January 1999. For Australia, Canada, New Zealand, the share of systematic variation is larger over the second subsample than over the first one. For Denmark, France, Germany, Italy, the results obtained on the pre-Euro sample are similar to those reported in the main paper for the whole sample by construction: the euro area countries are excluded after the introduction of the euro. For Switzerland and the UK, the results are similar across samples. The Japanese Yen is the only developed currency with a clear decline in the share of systematic risk post 1998.

[Table 8 about here.]

[Table 9 about here.]

In order to study more precisely the time-variation in currency R^2s and loadings, the same regressions as in Table 1 are run but on rolling windows of 60 months (5 years). For the purpose of reporting the results, this section focuses on six countries: Australia, Canada, Japan, New Zealand, Switzerland, and the United Kingdom, notably in order to avoid 13 tiny subplots in the following figures.

There is no sign that the full sample corresponds to particularly high R^2s – higher values can be attained on shorter subsamples. For Japan, Switzerland, and the United Kingdom, the adjusted R^2s remain significantly above 0 throughout the sample. For Australia and New Zealand, some samples ending in the second half of the 90s lead to zero or negative adjusted R^2s. For Canada, R^2s are significantly different from 0 only over samples ending in the last ten years.

Figure 5 reports the time-varying R^2s. The solid lines present the time-varying R^2s (R_t^2 corresponds to an estimate over the sample from $t - 60$ to t). The dotted lines correspond to the estimated R_t^2 at date t plus or minus one standard deviation of the estimate. Standard deviations on R^2s are obtained by bootstrapping the regressions, assuming that changes in exchange rates are *i.i.d*. Standard deviation thus take into account the small size of the rolling windows. The dash-dotted line reports the R^2s obtained on the full sample (as in Table 1).

[Figure 5 about here.]

Appendix D Pseudo-Predictability Tests

The following experiment exploits the persistence of factor loadings. Assume that the carry and dollar factors are known one period in advance. As noted in the main text, the pseudo-predicted change in exchange rate is thus:

$$\widehat{\Delta s_{t+1}} = \alpha_t + \beta_t(i_t^\star - i_t) + \gamma_t(i_t^\star - i_t)Carry_{t+1} + \delta_t Carry_{t+1} + \tau_t Dollar_{t+1},$$

where α_t, β_t, γ_t, δ_t, and τ_t are estimated on samples that end at date t. Table 10 reports the standard deviation of log changes in spot exchange rates and the square root of mean squared errors (RMSE) obtained in the experiment above. These RMSE are compared to those obtained by assuming that exchange rates are random walks with drifts (i.e., when only α_t is estimated). Standard deviations and RMSE are annualized (i.e., multiplied by $\sqrt{12}$) and reported in percentages. Compared to the random walk, the decrease in RMSE is large: the ratios range from 0.4 to 0.9 for developed countries.

[Table 10 about here.]

A very large literature attempts to predict changes in exchange rates at the bilateral level (see Rossi (2013) for a survey). The experiment in this paper offers two insights to this literature. First, it gives a new benchmark. Table 10 shows that models in international economics and finance should seek to reduce the RMSE by 10% to 70% (depending on the currency) compared to a prediction based on a random walk. Additional pseudo-predictability might come from better predictions of the factor loadings and the discovery of new factors. Second, efforts should be focused on predicting the dollar and carry components in order to move beyond pseudo-predictability. These two components average out idiosyncratic changes in exchange rates and thus constitute better test assets for any model in international finance than individual exchange rates. Building on this paper, Malone, Gramacy and ter Horst (2013) report similar predictability results on pseudo-predictability tests but also encouraging results on actual forecasting exercises.

Appendix E Other Factors

Other factors are potential candidates to describe exchange rate changes. Momentum, for example, appears as a pervasive phenomenon in equity markets and seems also present in currency markets (see Menkhoff, Sarno, Schmeling and Schrimpf (2012b) and Asness, Moskowitz, and Pedersen, 2013). The equity literature has proposed many different ways to pick past winners and losers: for example, measuring returns over 1 to 12 months before sorting stocks, or adding lags of 1 to n months between the time stocks are sorted and the date portfolios are formed. I do not explore all the potential definitions, but conduct a simple experiment.

Momentum portfolios are formed by sorting countries on their past currency excess returns (measured over the previous month). The obtained cross-section of excess returns is only partly explained by the carry and dollar factors. But a third potential factor emerges; it corresponds to the third component of the momentum-sorted portfolios. This momentum factor, however, does not add much explanatory power beyond the carry and dollar factors. It is significant only for the U.K, but never in the other 12 developed countries. Similar results appear by sorting countries on their past three-month returns (instead of one-month returns). These negative results do not rule out the existence of an independent momentum factor in bilateral exchange rates as many other definitions of momentum can be tested. Adding a momentum factor would improve the description of bilateral exchange rates since the carry and dollar factors cannot explain the full cross-section of currency momentum portfolios (see Menkhoff et al. 2012).

Focusing on the currency market literature, another potential factor emerges: Ang and Chen (2010) show that sorting countries on the *changes* in short term interest rates also leads to a cross-section of currency excess returns. A potential factor could correspond to the following long-short strategy: long the last portfolio (larges changes in foreign interest rates) and short the first portfolio (small changes in foreign interest rates). This strategy delivers positive currency excess returns. As for the carry factor, the focus is on the exchange rate components of these portfolios. In a similar set of regressions, the additional factor appears significant for Denmark, Germany, Switzerland, and the U.K. but does not deliver significant increases in R^2s.

Again, these findings do not rule out the existence of other factors that account for bilateral changes in exchange rates. Future research will certainly uncover some new factors, but this study is limited to the potential factors already established by previous empirical and theoretical literature.

Appendix F Principal Components of Bid-Ask Spreads

Some authors argue that price pressure or other informational frictions (like moral hazard) are key mechanisms on currency markets. There is no formal empirical test of these mechanisms on currency markets, but the intuition suggests that they should affect the dynamics of bid-ask spreads.

Is there systematic variation in bid-ask spreads? Certainly, and the recent crisis offers a clear example, as many bid-ask spreads increased at the same time. But these bid-ask spreads are not strongly correlated with currency factors. In the data, the dollar and carry factors only explain a small fraction of the changes in bid-asks spreads. The average R^2 is less than 8% across developed countries. The carry, conditional carry, and dollar factors rarely appear significant. The most significant loadings are on interest rate differences. Overall, bid-ask spreads exhibit some comovement, but their variations are two orders of magnitude smaller than the changes in midquotes, and thus cannot infirm the benchmark results in this paper.

Appendix G Dollar Beta Portfolios

Dollar beta portfolios are obtained by sorting currencies on their dollar betas. Table 11 tests the robustness of the dollar beta portfolio return characteristics to the length of the rolling windows used to compute the dollar betas. While the main text reports results obtained on 60-month rolling windows (Table 4), Panel I (II) of Table 11 reports summary statistics on portfolio formed using 72 (48)-month rolling windows. With the 60-month and 72-month rolling windows, the resulting cross-section of average currency excess returns is monotone, increasing from low to high dollar beta portfolios. With the 48-month rolling windows, the overall pattern is similar but the middle portfolio exhibits slightly higher average returns than the next one (although the difference is not significant). In all cases, high dollar beta portfolio exhibit higher average excess returns that low dollar beta portfolios. After conditioning on the average forward discount, the average return on a long-short strategy is 5.5% per year using 72-month rolling windows and 5.9% using 48-month rolling windows. These average excess returns are significantly different from zero and close to the one reported in the main text (5.2%).

Finally Table 12 reports asset pricing experiments on the benchmark dollar beta portfolios using a simple long-minus-short risk factor (built from the same set of portfolios used as test assets). The loadings on this long-minus-short risk factor (which captures the global component of the dollar factor) increase monotonically across portfolios.

[Table 11 about here.]

[Table 12 about here.]

Appendix H Correlations Among Factors

This section studies the correlation between the different risk factors and their volatilities. I consider risk factors built from portfolios of countries sorted by interest rates, carry betas, and dollar betas.

Table 13 reports the summary statistics of currency portfolios of countries sorted by either their short-term interest rates or their carry betas. This is a reminder of the results in Lustig, Roussanov, and Verdelhan (2011). Both sorts deliver a cross-section of average currency excess returns, although the former sort leads to large carry trade average excess returns than the latter. Sorting by carry betas leads to a monotonic cross-section of average nominal interest rates across portfolios.

[Table 13 about here.]

Table 14 reports the correlations between three factors: the dollar, the global component of the dollar, and the carry factor, as well as their respective volatilities.

[Table 14 about here.]

The carry factor is obtained by sorting countries by their short-term interest rates; it corresponds to the exchange rate changes of the last portfolio minus the exchange rate changes of the first portfolio (and denoted Carry (HML-IR) in the table. The table reports its correlation with another long-short proxy obtained by sorting countries by their carry betas; this proxy corresponds to the exchange rate changes of the last portfolio minus the exchange rate changes of the first portfolio (and denoted Carry (HML-Beta) in the table). The carry betas are obtained by regressing each bilateral exchange rate on the carry factor over rolling windows of three years. Table 13 reports the characteristics of the currencies portfolios built on carry betas. The dollar factor is the average of all exchange rates defined in U.S. dollars (denoted Dollar). The global component of the dollar factor corresponds to the difference between the exchange rate of the last dollar beta-sorted portfolio minus the exchange rate of the first dollar beta-sorted portfolio. All those factors are obtained on monthly series.

