Global and Regional Risk in Currency Returns

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June 27, 2019

Abstract

This paper presents an asset pricing model for an integrated financial economy in a multi-currency framework where asset prices are driven by three dimensions of risk: global *risk*, regional risk and country specific risk. Under this framework all risks are common since by trading assets across countries agents are able to load on foreign risk, however the solution of the model impose restrictions on the loading coefficients and as a result only the dispersion in global and regional coefficients are needed to explain currency returns. I test the model with a lineal factor model at the pair currency level with a sample of 42 countries from 5 different regions and show that, as the model predicted, regional and global factors help to explain the dispersion in currency returns.

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1 Introduction

This paper studies the how regional common factors can explain currency returns at the pair currency level. I build returns on regional portfolios for 5 geographical regions: Americas, Europe, Asia, Australia and Africa and show that regional factor help explain the time series and cross-section of currency returns in a non-arbitrage model for international finance.

The *Forward Premium Puzzle* (FPP) is an empirical regularity where *Uncovered Interest Rate Parity* (UIP) fail. The UIP is a proposal that relates interest rate differentials between two countries to their percentage changes in the nominal exchange rate. Formally under UIP expectations of depreciation/appreciation of the currency are related to the interest rate differential by

$$E_0\left[\frac{Q_T}{Q_0}\right] = \frac{(1+r^d)}{(1+r^f)} \tag{1}$$

where Q_t represents the nominal exchange rate in period t defined as the number of domestic currency units required to purchase one unit of foreign currency. r^d represents the risk free interest rate in the domestic country and $r^f$the risk free rate in the foreign country $E_0[.]$ denotes the expectation given the information set available at time $t = 0$. It is common to present the UIP relation in logarithms as

$$e_t \approx r^d - r^f \tag{2}$$

where e_t represents the logarithm of the expected percentage change in the nominal exchange rate. The FPP manifests as average changes in the exchange rate that are less than the interest rate differentials. This regularity has led to a financial portfolio strategy known as the *carry trade* in which investors borrow money from countries with low interest rates, convert that money into currency from countries with high interest rates where they lend it.

The existence of this phenomena has been attributed by Fama (1984) [11] to the existence of a currency risk premium

$$e_t \approx r^d - r^f + \Phi_t \tag{3}$$

where Φ_t represents the currency risk premium. The FPP is a regularity that has been persistent and has caught the attention of the international finance literature. Hodrick (1987) [17] and Engel (1995) [10] present a literature review. This paper contributes to this literature as it presents an asset pricing model for an integrated financial economy in a multi-currency framework where the risk premium arises from differences across countries on how agents weight in common global and regional risk factors. The model suggests that to generate a risk premium to solve for the FPP exchange rates must be driven by dimensions of risk that also drive the domestic stochastic discount factor. In my model with complete markets these are regional and global risks.

The FPP paradox has been approached by both a macroeconomic perspective: with models that start with agents, preferences and budget constraints and by a financial perspective: with models that start from an analysis of the returns. This paper adopts a financial approximation as presented by Backus, Foresi and Telmer (2001) [2] they show that the anomaly can by explained by the relative variance between the stochastic discount factors between the two economies. The stochastic discount factor (SDF) is the process by which agents discount future payoffs. Baillie and Bollerslev (2000) [3] follow this line and present a theoretical model to show that when the variance of the SDF presents a high level of persistence it is possible to replicate the empirical evidence documented by the FPP. Other studies relate the volatility of the SDF to macroeconomic variables as in Brant, Cochrane and Santa Clara (2006) [4] who call for the need for *common* risk factors to account for the anomaly and connect it to the volatility of consumption. Colacito and Croce (2011) [9] present a macroeconomic model where the common risk factor arises from the high correlation in the long run expected growth between the economies.

To explain the dispersion in currency returns common factors are no sufficient, we should also have dispersion on the exposition to this common component of risk. Lustig, Roussanov and Verdelhan (2011) [19], henceforth LRV, propose an asset pricing model in which there are two common factor, one of which is the global risk factor that drives both currencies and interest rates, they show that when there are differences in the exposure to this global risk across currencies the carry trade emerges as a factor that helps explain the cross-variation in currency returns. LRV test their model on currency portfolios formed based on interest rate differentials. Menkhoff et al. (2012) [20] also propose an asset pricing model with two factors, one of which is the FX volatility factor for which currencies have different exposure with high interest rate countries less expose to this factor. In this paper I propose a model in which there is more than one common risk for which countries have different exposure and these are associated by the geographical region the country belongs to. I propose a geographical factor since currencies and interest rates from countries in the same region have a tendency to move together. There is empirical evidence that financial markets are segregated by regions as in Griffin (2002) [15] and Fama and French (2012) [13] who document how local factors perform better at explaining local stock returns than global factors do, in fact Fama and French speculate that this regularity might be explained by currency risk.

The need to additional factors should not come as a surprise as in finance most asset pricing models that are successful explaining expected returns use more than one factor. Fama and French (1992) [12] in their seminal paper propose a three factor model to explain the cross-variation in US stock returns and their model has become the benchmark in the finance literature. Bayer, Ellickson and Ellickson (2010) [5] present a theoretical asset pricing model for the housing market and show that the widely used Case and Shiller index (1989) [7] for the housing market can be seen as a two factor model. More recently in the currency return literature Verdelhan (2018) [25] develops a model build on the LRV model in which a second global factor is added, this new factor is the dollar factor that comes from sorting currencies based on the dollar beta from the LRV estimation. The regional factors proposed in this paper are different because they not come from sorting betas or returns, but on characteristics that could potentially link more natural to economic and social factors. In this line Lustig and Richmond (2017) [18] show that the distance between countries is related to the exposition of a currency pair to systematic currency risk with exposition increasing as countries are more distant, in their paper the distance is measure by physical distance, language, natural resources and boundaries. My geographical region portfolios are related to the measures of distance but this paper is different because it frames the regional risk as a common factor that explains the time series and cross-section of currency returns. Richmond (2019) [23] links the carry trade factor with the trade centrality of a country and develops a general equilibrium model in which more central countries have lower interest rates and load more on global risk, he further shows that a portfolio based on trade centrality has a close to one to one relation with the carry trade portfolio.

In the empirical section I present a study of a multi-factor asset pricing model for currency returns, with global and regional risks as factors that explain how currencies are priced where instead of testing the model on portfolios of currencies I test the model at the currency pair level. Recent literature such as Verdelhan (2018) [25] and Lustig and Richmond (2017) [18] estimate models at the pair currency level but there are few studies that do so, this paper contribute to this growing literature. This paper also contributes to the literature because I introduce the geographical regions as dimensions of risk with pricing implications. I estimate the model from an stochastic discount factor specification from a conditional linear factor model that explains the cross-section of currency returns. I test the model using monthly observations of exchange rates and interest rates from January 1970 to September 2018 and provide evidence that the regional factors help explain currency returns.

The remaining of the paper is organized as follows: Section (2) presents the asset pricing model. Section (3) presents the data. Section (4) presents the econometric technique. Section (5) reports the empirical findings. Section (6) concludes.

2 Model

I present an asset pricing model for an integrated financial market in a multi-currency framework where agents can freely trade assets regardless of the country where the asset was issued. There are I countries in the model each with its own currency, countries are distributed into G geographical regions with $G \leq I$ and each country can only belong to one geographical region. Let's further assume that assets from each country are exposed to three independent dimensions of risk: 1. Global risk, 2. Regional risk that is specific to the geographical region that the country belongs to and 3. Country specific risk, therefore the integrated financial market is driven by $D = I + G + 1$ dimensions of risk. I also assume that the integrated financial market is complete and that asset prices are driven by a $D-$ dimensional Brownian motion $W = \left(W^1, W^2, ..., W^D\right)$ on a filtered probability space $(\Omega, \mathcal{F}, \mathbb{F}, \mathbb{P})$ where $\mathbb{F} = (\mathcal{F}_t)_{t\geq 0}$ is the filtration generated by W and that asset price processes are represented by multidimensional geometric Brownian motions (GBM) an assumption that is consistent with the limited liability of assets because these processes are guaranteed to be non-negative.