The volatilities are built from daily changes in exchange rates. The volatility of the carry factor (denoted Carry (HML-IR) Vol) corresponds to the standard deviation over one month of the daily changes in exchange rates of the carry factor. To build the carry factor at the daily frequency, countries are sorted by their one-month interest rates on a daily basis. The volatility of the dollar factor (denoted Dollar Vol) corresponds to the standard deviation over one month of the daily changes in exchange rates of the dollar factor. To build the volatility of the global component of the dollar factor (denoted Dollar Global Vol), I built dollar beta portfolios at the daily frequency. The dollar betas used for each day of the month corresponds to their value at the monthly frequency. The volatility of the global component of the dollar factor is then obtained as the standard deviation over one month of the corresponding daily changes of exchange rates.

Table 14 shows that the carry factor exhibits a large correlation (0.6) with its proxy based on carry-beta sorted portfolios. The dollar factor appears highly correlated with its global component (0.85): although the global component captures global shocks that do not necessarily originate in the U.S., I keep the name "dollar" because of this high correlation. The dollar factor appears marginally correlated with the carry factor (0.25) but not with the proxy of the carry factor: the correlation is insignificant. Likewise, the global component of the dollar factor appears uncorrelated to the carry factor and its carry-beta-based proxy.

The factors' volatilities appear all significantly correlated to each other: the correlation between the volatility of the carry factor and the volatility of the global component of the dollar factor is for example 0.4. Those volatilities are significantly correlated to the carry factor but not to the global component of the dollar factor.

Appendix I Other Base Currencies and Cross-Rates

All regressions so far pertain to exchange rates defined with respect to the U.S. Dollar. Similar results, however, emerge with other base currencies. I consider exchange rates defined with respect to the Japanese Yen, U.K. pound, and Swiss Franc. Each time, I keep the same convention: there is no i subscript for the home country. Regression tests, for example for pound-based exchange rates, are thus:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i (r_{i,t} - r_t) + \gamma_i (r_{i,t} - r_t) Carry_{t+1} + \delta_i Carry_{t+1} + \tau_i Pound_{t+1} + \varepsilon_{i,t+1}.$$

where $\Delta s_{i,t+1}$ denotes the bilateral exchange rate in foreign currency per U.K. Pound and $Pound_{t+1}$ corresponds to the average change in exchange rates against the U.K. Pound. The $Carry$ factor is not changed much as it is dollar-neutral. The shares of systematic risk range from 39% to 71% for pound-based currencies, from 65% to 82% for Yen-based currencies, and from 35% to 77% for franc-based currencies. In each case, a country-specific factor appears necessary to account for exchange rate variation.

The dollar factor is thus a basis factor, linked to the choice of the basis currency. The dollar factor, however, explains also part of some cross-rates changes (i.e. exchange rates not defined with respect to the U.S. dollar). Table 6 in the main text and Table 15 in the Appendix reports results for respectively the Japanese Yen, the U.K. pound, the Australian Dollar, and the Swiss Franc. The dollar factor is a significant factor of cross-rates for currencies that exhibit very different loadings on the dollar factor in their U.S. dollar based exchange rates in the first place. Going back to Table 1, the Yen/Dollar exchange rate, for example, has a loading of 0.98 on the dollar factor, whereas the Swiss Franc/Dollar has a loading of 1.36. As a result, the Swiss Franc/Yen exchange rate exhibits a large and positive loading on the dollar factor. The reduced-form model presented in the main text provides an intuition for this finding. Recall that the dollar factor captures U.S.-specific shocks to the U.S. pricing kernel as well as global shocks. In a no-arbitrage model, the Swiss Franc / Yen exchange rate depends on the Swiss and Japanese SDFs and there is thus no role for U.S.-specific shocks, but the Swiss Franc / Yen exchange rate also depends on global shocks that affect the dollar factor as well.

[Table 15 about here.]

To provide some preliminary intuition on this novel global risk factor, Figure 6 presents the 12-month cumulative returns on a simple investment strategy: long the high dollar beta portfolio and short the low dollar beta portfolio. This simple long-short strategy focuses on global risk, not U.S.-specific risk. Figure 6 compares the currency returns with the troughs of the business cycles in the G7 countries, as determined by the OECD. All low returns tend to happen close to those troughs. With the exception of the 2003 trough in three European countries, all recorded troughs coincide with low realized excess returns. The lowest return in the sample happens during the recent global recession.

[Figure 6 about here.]

Appendix J Country-Level Asset Pricing

I run country-level asset pricing tests in order to complement the evidence reported using currency portfolios and to check that the carry and dollar factors are priced risk factors.

Country-level asset pricing tests follow the Fama and MacBeth's (1973) procedure. The tests are similar to those reported in Lustig et al. (2011), except that the average currency market excess return RX used in Lustig et al. (2011) is replaced by its conditional counterpart, obtained as the dollar excess return multiplied by the sign of the average forward discount, $(\overline{i_t^i - i_t})RX$. This modification is key: the risk price of the former is not statistically significant, while the risk price of the latter is. This difference is consistent with the absence of arbitrage. No arbitrage implies that the market price of risk should be equal to the mean of the risk factor. The average currency market excess return RX is not statistically different from zero, while its conditional counterpart $\overline{(i_t^i - i_t)RX}$ is. The Fama and MacBeth (1973) procedure is described in the notes to Table 16. To save space, I focus here on the results.

Unconditional country currency risk premia Panel A of Table 16 reports the market prices of risk obtained on unconditional currency excess returns. They are positive and less than one standard error from the means of the risk factors, which are reported in Panel D of Table 16. The RMSE and the mean absolute pricing error are larger than those obtained on currency portfolios, but the null hypothesis that all pricing errors are jointly zero cannot be rejected. High beta countries tend to offer high unconditional currency excess returns.

Conditional country currency risk premia I now turn to conditional risk premiums, first reporting results obtained with managed investments and then turning to time-varying factor betas. Investors can adjust their position in a given currency based on the interest rate at the start of each period to exploit return predictability. Such managed investment strategies correspond to *conditional* expected excess returns and complement the raw currency excess returns. For example, investors would invest more in high interest rate currencies in order to pocket the carry trade risk premium. Likewise, investors would go long all foreign currencies when the average forward discount is positive in order to pocket the dollar risk premium. To construct these managed positions, each currency excess return is thus multiplied by the appropriate beginning-of-month forward discount (normalized by subtracting the average forward discount across currencies and dividing by the cross-sectional standard deviation of forward discounts in the given period).

The Fama and MacBeth (1973) procedure applies to the large set of raw and managed currency excess returns. Panel B of Table 16 shows that the cross-sectional fit improves and the risk prices are more precisely estimated. Market prices of risk are positive and significant and in line with those obtained on the unconditional returns. The carry and conditional dollar risk factors are clearly priced in the cross-section of country-level currency excess returns.

Instead of enlarging the asset space to include managed returns, betas can be modeled as linear functions of the conditioning variables. In particular, it is natural to assume that each country's loading on the carry factor is a linear function of the country's forward discount. Likewise, each country's loading on the dollar factor is a linear function of the average forward discount. The results of the estimation are in Panel C of Table 16. This method produces very similar results to the managed returns approach, which provides further evidence for the role of forward discounts in capturing the currencies' dynamic exposures to common sources of risk.

Overall, the country-level results are thus fully consistent with the portfolio-level results and support the interpretation of the carry and dollar factors as risk factors.

[Table 16 about here.]

Appendix K Exchange Rate Volatilities

Table 17 reports regression results of changes in exchange rate volatilities on the Carry and Dollar factors:

$$\Delta\sigma_{\Delta s,t+1} = \alpha + \beta(i^\star_t - i_t) + \gamma(i^\star_t - i_t)Carry_{t+1} + \delta Carry_{t+1} + \tau Dollar_{t+1} + \rho\sigma_{\Delta s,t} + \varepsilon_{t+1},$$

where $\sigma_{\Delta s,t+1}$ denotes the change in monthly volatility of the bilateral exchange rate in foreign currency per U.S. dollar. Likewise, Table 18 reports regression results of changes in exchange rate volatilities on the changes in volatilities of the Carry and Dollar factors:

$$\Delta\sigma_{\Delta s^i,t+1} = \alpha + \beta\Delta\sigma_{Dollar,t+1} + \gamma\Delta\sigma_{Carry,t+1} + \rho\sigma_{\Delta s,t} + \varepsilon_{t+1},$$

In both cases, since currency volatilities are persistent, the tests control for the lagged value of country i exchange rate volatility. The results are commented in the main text.

[Table 17 about here.]

[Table 18 about here.]