The model is built under an asset pricing framework that relates expected returns in currency investments to their associated risk. Under this approach equilibrium conditions are achieved not by a set of restrictions that equate supply and demand of currencies but by the imposition of the assumption of absence of arbitrage opportunities, that is: there is not a self-financing portfolio of currencies and the risk free asset that can guaranty no losses and the expectation of profits in the future.

2.1 The exchange rate and the stochastic discount factor

Let's assume that for each country there is a risk free asset in the local currency. Since markets are complete, there are no arbitrage opportunities and assets prices follow a multidimensional (GBM) then there is unique stochastic discount factor for each country i given by the SDE

$$d\Lambda_t^i = \Lambda_t^i \left[-r_t^i dt - \alpha^i dW_t^\omega - \sum_{g=1}^{G} \delta_t^{ig} dW_t^g - \theta^i dW_t^i \right] \tag{4}$$

(see Shreve 2004 [24]) where r_t^i is the instantaneous rate of return of the risk free asset for country i, α_t^i is the market price of risk for global risk for country i, δ_t^{ig} is the market price of risk for country i to regional risk g and θ_t^i is the market price of risk for country specific risk i. The instantaneous rate of return and the market prices of risk are parameters assumed to be adapted to the filtration generated by the $D-$dimensional Brownian motion W. Note that I'm assuming that country specific risk for foreign countries is not priced in the domestic economy, as commonly assumed in the literature.

There is one important result from (4) although we assumed that assets issued in country i are only driven by: global risk, regional risk for the which the domestic country belongs to and domestic risk, under this framework the SDF is driven by a linear combination of not three but $G + 2$ underlying components of risk: one global component, one country specific components of risk and G regional components of risk. This reflects the fact that by trading foreign assets domestic agents not only load on foreign risk but that these risks may have pricing implications for the domestic investor.

The assumption of absence of arbitrage opportunities implies that the exchange rate not only links currencies but it also links the stochastic discount factors as proposed by Backus, Foresi and Telmer (2001)

$$Q_t^{ij} \Lambda_t^i = \Lambda_t^j \tag{5}$$

I define the nominal exchange rate between country i and country j as Q_t^{ij} which represents the number of domestic currency units from country i required to purchase one unit of currency from foreign country j at time t[1]. I specify exchange rates by the pair (i, j) where the first letter denotes the domestic country and the latter the foreign country. Since there are I countries there are two permutation of I different exchange rates $P(I, 2)$.

The exchange rate process between country i and country j is assumed to be driven by the dimensions of risk to which the pair of countries are directly exposed to. This assumption leads to 5 dimensions of risk driving the exchange rate Q_t^{ij}: 1. Global risk, 2. Regional risk from the region that country i belongs to, 3. Regional risk from the region that country j belongs to, 4. Country specific risk from country i, and 5. Country specific risk from country j. I assume that exchange rate process Q_t^{ij} is a multidimensional geometric Brownian motion characterized by the stochastic differential equation (SDE)

$$dQ_t^{ij} = Q_t^{ij} \left[\mu_t^{ij} dt + \sigma_t^{ij} d\mathbb{W}_t^{ij} \right] \tag{6}$$

Equation (6) expresses the instantaneous rate of appreciation/depreciation of the currency of country i with respect to the currency of country j at time t as having two components: a deterministic component represented by $\mu_t^{ij} dt$ where μ_t^{ij} is the instantaneous rate of appreciation/depreciation of currency i with respect to currency j and a stochastic component represented by $\sigma_t^{ij} d\mathbb{W}_t^{ij}$ where σ_t^{ij} is the volatility of the rate of appreciation/depreciation of such exchange rate and $\mathbb{W}_t^{ij}$ is a one

[1] Through the document subscripts are reserved to denote time and superscripts to identify assets and countries.

dimensional Brownian motion that is a assumed to be a linear combination of the 5 underlying independent dimensions of risk driving the exchange rate process between the two countries. Let´s assume without loss of generality that country i belongs to region f and country j belongs to region h. From the perspective of country i region f is its *domestic region* and region h is a *foreign region*, The stochastic component $\sigma_t^{ij} d\mathbb{W}_t^{ij}$ is given by

$$\sigma_t^{ij} d\mathbb{W}_t^{ij} = \sigma_t^{ij,\omega} dW_t^{\omega} + \sigma_t^{ij,f} dW_t^{f} + \sigma_t^{ij,h} dW_t^{h} + \sigma_t^{ij,i} dW_t^{i} + \sigma_t^{ij,j} dW_t^{j} \tag{7}$$

with

$$\left(\sigma_t^{ij}\right)^2 = \left(\sigma_t^{ij,\omega}\right)^2 + \left(\sigma_t^{ij,f}\right)^2 + \left(\sigma_t^{ij,h}\right)^2 + \left(\sigma_t^{ij,i}\right)^2 + \left(\sigma_t^{ij,j}\right)^2 \tag{8}$$

where W_t^{ω} is a Brownian motion representing global risk, W_t^f and W^h are independent Brownian motions representing regional risk for regions f and h respectively and W_t^i and W_t^j are independent Brownian motions representing country specific risk for counties i and j respectively. The parameters $\sigma_t^{ij,\omega}, \sigma_t^{ij,f}, \sigma_t^{ij,h}, \sigma_t^{ij,i}$ and $\sigma_t^{ij,j}$ represent the instantaneous volatility of each of the 5 underlying dimensions of risk. Equation (8) states that the variance of the exchange rate process is the sum of the variances of the underlying dimensions of risk since risks are independent of each other. The parameters from (6) and (8) are assumed to be adapted to the filtration generated by the $D-$dimensional Brownian motion W. Exchange rates across currencies are also linked by

$$Q_t^{ij} = \frac{1}{Q_t^{ji}} \tag{9}$$

$$Q_t^{ij} = \frac{Q_t^{ik}}{Q_t^{jk}} \tag{10}$$

equation (9) states the exchange rate between currency i and currency j from the perspective of country i is just the reciprocal of the exchange rate between these two countries but from the perspective of country j. Equation (10) states that the exchange rate between country i and country j most be equal to the ratio of the exchange rate between country i and a third country k and the exchange rate between country j and country k.

The model proposed here is a generalization of the model in LRV which they use to show that dispersion in common factors help explain the cross section of currency return, in their model there is no regional risk so the domestic and foreign stochastic discount factors are given by

$$d\Lambda_t^i = \Lambda_t^i \left[-r_t^i dt - \alpha_t^i dW_t^{\omega} - \theta_t^i dW_t^i\right]$$

$$d\Lambda_t^j = \Lambda_t^j \left[-r_t^j dt - \alpha_t^j dW_t^{\omega} - \theta_t^j dW_t^j\right]$$

and therefore

$$\mu_t^{i,j} = r_t^i - r_t^j + \gamma_t^{ij} \tag{11}$$

where

$$\gamma_t^{ij} = \left(\theta_t^i\right)^2 + \alpha_t^{i\omega}\left(\alpha_t^{i\omega} - \alpha_t^{j\omega}\right) \tag{12}$$

$$\left(\sigma_t^{ij}\right)^2 = \left(\theta_t^i\right)^2 + \left(\theta_t^j\right)^2 + \left(\alpha_t^{i\omega} - \alpha_t^{j\omega}\right)^2 \tag{13}$$

equation 12 is the risk premium as in LRV where $\left(\theta_t^i\right)^2$ is the price of dollar risk, $\alpha_t^{i\omega}$ is the price of global risk demanded by the domestic investor and $\alpha_t^{j\omega}$ is the price of global risk demanded by the foreign investor. In this model differences in the premium across currencies arise from differences in the prices of global risk across countries, since the dollar price of risk $\left(\theta_t^i\right)^2$ is the same regardless the foreign country. In addition, LRV model the dynamics of the prices of risk as governed by permanent and transitory components that at the same time drive interest rates in such way that higher prices of global risk imply lower interest rates, this feature yields dynamics for interest rates and excess currency returns that are consistent with the empirical forward premium regularity, they further show that this feature can be proxy by the carry trade return.