Table 8: Carry and Dollar Factors: Monthly Tests in Developed Countries, Pre-Euro

Country	α	β	γ	δ	τ	R^2	$R^2_{\$}$	$R^2_{no\ \$}$	W	N
Australia	0.56	-1.19	0.62	0.04	0.20	4.77	1.97	3.23		168
	(0.31)	(0.61)	(0.49)	(0.12)	(0.13)	(4.39)	[3.49]	[4.73]		
Canada	0.20	-1.22	-0.06	0.11	0.07	8.11	4.63	7.00	***	168
	(0.11)	(0.51)	(0.18)	(0.04)	(0.04)	(4.30)	[3.41]	[4.12]		
Denmark	-0.16	0.03	0.61	-0.12	1.44	91.06	88.67	15.09	***	168
	(0.08)	(0.44)	(0.15)	(0.04)	(0.04)	(1.49)	[2.15]	[5.34]		
France	-0.15	-0.10	0.80	-0.13	1.38	90.97	87.58	12.30	***	181
	(0.07)	(0.34)	(0.14)	(0.03)	(0.04)	(1.53)	[1.96]	[5.82]		
Germany	-0.21	-0.03	0.79	-0.03	1.42	91.00	88.35	22.83	***	181
	(0.09)	(0.34)	(0.17)	(0.04)	(0.04)	(1.38)	[1.81]	[6.10]		
Italy	-0.03	0.26	0.68	-0.07	1.24	68.97	64.59	2.16	***	177
	(0.22)	(0.69)	(0.20)	(0.11)	(0.10)	(5.23)	[6.81]	[6.09]		
Japan	-0.55	-1.30	-0.19	-0.32	1.06	42.85	40.20	4.59	***	181
	(0.26)	(1.11)	(0.42)	(0.10)	(0.11)	(5.62)	[4.98]	[4.84]		
New Zealand	0.54	-1.20	0.56	-0.12	0.48	13.73	11.75	4.06		168
	(0.23)	(0.37)	(0.42)	(0.13)	(0.10)	(5.74)	[6.73]	[4.48]		
Norway	-0.11	0.47	0.43	0.01	1.29	80.61	78.19	4.05	***	168
	(0.15)	(0.45)	(0.13)	(0.06)	(0.07)	(2.98)	[3.33]	[5.55]		
Sweden	0.11	-0.35	1.00	-0.03	1.20	72.14	63.64	11.65	***	168
	(0.19)	(0.60)	(0.19)	(0.07)	(0.07)	(4.58)	[5.53]	[6.20]		
Switzerland	-0.16	-0.04	0.95	0.04	1.48	82.71	79.27	16.83	***	181
	(0.13)	(0.40)	(0.18)	(0.06)	(0.07)	(2.34)	[2.57]	[5.56]		
United Kingdom	-0.19	0.41	0.83	-0.02	1.16	58.33	56.08	6.74	*	181
	(0.23)	(0.85)	(0.61)	(0.15)	(0.10)	(4.87)	[5.13]	[5.26]		

Notes: This table reports country-level results from the following regression:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i(r_{i,t} - r_t) + \gamma_i(r_{i,t} - r_t)Carry_{t+1} + \delta_i Carry_{t+1} + \tau_i Dollar_{t+1} + \varepsilon_{i,t+1}.$$

where $\Delta s_{i,t+1}$ denotes the bilateral exchange rate in foreign currency per U.S. dollar, and $r_{i,t} - r_t$ is the interest rate difference between the foreign country and the U.S., $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar_{t+1}$ corresponds to the average change in exchange rates against the U.S. dollar. The table reports the constant α, the slope coefficients β, γ, δ, and τ, as well as the adjusted R^2 of this regression (in percentage points) and the number of observations N. Standard errors in parentheses are Newey andWest (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The standard errors for the R^2s are reported in brackets; they are obtained by bootstrapping. $R^2_{\$}$ denotes the adjusted R^2 of a similar regression with only the *Dollar* factor (i.e., without the conditional and unconditional *Carry* factors). $R^2_{no\ \$}$ denotes the adjusted R^2 of a similar regression without the *Dollar* factor. W denotes the result of a Wald test: the null hypothesis is that the loadings γ and δ on the conditional and unconditional carry factors are jointly zero. Three asterisks (***) correspond to a rejection of the null hypothesis at the 1% confidence level; two asterisks and one asterisk correspond to the 5% and 10% confidence levels. Data are monthly, from Barclays and Reuters (Datastream). All variables are in percentage points. The sample period is 11/1983–12/1998.

Table 9: Carry and Dollar Factors: Monthly Tests in Developed Countries, Post-Euro

Country	α	β	γ	δ	τ	R^2	$R^2_{\$}$	$R^2_{no\ \$}$	W	N
Australia	-0.28	0.06	0.20	0.27	1.71	72.03	69.21	16.23	***	144
	(0.28)	(1.26)	(0.60)	(0.14)	(0.10)	(5.45)	[5.96]	[7.70]		
Canada	-0.29	0.19	-1.65	0.19	0.76	38.11	34.08	12.58	*	144
	(0.15)	(2.35)	(1.32)	(0.09)	(0.11)	(10.65)	[8.34]	[10.66]		
Denmark	0.08	-1.29	0.01	-0.28	1.62	81.59	77.40	1.48	***	144
	(0.12)	(0.92)	(0.21)	(0.05)	(0.08)	(3.62)	[3.99]	[5.81]		
Euro Area	0.07	-0.52	0.10	-0.28	1.62	80.60	76.22	-0.05	***	143
	(0.11)	(0.86)	(0.23)	(0.05)	(0.08)	(3.81)	[4.09]	[4.66]		
Japan	-0.34	-0.71	0.04	-0.43	0.45	12.66	3.44	5.62	***	144
	(0.42)	(1.36)	(0.96)	(0.27)	(0.22)	(6.90)	[5.76]	[5.01]		
New Zealand	-0.48	1.44	0.09	0.04	1.71	58.21	58.68	5.77		144
	(0.41)	(1.49)	(0.61)	(0.17)	(0.11)	(6.37)	[6.22]	[5.54]		
Norway	-0.01	-0.39	0.42	-0.15	1.48	62.23	61.94	1.49		144
	(0.16)	(0.85)	(0.42)	(0.09)	(0.19)	(7.56)	[7.67]	[5.46]		
Sweden	0.04	-0.76	0.57	-0.20	1.75	77.65	75.59	2.06	***	144
	(0.11)	(0.46)	(0.28)	(0.06)	(0.08)	(3.80)	[3.87]	[4.04]		
Switzerland	-0.30	-1.25	0.50	-0.41	1.52	64.39	52.97	2.62	***	144
	(0.20)	(1.05)	(0.64)	(0.15)	(0.10)	(4.41)	[5.20]	[3.88]		
United Kingdom	0.11	0.05	-0.83	0.01	0.86	39.23	38.94	4.30		144
	(0.19)	(1.35)	(0.51)	(0.12)	(0.18)	(10.95)	[11.11]	[7.38]		

Notes: This table reports country-level results from the following regression:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i(r_{i,t} - r_t) + \gamma_i(r_{i,t} - r_t)Carry_{t+1} + \delta_i Carry_{t+1} + \tau_i Dollar_{t+1} + \varepsilon_{i,t+1}.$$

where $\Delta s_{i,t+1}$ denotes the bilateral exchange rate in foreign currency per U.S. dollar, and $r_{i,t} - r_t$ is the interest rate difference between the foreign country and the U.S., $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar_{t+1}$ corresponds to the average change in exchange rates against the U.S. dollar. The table reports the constant α, the slope coefficients β, γ, δ, and τ, as well as the adjusted R^2 of this regression (in percentage points) and the number of observations N. Standard errors in parentheses are Newey andWest (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The standard errors for the R^2s are reported in brackets; they are obtained by bootstrapping. $R^2_{\$}$ denotes the adjusted R^2 of a similar regression with only the *Dollar* factor (i.e., without the conditional and unconditional *Carry* factors). $R^2_{no\ \$}$ denotes the adjusted R^2 of a similar regression without the *Dollar* factor. W denotes the result of a Wald test: the null hypothesis is that the loadings γ and δ on the conditional and unconditional carry factors are jointly zero. Three asterisks (***) correspond to a rejection of the null hypothesis at the 1% confidence level; two asterisks and one asterisk correspond to the 5% and 10% confidence levels. Data are monthly, from Barclays and Reuters (Datastream). All variables are in percentage points. The sample period is 1/1999–12/2010.