I extend the LRV model and assume that in addition to global and domestic risk, the SDFs are driven by some additional common components of risk that are associated with the geographical region that countries belong to, for simplicity I assume that the prices of risk of such regional risk factors do not drive interest rates since my purpose is not to explain how currency excess returns are related to interest rates but to show how additional common components of risk can help explain the dynamics of currency returns. In the model with regional risk the domestic and foreign stochastic discount factors are given by

$$d\Lambda_t^i = \Lambda_t^i \left[-r_t^i dt - \alpha_t^i dW_t^\omega - \sum_{g=1}^{G} \delta_t^{ig} dW_t^g - \theta_t^i dW_t^i \right] \tag{14}$$

$$d\Lambda_t^j = \Lambda_t^j \left[-r_t^j dt - \alpha_t^j dW_t^\omega - \sum_{g=1}^{G} \delta_t^{jg} dW_t^g - \theta_t^j dW_t^j \right] \tag{15}$$

2.1.1 Restricted model

Let´s begin with a simplified version of the model where all regional risk that is foreign is not priced $\delta_t^{ih} = \delta_t^{jg} = 0$, then when country i and j belong to the same region

$$\gamma_t^{ij} = \left(\theta_t^{ii}\right)^2 + \delta_t^{if}\left(\delta_t^{if} - \delta_t^{jf}\right) + \alpha_t^{i\omega}\left(\alpha_t^{i\omega} - \alpha_t^{j\omega}\right)$$

When country i and j belong to a different region.

$$\gamma_t^{ij} = \left(\theta_t^{ii}\right)^2 + \left(\delta_t^{if}\right)^2 + \alpha_t^{i\omega}\left(\alpha_t^{i\omega} - \alpha_t^{j\omega}\right)$$

When foreign regional risk is not priced regional risk acts a level in the risk premium for currency returns for countries in foreign geographical regions, much as the dollar factor in LRV model, but it helps to explain the dispersion of currency returns for countries from the same region as the domestic country like the global risk factor in LRV.

2.2 Full Model

Lets move to the full model where foreign regional risk can be priced by the domestic economy $\delta_t^{ih} \neq 0$ and $\delta_t^{jf} \neq 0$ then when country i and j belong to the same region as in the restricted model

$$\gamma_t^{ij} = \left(\theta_t^{ii}\right)^2 + \delta_t^{if}\left(\delta_t^{if} - \delta_t^{jf}\right) + \alpha_t^{i\omega}\left(\alpha_t^{i\omega} - \alpha_t^{j\omega}\right)$$

but when they are for different regions

$$\gamma_t^{ij} = \left(\theta_t^i\right)^2 + \delta_t^{if}\left(\delta_t^{if} - \delta_t^{jf}\right) + \delta_t^{ih}\left(\delta_t^{ih} - \delta_t^{jh}\right) + \alpha_t^{i\omega}\left(\alpha_t^{i\omega} - \alpha_t^{j\omega}\right)$$

and

$$\delta_t^{il} = \delta_t^{jl} l \neq f, h. \tag{16}$$

Equation (16) emerge from the restrictions on the cross exchange rates (9) and (10) and show that any regional specific risk l that is foreign for both country i and j should be priced equally by these two economies. Notice that the only vector of prices of risk on which we impose restrictions are the ones representing regional risk, there are not restrictions on how each country prices global risk or its own risk as in LRV.

In the full model regional risk brings dispersion in currency returns regardless of the region the foreign country belongs to, if regional risk is priced for foreign regions we should expect that this risk explains the dispersion of currency returns.

3 Data

I include in the sample currencies that have a floating foreign exchange regime as classified by their central bank or the International Monetary Fund (IMF) in its *Annual Report on Exchange Arrangements and Exchange Restrictions*. I collected data from Bloomberg on the exchange rate and the one month money market interest rate. Other studies use the implied interest rate differentials from the *no-arbitrage* forward price formula that connects spot, forward and interest rate differentials, however for developing countries forward prices are not always available and liquidity in this markets is usually low, therefore I consider money market interest rates are more suitable.