Table 10: Pseudo-Predictability: Risk Factors vs Random Walk vs Principal Components

Country	$\sigma_{\Delta s}$	$RMSE$	$RMSE_{RW}$	$\frac{RMSE}{RMSE_{RW}}$	$RMSE_{PC}$	$\frac{RMSE_{PC}}{RMSE_{RW}}$
			Panel A: Developed Countries			
Australia	12.01	10.09	11.48	0.88	12.29	1.07
Canada	7.04	6.72	7.39	0.91	7.76	1.05
Denmark	11.06	4.47	10.76	0.42	10.86	1.01
Euro Area	10.73	4.66	11.05	0.42	11.32	1.02
France	11.20	3.81	10.66	0.36	10.74	1.01
Germany	11.72	3.98	10.90	0.36	10.89	1.00
Italy	11.30	7.58	11.14	0.68	10.87	0.98
Japan	11.50	10.28	11.30	0.91	11.74	1.04
New Zealand	12.18	9.41	11.26	0.84	11.98	1.06
Norway	10.99	6.14	10.88	0.56	11.04	1.02
Sweden	11.47	6.59	11.82	0.56	11.45	0.97
Switzerland	11.91	6.49	11.31	0.57	11.47	1.01
United Kingdom	10.52	7.48	9.89	0.76	10.01	1.01
			Panel B: Developing Countries			
Hong Kong	0.54	0.48	0.47	1.03	0.47	1.00
Czech Republic	13.13	8.20	13.17	0.62	13.49	1.02
Hungary	13.73	8.70	14.91	0.58	14.54	0.98
India	5.91	5.36	6.10	0.88	6.04	0.99
Indonesia	30.79	28.88	18.38	1.57	17.41	0.95
Kuwait	2.69	2.23	2.88	0.77	3.13	1.09
Malaysia	10.57	7.77	11.30	0.69	11.35	1.00
Mexico	9.36	7.90	9.02	0.88	9.50	1.05
Philippines	9.68	6.83	7.13	0.96	7.39	1.04
Poland	13.82	8.34	16.58	0.50	14.39	0.87
Saudi Arabia	0.35	1.35	0.39	3.49	0.68	1.77
Singapore	5.30	3.86	5.32	0.73	5.31	1.00
South Korea	15.47	12.19	13.97	0.87	13.97	1.00
South Africa	17.56	10.55	14.11	0.75	12.32	0.87
Taiwan	5.88	4.22	4.73	0.89	4.89	1.03
Thailand	12.85	8.69	7.00	1.24	7.21	1.03
Turkey	18.01	22.83	19.22	1.19	20.18	1.05
United Arab Emirates	0.18	1.53	0.27	5.62	0.84	3.06

Notes: This table reports the standard deviation of log changes in spot exchange rates (denoted $\sigma_{\Delta s}$), as well as the square root of mean squared errors ($RMSE$) obtained with the carry and dollar factors and with the first three principal components ($RMSE_{PC}$). These RMSE use the carry and dollar slope coefficients obtained in the previous period. These RMSE do *not* correspond to out-of-sample predictions because the carry and dollar factors and the principal components are assumed to be known one period in advance. The table also reports the RMSE obtained by assuming that exchange rates are random walk with drifts (denoted $RMSE_{RW}$), as well as the ratio of RMSE obtained with factors or principal components to the random walk benchmark $RMSE_{RW}$. Data are monthly, from Barclays and Reuters (Datastream). Standard deviations and RMSEs are annualized (i.e multiplied by $\sqrt{12}$) and reported in percentages. The sample period is 11/1983–12/2010.

Table 11: Portfolios of Countries Sorted By Dollar Exposures: Robustness Checks

	Panel I: 72-month Rolling Windows					
Portfolio	1	2	3	4	5	6
	Spot change: Δs					
Mean	−0.82	−2.86	−2.84	−3.16	−4.87	−5.18
Std	2.98	5.79	6.08	7.82	10.24	10.39
	Forward Discount: $f - s$					
Mean	0.40	0.74	1.08	1.43	1.81	2.15
Std	0.51	1.16	1.19	1.43	0.66	0.50
	Excess Return: rx					
Mean	1.21	3.60	3.92	4.59	6.68	7.33
	[0.63]	[1.28]	[1.28]	[1.68]	[2.23]	[2.25]
Std	3.03	5.88	6.10	7.65	10.22	10.35
SR	0.40	0.61	0.64	0.60	0.65	0.71
	Excess Return: rx (with bid-ask spreads)					
Mean	0.50	2.19	2.19	3.14	5.43	6.06
	[0.63]	[1.26]	[1.33]	[1.66]	[2.25]	[2.23]

	Panel II: 48-month Rolling Windows					
Portfolio	1	2	3	4	5	6
	Spot change: Δs					
Mean	−0.34	−2.37	−4.67	−2.66	−2.42	−5.38
Std	2.79	5.51	6.47	7.89	10.53	10.63
	Forward Discount: $f - s$					
Mean	0.57	0.70	1.07	0.99	2.22	2.04
Std	0.75	1.07	1.11	1.43	0.69	0.56
	Excess Return: rx					
Mean	0.91	3.07	5.75	3.65	4.64	7.42
	[0.61]	[1.14]	[1.33]	[1.66]	[2.20]	[2.36]
Std	2.95	5.42	6.40	7.92	10.51	10.59
0.31	0.57	0.90	0.46	0.44	0.70	
	Excess Return: rx (with bid-ask spreads)					
Mean	0.14	1.69	4.04	2.22	3.37	6.09
	[0.61]	[1.14]	[1.34]	[1.69]	[2.11]	[2.29]

Notes: This table reports summary statistics on portfolios of currencies sorted on their exposure to the dollar factor. See Section 3 for details on the construction of these portfolios. The table reports, for each portfolio, the mean and standard deviations of the average change in log spot exchange rates Δs, the average log forward discount $f - s$, and the average log excess return rx without bid-ask spreads. All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations and the mean excess returns net of bid-ask spreads. Panel I reports results obtained when sorting countries by their dollar betas estimated over 72-month rolling windows. Panel II reports reports results obtained when sorting countries by their dollar betas estimated over 48-month rolling windows. Data are monthly, from Barclays and Reuters in Datastream. The sample period is 12/1988–12/2010.

Table 12: Portfolios of Countries Sorted By Dollar Exposures: Long-Minus-Short Factor

	Panel I: Summary Statistics					
Portfolio	1	2	3	4	5	6
	Spot change: Δs					
Mean	−0.97	−2.12	−2.88	−3.66	−2.99	−5.07
Std	3.29	5.31	6.70	7.72	10.19	10.68
	Forward Discount: $f - s$					
Mean	0.34	0.74	0.99	1.47	2.00	2.07
Std	0.54	1.11	1.24	1.44	0.70	0.55
	Excess Return: rx					
Mean	1.31	2.86	3.87	5.13	4.99	7.14
	[0.70]	[1.17]	[1.41]	[1.61]	[2.16]	[2.18]
Std	3.34	5.38	6.68	7.62	10.20	10.64
SR	0.39	0.53	0.58	0.67	0.49	0.67
	Excess Return: rx (with bid-ask spreads)					
Mean	0.58	1.43	2.11	3.73	3.73	5.84
	[0.72]	[1.11]	[1.40]	[1.61]	[2.05]	[2.37]
	Panel II: Risk Prices					
	$\lambda_{HML\$Beta}$	$b_{HML\$Beta}$	R^2	$RMSE$	χ^2	
GMM_1	8.47	0.60	48.09	1.40		
	[2.74]	[0.20]			45.36	
GMM_2	6.55	0.47	19.77	1.75		
	[2.31]	[0.16]			54.84	
FMB	8.47	0.60	66.42	1.40		
	[2.57]	[0.18]			7.03	
	[2.58]	[0.18]			8.46	
Mean	6.12					
	Panel III: Factor Betas					
Portfolio	1	2	3	4	5	6
α	1.74	2.04	2.22	2.40	0.73	1.74
	[1.06]	[1.13]	[1.31]	[1.27]	[1.30]	[1.06]
β	−0.07	0.14	0.28	0.48	0.74	0.93
	[0.03]	[0.04]	[0.04]	[0.04]	[0.05]	[0.03]
R^2	5.40	8.36	20.42	46.92	62.05	90.54

Notes: Panel I reports summary statistics on portfolios of currencies sorted on their exposure to the dollar factor. See Section 3 for details on the construction of these portfolios. The table reports, for each portfolio, the mean and standard deviations of the average change in log spot exchange rates Δs, the average log forward discount $f - s$, and the average log excess return rx without bid-ask spreads. All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations and the mean excess returns net of bid-ask spreads. Panel II reports results from GMM and Fama-McBeth asset pricing procedures. The risk factor is the difference between the return on the last portfolio minus the return on the first portfolio. The market price of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings ($m_{t+1} = 1 - bCond.Dollar_{t+1}$). The last row reports the mean of the risk factor. Excess returns used as test assets and risk factors do not take into account bid-ask spreads. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. The second step of the FMB procedure does not include a constant. Panel III reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The alphas are annualized and in percentage points. Data are monthly, from Barclays and Reuters in Datastream. The sample period is 12/1988–12/2010.

Table 13: Portfolios of Countries Sorted By Interest Rates and Carry Betas

Panel I: Interest Rates Sorts						
Portfolio	1	2	3	4	5	6
			Spot change: Δs			
Mean	−0.87	−0.92	−1.12	−2.44	−0.92	2.74
Std	8.06	7.39	7.66	7.55	8.72	9.79
			Forward Discount: $f - s$			
Mean	−2.90	−1.19	−0.08	0.99	2.66	8.87
Std	0.54	0.48	0.46	0.51	0.63	1.87
			Excess Return: rx			
Mean	−2.03	−0.27	1.04	3.43	3.58	6.13
Std	8.15	7.46	7.70	7.64	8.78	9.80
S.R.	−0.25	−0.04	0.14	0.45	0.41	0.63

Panel II: Carry Beta Sorts						
Portfolio	1	2	3	4	5	6
			Spot change: Δs			
Mean	−1.34	−1.63	−1.32	−2.16	−0.44	0.40
Std	8.66	7.74	8.13	7.85	8.83	8.75
			Forward Discount: $f - s$			
Mean	−1.35	−0.36	0.76	1.04	1.54	3.74
Std	0.65	0.65	0.76	0.65	0.72	0.58
			Excess Return: rx			
Mean	−0.01	1.28	2.07	3.19	1.98	3.34
Std	8.77	7.77	8.16	7.88	8.79	8.73
S.R.	−0.00	0.16	0.25	0.41	0.23	0.38

Notes: This table reports summary statistics on portfolios of currencies sorted by their short-term interest rates (Panel I) or by their exposure to the carry factor (Panel II). The table reports, for each portfolio, the mean and standard deviations of the average change in log spot exchange rates Δs, the average log forward discount $f - s$, and the average log excess return rx without bid-ask spreads. All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Carry betas estimated over 36-month rolling windows. Data are monthly, from Barclays and Reuters in Datastream. The sample period is 12/1988–12/2010.

Table 14: Correlations between Dollar, Dollar Global, and Carry Factors: Levels and Volatilities

	Carry (HML-IR)	Carry (HML-Beta)	Dollar	Dollar Global (HML-Beta)	Carry Vol (HML-IR)	Dollar Vol	Dollar Global Vol
Carry (HML-IR)	1.00						
Carry (HML-Beta)	0.62	1.00					
	[0.04]						
Dollar	0.25	0.12	1.00				
	[0.08]	[0.09]					
Dollar Global (HML-Beta)	0.09	0.06	0.85	1.00			
	[0.09]	[0.11]	[0.03]				
Carry (HML-IR) Vol	0.38	0.28	0.23	0.14	1.00		
	[0.09]	[0.10]	[0.10]	[0.10]			
Dollar Vol	0.28	0.18	0.16	0.14	0.53	1.00	
	[0.07]	[0.10]	[0.11]	[0.10]	[0.07]		
Dollar Global Vol	0.23	0.12	0.15	0.16	0.37	0.62	1.00
	[0.07]	[0.11]	[0.11]	[0.11]	[0.09]	[0.07]	

Notes: The table reports the correlations between three factors: the dollar, the global component of the dollar, and the carry factor, as well as their respective volatilities. The carry factor is obtained by sorting countries by their short-term interest rates; it corresponds to the exchange rate changes of the last portfolio minus the exchange rate changes of the first portfolio (and denoted Carry (HML-IR) in the table. The table reports its correlation with another long-short proxy obtained by sorting countries by their carry betas; this proxy corresponds to the exchange rate changes of the last portfolio minus the exchange rate changes of the first portfolio (and denoted Carry (HML-Beta) in the table). The carry betas are obtained by regressing each bilateral exchange rate on the carry factor over rolling windows of three years. Table 13 reports the characteristics of the currencies portfolios built on carry betas. The dollar factor is the average of all exchange rates defined in U.S. dollars (denoted Dollar). The global component of the dollar factor corresponds to the difference between the exchange rate of the last dollar beta-sorted portfolio minus the exchange rate of the first dollar beta-sorted portfolio. All those factors are obtained on monthly series. The volatilities are built from daily changes in exchange rates. The volatility of the carry factor (denoted Carry (HML-IR) Vol) corresponds to the standard deviation over one month of the daily changes in exchange rates of the carry factor. To build the carry factor at the daily frequency, countries are sorted by their one-month interest rates on a daily basis. The volatility of the dollar factor (denoted Dollar Vol) corresponds to the standard deviation over one month of the daily changes in exchange rates of the dollar factor. To build the volatility of the global component of the dollar factor (denoted Dollar Global Vol), dollar beta portfolios are built at the daily frequency. The dollar betas used for each day of the month corresponds to their value at the monthly frequency. The volatility of the global component of the dollar factor is then obtained as the standard deviation over one month of the corresponding daily changes of exchange rates. The standard errors in brackets are obtained by boostrapping. Data are daily and monthly, from Barclays and Reuters in Datastream. The sample period is 12/1988–12/2010.

Table 15: Other Base Currencies and Cross Exchange Rates: Australian Dollar and Swiss Franc

Country	α	γ	δ	τ	R^2	α	γ	δ	τ	R^2	N
	Australian Dollar-based Exchange Rates					Swiss Franc-based Exchange Rates					
Switzerland/Australia	0.10	0.83	-0.31	-0.33	**24.81**	-0.05	2.98	-0.34	-0.39	**44.15**	266
	(0.18)	(0.57)	(0.12)	(0.10)	(7.00)	(0.18)	(0.42)	(0.14)	[0.10]	[4.93]	
Canada	-0.01	1.33	-0.02	-0.16	**10.91**	-0.15	0.21	0.35	-0.67	**39.51**	266
	(0.14)	(0.64)	(0.09)	(0.06)	(5.41)	(0.16)	(0.44)	(0.12)	[0.10]	[6.62]	
Denmark	0.13	1.62	-0.22	0.45	**40.24**	0.07	-1.20	0.43	0.01	**19.37**	266
	(0.17)	(0.37)	(0.09)	(0.08)	(5.46)	(0.08)	(0.22)	(0.07)	[0.03]	[5.78]	
Euro Area	0.37	1.29	-0.34	0.11	**26.08**	0.15	-0.39	0.35	0.07	**22.28**	143
	(0.20)	(0.67)	(0.18)	(0.07)	(7.06)	(0.10)	(0.62)	(0.13)	[0.04]	[8.12]	
France	-0.12	0.78	-0.12	0.99	**73.96**	-0.03	-0.71	0.22	-0.07	**6.84**	122
	(0.18)	(0.42)	(0.08)	(0.07)	(4.16)	(0.12)	(0.23)	(0.08)	[0.04]	[4.84]	
Germany	-0.10	0.91	-0.05	1.01	**75.09**	-0.02	0.03	0.05	-0.06	**1.31**	122
	(0.19)	(0.37)	(0.09)	(0.07)	(4.27)	(0.13)	(0.36)	(0.06)	[0.04]	[4.42]	
Italy	0.12	1.51	-0.16	0.88	**64.76**	0.21	1.09	-0.16	-0.15	**25.73**	122
	(0.21)	(0.37)	(0.11)	(0.08)	(5.93)	(0.21)	(0.25)	(0.14)	[0.08]	[7.20]	
Japan	0.11	2.57	0.28	-0.02	**30.96**	-0.00	0.39	-0.23	-0.45	**23.67**	266
	(0.23)	(0.72)	(0.30)	(0.13)	(7.06)	(0.17)	(0.65)	(0.12)	[0.07]	[6.02]	
New Zealand	0.07	1.71	-0.36	0.17	**13.55**	-0.03	1.99	-0.42	-0.26	**28.92**	266
	(0.13)	(0.80)	(0.12)	(0.07)	(8.42)	(0.18)	(0.37)	(0.16)	[0.08]	[5.36]	
Norway	0.09	1.22	-0.22	0.37	**24.76**	-0.00	0.44	0.21	-0.08	**13.56**	266
	(0.18)	(0.35)	(0.08)	(0.10)	(6.23)	(0.12)	(0.48)	(0.13)	[0.07]	[5.39]	
Sweden	0.14	2.18	-0.10	0.41	**40.22**	0.09	0.53	0.24	-0.02	**14.87**	266
	(0.16)	(0.41)	(0.08)	(0.07)	(5.60)	(0.12)	(0.37)	(0.12)	[0.06]	[4.92]	
Switzerland/Australia	0.05	2.98	0.34	0.39	**44.15**	-0.05	0.27	0.11	-0.84	**69.03**	266
	(0.18)	(0.42)	(0.14)	(0.10)	(5.36)	(0.10)	(0.29)	(0.07)	[0.05]	[3.70]	
United Kingdom	0.18	2.23	-0.19	0.24	**13.38**	0.03	-1.07	0.70	-0.36	**23.15**	266
	(0.19)	(0.60)	(0.10)	(0.10)	(6.45)	(0.14)	(0.53)	(0.20)	[0.08]	[4.61]	

Notes: This table reports country-level results from the following regression:

$$\Delta s_{i,t+1} = \alpha_i + \beta_i(r_{i,t} - r_t) + \gamma_i(r_{i,t} - r_t)Carry_{t+1} + \delta_i Carry_{t+1} + \tau_i Dollar^{global}_{t+1} + \varepsilon_{i,t+1},$$

where $\Delta s_{i,t+1}$ denotes the bilateral exchange rate in foreign currency per Australian Dollar (left panel) or per Swiss Franc (right panel), and $r_{i,t} - r_t$ is the interest rate difference between the foreign country and Australia (left panel) or Switzerland (right panel), $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar^{global}_{t+1}$ corresponds to the change in exchange rates in a high dollar-beta portfolio minus the change in exchange rates in a low dollar-beta portfolio. See the caption of Table 5 for the definition of the variables and the list of parameters reported. Note that, as in Table 5 but unlike in the previous tables, the currency on the left-hand side of these regressions is not excluded from the portfolios on the right-hand side. In the left panel (where exchange rates are defined in units of foreign currency per Australian Dollar), regression results for Australia are replaced by those for Switzerland (Swiss Franc per Australian Dollar). Likewise, in the right panel (where exchange rates are defined in units of foreign currency per Swiss Franc), regression results for Switzerland are replaced by those for Australia (Australian Dollar per Swiss Franc). Data are monthly, from Barclays and Reuters (Datastream). All variables are in percentage points. The sample period is 11/1983–12/2010.

Table 16: Country-Level Asset Pricing

$\lambda_{HML_{FX}}$	$\lambda_{Cond.RX}$	$b_{HML_{FX}}$	$b_{Cond.RX}$	R^2	$RMSE$	$MAPE$	χ^2
			Panel A: Unconditional Betas				
4.02	3.99	4.59	7.83	28.89	3.15	2.13	
[2.35]	[2.76]	[2.86]	[5.65]				40.67
			Panel B: Raw and Managed Currency Excess Returns				
4.93	5.88	5.55	11.64	50.32	3.47	1.83	
[2.43]	[1.41]	[2.98]	[2.91]				45.43
			Panel C: Dynamic Betas using Forward Discounts				
6.37	6.43	7.27	12.63	41.05	2.62	1.77	
[2.27]	[1.35]	[2.78]	[2.75]				70.19
			Panel D: Risk Factors' Expected Excess Returns				
4.82	5.51						
[1.95]	[1.36]						

Notes: The table reports results from Fama-MacBeth asset pricing procedure using individual currency excess returns. The Fama and MacBeth procedure has two steps. In the first step, time-series regressions of each country i's currency excess return are run on a constant, the carry trade excess return HML_{FX}, and the conditional dollar excess return (obtained as the dollar excess return multiplied by the sign of the average forward discount, i.e. $Cond.RX = Sign\,(\overline{r_{i,t}} - r_t) \times RX$):

$$Rx^i_{t+1} = c^i + \beta^i_{HML} HML_{FX,t+1} + \beta^i_{Dollar} Cond.RX_{t+1} + \epsilon_{i,t+1}, \text{for a given } i, \forall t.$$

The second step runs cross-sectional regressions of all currency excess returns on betas:

$$Rx^i_t = \lambda_{HML,t}\beta^i_{HML} + \lambda_{RX,t}\beta^i_{RX} + \xi_t, \text{for a given } t, \forall i.$$

The market price of risk is the mean of all these slope coefficients: $\lambda_c = \frac{1}{T}\sum_{t=1}^{T} \lambda_{c,t}$ for c = HML, $Cond.RX$. Panel A reports the results of the Fama-MacBeth procedure on raw currency excess returns at the country-level. Panel B uses both raw and managed excess currency returns. Managed excess returns are obtained by multiplying the raw returns by the country-specific forward discounts (normalized by subtracting the average forward discount across currencies and dividing by the cross-sectional standard deviation of forward discounts in the given period) and the average forward discount. Panel C focuses on raw returns but considers conditional betas. The estimation assumes that $\beta^i_{HML,t} = h^i_0 + h^i_1 (\widetilde{r_{i,t} - r_t})$, where $(\widetilde{r_{i,t} - r_t})$ is the country-specific forward discount, standardized as described above, and $\beta^i_{RX,t} = d^i_0 + d^i_1 \overline{(r_{i,t} - r_t)}$, where $\overline{(r_{i,t} - r_t)}$ is the sign of the average forward discount. The parameters h^i_0, h^i_1, d^i_0, and d^i_1 can be estimated from the linear regression:

$$Rx^i_{t+1} = c^i + h^i_0 HML_{FX,t+1} + h^i_1 (\widetilde{r_{i,t} - r_t}) HML_{FX,t+1} + d^i_0 RX_{t+1} + d^i_1 \overline{(r_{i,t} - r_t)} RX_{t+1} + \epsilon_{i,t+1}, \text{for a given } i.$$

The factor risk prices $\lambda_{HML,t}$ and $\lambda_{RX,t}$ can then be estimated by running a second-stage cross-sectional regressions on the fitted conditional betas:

$$Rx^i_{t+1} = \lambda_{HML,t}\beta^i_{HML,t} + \lambda_{RX,t}\beta^i_{RX,t} + \xi_{t+1}, \text{for a given } t, \forall i,$$

Panel D simply reports the mean of the risk factors. Market prices of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$, the mean absolute pricing error $MAPE$, and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings ($m_{t+1} = 1 - bf_{t+1}$, where m denotes the SDF and f the risk factors). Excess returns used as test assets do *not* take into account bid-ask spreads because one does not know *a priori* whether investors should take a short or a long position on each particular currency. Risk factors HML and $Cond.RX$ come from portfolios of currency excess returns that take into account bid-ask spreads. All excess returns are multiplied by 12 (annualized). There is no constant in the second step of the FMB procedure. The standard errors in brackets are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). Data are monthly, from Barclays and Reuters in Datastream. The sample period is 11/1983–12/2010.

Table 17: Changes in Volatilities: Monthly Tests in Developed Countries — Carry and Dollar Factors

	α	β	γ	δ	τ	ρ	R^2	W	N
Australia	25.93	7.16	1.53	3.17	2.79	-0.43	29.30	**	312
	(4.09)	(7.11)	(3.53)	(1.65)	(1.91)	(0.07)	[9.88]		
Canada	6.61	-3.24	-3.92	1.32	0.61	-0.17	14.51	**	312
	(1.62)	(4.09)	(3.99)	(0.53)	(0.68)	(0.04)	[5.34]		
Denmark	31.93	8.77	0.05	1.79	0.23	-0.54	29.26	***	312
	(3.83)	(3.21)	(1.50)	(0.46)	(0.65)	(0.06)	[5.82]		
Euro Area	24.86	9.61	0.57	1.66	1.12	-0.40	23.61	**	143
	(5.27)	(8.41)	(2.38)	(0.66)	(1.00)	(0.09)	[7.79]		
France	44.40	19.61	3.17	1.72	-0.48	-0.77	37.77	**	181
	(5.27)	(6.69)	(2.83)	(0.60)	(0.83)	(0.08)	[6.77]		
Germany	41.79	3.97	2.43	1.36	-0.99	-0.65	31.49		181
	(4.99)	(5.48)	(2.48)	(0.72)	(0.83)	(0.07)	[6.91]		
Italy	30.23	17.41	0.39	1.72	-0.66	-0.61	31.95	*	177
	(4.80)	(9.81)	(2.34)	(0.83)	(0.85)	(0.06)	[6.07]		
Japan	35.47	-2.69	-1.53	1.72	0.60	-0.58	32.70	***	325
	(5.26)	(5.91)	(3.05)	(0.86)	(0.88)	(0.08)	[6.31]		
New Zealand	23.11	14.20	3.73	1.83	1.42	-0.42	27.84	***	312
	(4.36)	(7.44)	(2.75)	(1.02)	(1.32)	(0.08)	[5.77]		
Norway	26.50	2.45	0.47	2.24	1.74	-0.43	27.08	***	312
	(5.66)	(4.25)	(1.91)	(0.77)	(0.94)	(0.10)	[5.96]		
Sweden	22.94	-1.73	1.80	1.25	1.14	-0.36	20.42	***	312
	(5.21)	(3.61)	(1.61)	(0.62)	(0.67)	(0.09)	[6.38]		
Switzerland	42.18	9.47	2.23	2.59	-1.47	-0.60	34.27	***	325
	(3.68)	(4.72)	(1.73)	(0.66)	(0.71)	(0.05)	[5.67]		
United Kingdom	22.15	14.77	-1.72	2.25	1.29	-0.43	26.54	***	325
	(3.78)	(5.51)	(4.50)	(1.03)	(0.61)	(0.08)	[6.45]		

Notes: This table reports country-level results from the following regression:

$$\Delta\sigma_{\Delta s,t+1} = \alpha + \beta(i_t^\star - i_t) + \gamma(i_t^\star - i_t)Carry_{t+1} + \delta Carry_{t+1} + \tau Dollar_{t+1} + \rho\sigma_{\Delta s,t} + \varepsilon_{t+1},$$

where $\sigma_{\Delta s,t+1}$ denotes the change in monthly volatility of the bilateral exchange rate in foreign currency per U.S. dollar, $i_t^\star - i_t$ is the interest rate difference between the foreign country and the U.S., $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar_{t+1}$ corresponds to the average change in exchange rates against the U.S. dollar. The monthly volatility of the exchange rate is obtained as the standard deviation of the daily changes in exchange rates. The table reports the constant α, the slope coefficients β, γ, δ, τ, and ρ, as well as the adjusted R^2 of this regression (in percentage points) and the number of observations N. Standard errors in parentheses are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The standard errors for the R^2s are reported in brackets; they are obtained by bootstrapping. W denotes the result of a Wald test: the null hypothesis is that the loadings γ and δ on the conditional and unconditional carry factors are jointly zero. Three asterisks (***) correspond to a rejection of the null hypothesis at the 1% confidence level; two asterisks and one asterisk correspond to the 5% and 10% confidence levels. Data are monthly, from Barclays and Reuters (Datastream). All variables are in percentage points. The sample period is 11/1983–12/2010.

Table 18: Changes in Volatilities: Monthly Tests in Developed Countries —- Carry and Dollar Volatilities

	α	β	γ	ρ	R^2	W	N
Australia	21.07	0.76	0.30	-0.32	37.88	***	312
	(6.88)	(0.28)	(0.21)	(0.11)	[6.67]		
Canada	4.68	0.33	0.13	-0.12	29.39	***	312
	(1.62)	(0.07)	(0.05)	(0.05)	[5.82]		
Denmark	10.17	1.19	-0.03	-0.16	71.01	***	312
	(2.04)	(0.08)	(0.06)	(0.03)	[4.29]		
Euro Area	14.30	0.93	-0.12	-0.24	43.08	***	143
	(4.28)	(0.15)	(0.09)	(0.07)	[6.73]		
France	8.63	1.37	0.08	-0.14	78.56	***	183
	(2.64)	(0.09)	(0.05)	(0.04)	[3.96]		
Germany	7.06	1.34	0.06	-0.11	83.38	***	183
	(2.27)	(0.08)	(0.03)	(0.04)	[2.74]		
Italy	12.41	1.21	0.13	-0.20	69.52	***	183
	(2.52)	(0.11)	(0.07)	(0.04)	[5.01]		
Japan	26.54	0.66	0.16	-0.42	45.86	***	326
	(3.89)	(0.12)	(0.08)	(0.06)	[6.15]		
New Zealand	22.25	0.35	0.32	-0.32	28.13	**	312
	(5.24)	(0.21)	(0.16)	(0.08)	[6.50]		
Norway	14.44	1.13	0.02	-0.22	53.08	***	312
	(6.12)	(0.12)	(0.04)	(0.10)	[6.80]		
Sweden	11.29	1.09	-0.00	-0.18	53.08	***	312
	(4.22)	(0.11)	(0.07)	(0.07)	[5.71]		
Switzerland	21.83	1.05	-0.06	-0.32	57.10	***	326
	(3.53)	(0.11)	(0.07)	(0.05)	[6.41]		
United Kingdom	11.47	1.01	0.03	-0.20	57.96	***	326
	(2.48)	(0.09)	(0.05)	(0.05)	[6.03]		

Notes: This table reports country-level results from the following regression:

$$\Delta\sigma_{\Delta s^i,t+1} = \alpha + \beta\Delta\sigma_{Dollar,t+1} + \gamma\Delta\sigma_{Carry,t+1} + \rho\sigma_{\Delta s,t} + \varepsilon_{t+1},$$

where $\Delta\sigma_{\Delta s^i,t+1}$ denotes the change in the monthly volatility of the bilateral exchange rate in foreign currency i per U.S. dollar. $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar_{t+1}$ corresponds to the average change in exchange rates against the U.S. dollar. $\Delta\sigma_{Dollar,t+1}$ and $\Delta\sigma_{Carry,t+1}$ denote the change in the monthly volatility of the corresponding exchange rate series. The monthly volatility of the exchange rate is obtained as the standard deviation of the daily changes in exchange rates. The table reports the constant α, the slope coefficients β, γ, and ρ, as well as the adjusted R^2 of this regression (in percentage points) and the number of observations N. Standard errors in parentheses are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). The standard errors for the R^2s are reported in brackets; they are obtained by bootstrapping. W denotes the result of a Wald test: the null hypothesis is that the loadings β and γ on the dollar and carry volatilities are jointly zero. Three asterisks (***) correspond to a rejection of the null hypothesis at the 1% confidence level; two asterisks and one asterisk correspond to the 5% and 10% confidence levels. Data are monthly, from Barclays and Reuters (Datastream). All variables are in percentage points. The sample period is 11/1983–12/2010.

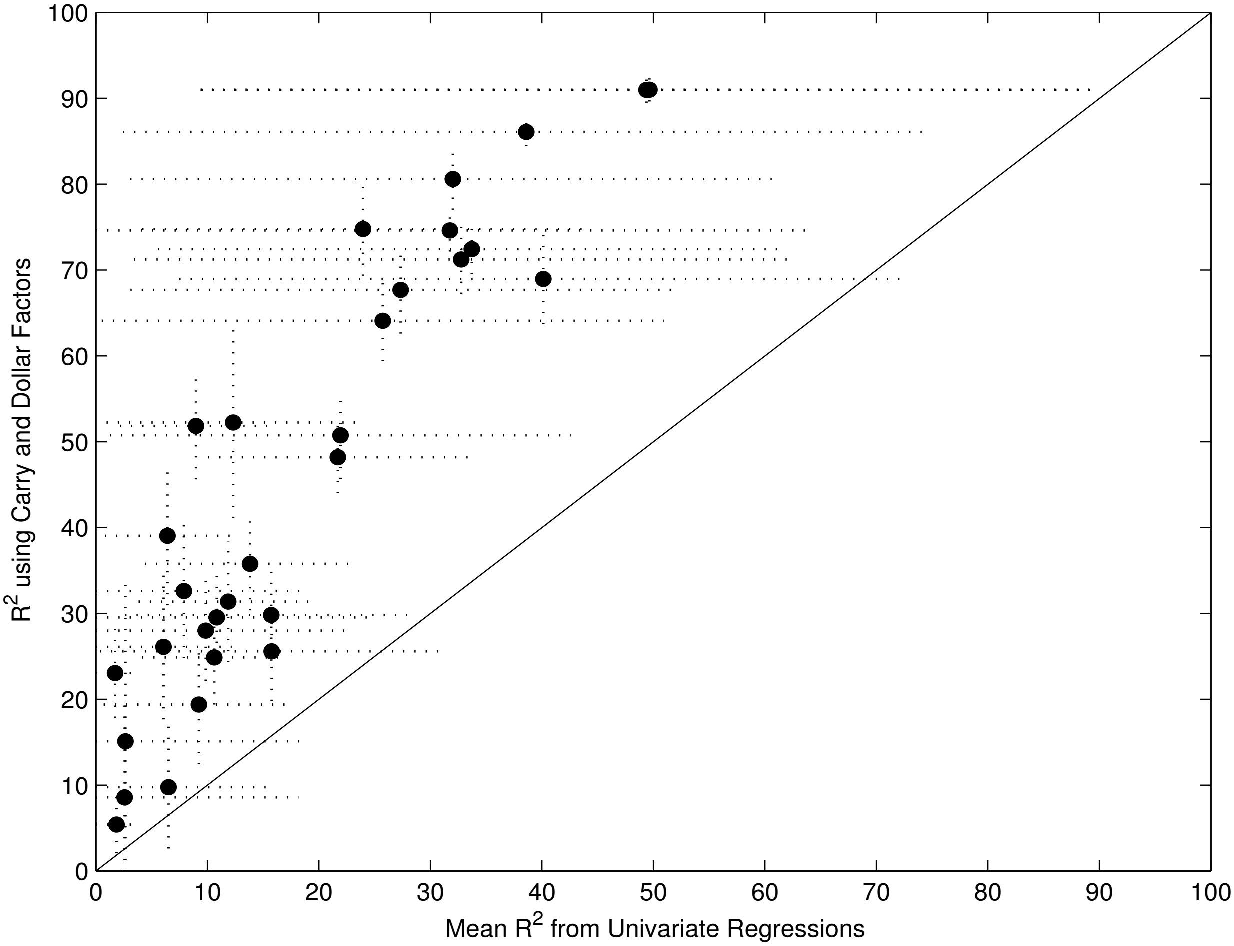

Figure 3: Measuring Systematic Risk with Factors vs. Individual Exchange Rates

The figure compares R^2s obtained with the carry and dollar factors (vertical axis) to those obtained from random univariate regressions of one exchange rate changes on others (horizontal axis).
Adjusted R^2s on the vertical axis correspond to the following regressions:

$$\Delta s_{t+1} = \alpha + \beta(i_t^\star - i_t) + \gamma(i_t^\star - i_t)Carry_{t+1} + \delta Carry_{t+1} + \tau Dollar_{t+1} + \varepsilon_{t+1},$$

where Δs_{t+1} denotes the bilateral exchange rate in foreign currency per U.S. dollar, $i_t^\star - i_t$ denotes the interest rate difference, $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar_{t+1}$ corresponds to the average change in exchange rates against the U.S. dollar. Dots correspond to point estimates, while dotted lines represent confidence intervals (defined as one-standard error above and below the point estimates). Standard errors are obtained by bootstrapping.
Adjusted R^2s on the horizontal axis correspond to the following experiment. Each currency i is regressed (in log changes) on a constant and another currency j ($i \neq j$):

$$\Delta s_{t+1}^i = \alpha + \beta \Delta s_{t+1}^j + \varepsilon_{t+1}^{i,j}.$$

Each regression delivers a pair-specific adjusted R-square, denoted $R^{2^{i,j}}$. For each currency i, the figure reports the mean of all $R^{2^{i,j}}$ for $j \neq i$). Dots correspond to the mean estimates, while dotted lines represent confidence intervals (defined as one-standard deviation above and below the mean estimates). Data are monthly. The sample period is 11/1983–12/2010.

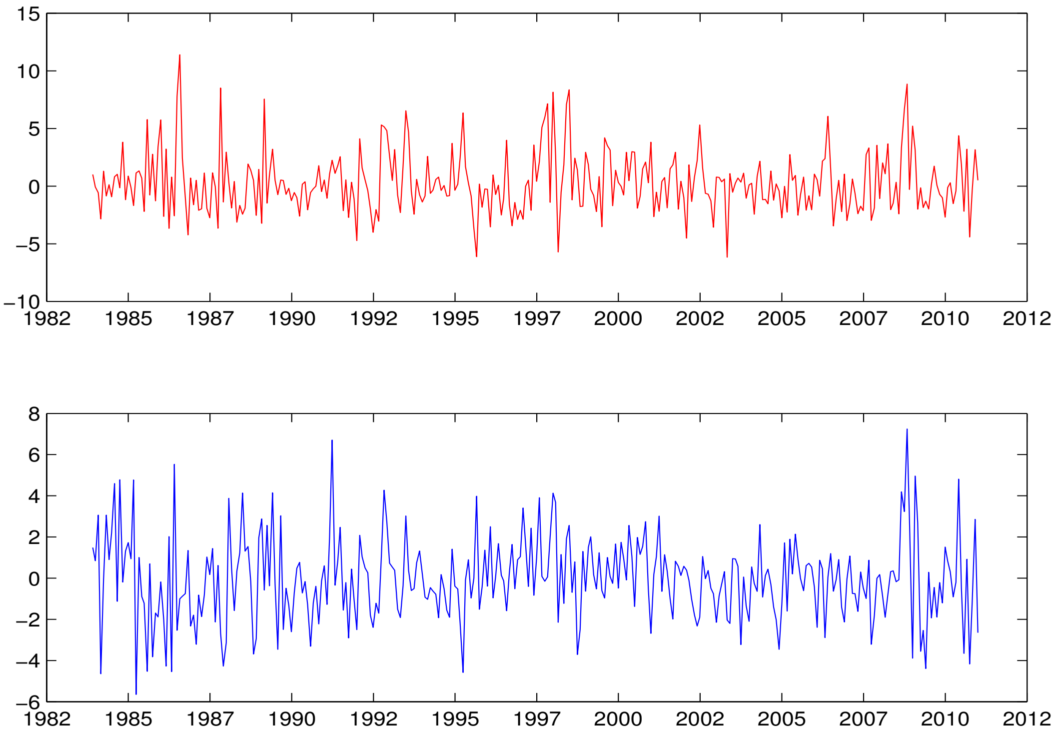

Figure 4: Carry and Dollar Factors at the Monthly Frequency

The figure presents the time-series of the carry and dollar factors. Data are monthly. The sample period is 11/1983–12/2010.

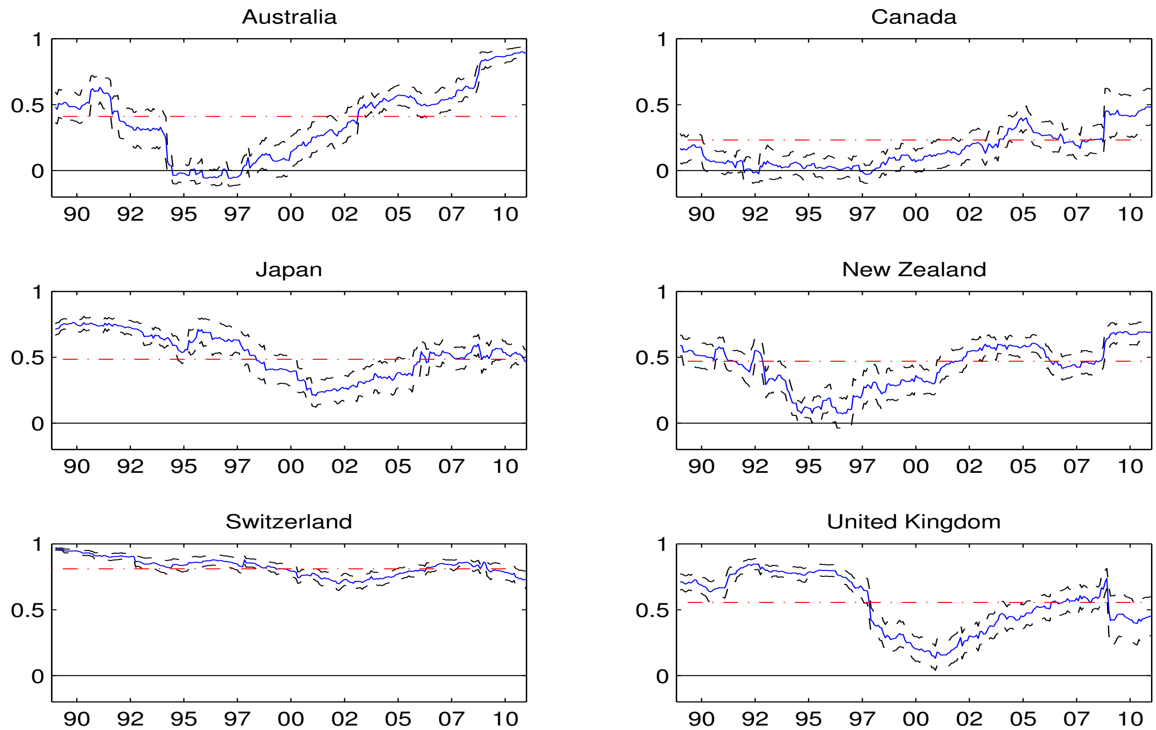

Figure 5: Adjusted R^2s Estimated on Rolling Windows

The figure plots the adjusted R^2 in the following regression:

$$\Delta s_{t+1} = \alpha_t + \beta_t(i_t^\star - i_t) + \gamma_t(i_t^\star - i_t)Carry_{t+1} + \delta_t Carry_{t+1} + \tau_t Dollar_{t+1} + \varepsilon_{t+1},$$

where Δs_{t+1} denotes the bilateral exchange rate in foreign currency per U.S. dollar, and $i_t^\star - i_t$ is the interest rate difference, $Carry_{t+1}$ denotes the dollar-neutral average change in exchange rates obtained by going long a basket of high interest rate currencies and short a basket of low interest rate currencies, and $Dollar_{t+1}$ corresponds to the average change in exchange rates against the U.S. dollar. Data are monthly and estimates are obtained on rolling windows of 60 months. . The solid line presents the time-varying R^2s (R_t^2 corresponds to an estimate over the sample from $t-60$ to t). The dotted line corresponds to the estimated value plus or minus one standard deviation of the estimate. This standard deviation is obtained by bootstrapping the regression above assuming that changes in exchange rates are *i.i.d*. The dash-dotted line reports the R^2 obtained on the full sample. The full sample period is 1/1983–12/2010.

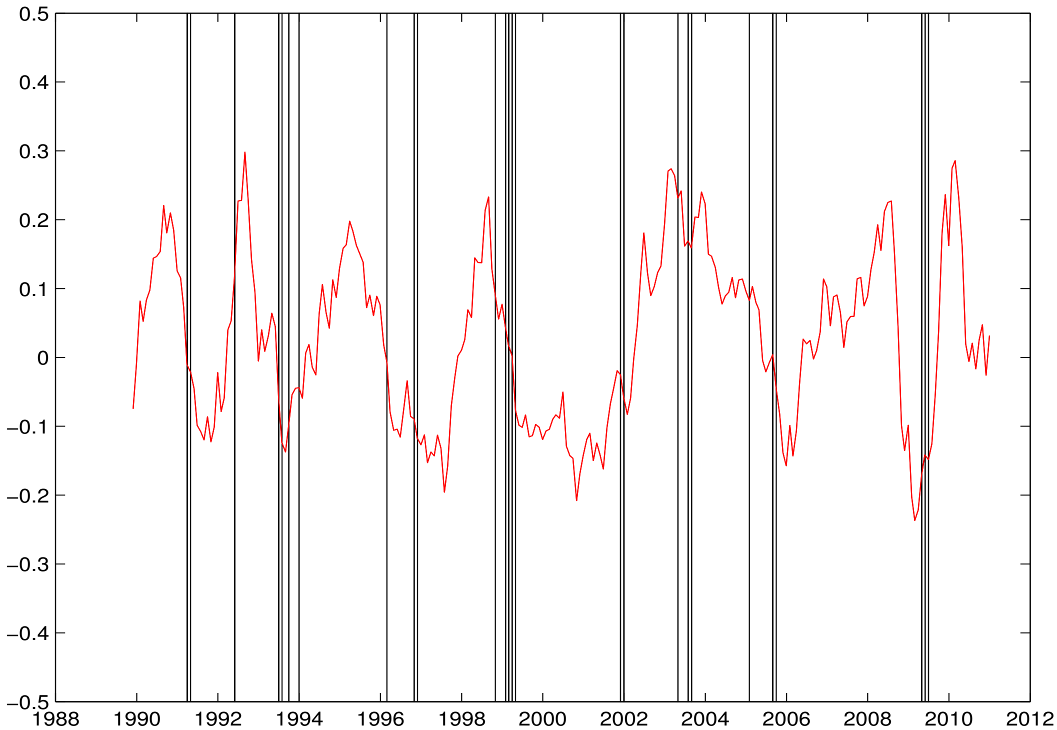

Figure 6: Twelve-month Returns on Dollar-beta Portfolios and G7 Troughs

The figure presents the cumulative 12-month returns obtained by going long the high dollar beta portfolio and short the low dollar beta portfolio. The long-short strategy focuses on the global component of the dollar risk factor. The figure also presents the trough dates of the G7 countries' business cycles established by the OECD. Data are monthly. The sample period is 11/1983–12/2010.