I collected monthly data from January 1971 to September 2018 for 41 currencies distributed in 5 geographical regions: 8 currencies from the Americas, 20 from Europe, 6 from Asia, 2 from Australia and 5 from Africa. All currencies are quoted against the U.S. dollar which is considered the home country in the analysis. Currencies in the sample are from: Colombia, Brazil, Canada*, Chile, Mexico, Paraguay, Peru, Uruguay, Euro*, Georgia, Moldova, Norway*, Poland, Romania, Serbia, Sweden*, United Kingdom*, India, Indonesia, Japan*, South Korea, Philippines, Thailand, Australia*, New Zealand*, Ghana, Madagascar, Mauritius, Mozambique, South Africa, Austria, Belgium*, Finland, France*, Germany*, Portugal, Spain, Czech Republic, Denmark*, Greece, Italy*.[2] The table 9 on the appendix reports for each currency the periods for which we have data. The currencies in my data set share many as those in LRV and Verdelhan (2018) [25] however the choice of money market interest rates and the restriction on including only currencies from floating exchange regimes make the sample a little different, for example, since my interest is to build regional currency portfolios I include 5 currencies from Africa whereas the previous two references only include the currency from south Africa, I also exclude the currencies from Saudi Arabia, Hong Kong and the United Arab Emirates because they are pegged. In section 5.1 I perform a series of checks to verify that the

[2]* indicates developed country as classified in LRV

Table 1: Descriptive Statistics for Regional Portfolios

Portfolio	Mean R^e	Std R^e	SR
Average	2.33%	7.14%	0.33
CT	8.86%	8.24%	1.07
Developed	1.12%	8.19%	0.14
Americas	1.94%	6.25%	0.31
Europe	2.52%	9.19%	0.28
Asia	2.10%	8.61%	0.24
Australia	2.04%	10.61%	0.19
Africa	2.13%	6.25%	0.34

Descriptive statistics for currency portfolios: The table presents the mean annual excess return for investing in the portfolios of foreign currency, its standard deviation and their Sharpe ratio. Data is monthly from January 1971 to September 2018. For Americas the sample begins in March 1973 and for Africa the sample begins in July 1993.

choice of sample is not affecting the results.

I compute currency excess returns for an American investor for each country and the following portfolios: 1. The average portfolio which is an equally weighted investment in all the currencies available during the period, 2. the carry trade portfolio which is an investment that takes a long position in currencies with high interest rates and a short position in currencies with low interest rates. To construct the carry trade portfolio I follow LRV, every month I classify currencies into 6 portfolios ranging from low interest rate to high interest rate. Currencies classified as high are those for which its interest rate is above the 83 percentile, currencies classified as low are those for which its interest rate is below the 16 percentile of the sample. 3. The developed portfolio which is an equally weighted investment in currencies from developed countries and 4. The regional portfolios which invest an equal amount of money in each of the currencies for an specific region. I identify 5 geographical regions: Americas, Europe, Asia, Australia and Africa. Regional portfolios include currencies from both developed and developing countries. Although for many European and developed countries I have data dating from 1971 I have some restrictions on data for African and Latin American countries, therefore I can´t construct regional portfolios for these two regions from the 1971 but later on the sample, the Americas portfolio starts in march 1975 and the African portfolio starts in July 1993 when there is at least 1 currency in the portfolio per month.

Table (1) presents the annual mean excess return, its standard deviation and the Sharpe ratio for the 8 currency portfolios. Regional currency mean annual excess returns range from 1.94% for Americas to 2.52% for Europe, showing little dispersion in returns across regions. The most volatile currency returns are those for Europe (9.19%) and Australia (10.61%) while returns for the Americas and Africa are the least volatile (6.25%) Sharpe ratios range from 0.19 for Australia to 0.34 for Africa. These Sharpe ratios are mostly lower than that of the average portfolio of 0.33 which is a more diversified portfolio. The carry trade return offers the highest excess return 8.86% and the highest Sharpe ratio of 1.07. The lowest Sharpe ratio is for the investment in currencies for developed countries that comes from a mean excess return of 1.12% and a standard deviation of 8.19%[3]

4 Methodology.

Factor models are models of the SDF that are linear in factors. A factor is a variable that captures a dimension of risk that influences how assets are priced. Following Cochrane (2005) [8] I assume a linear representation of the SDF on L factors of the following form

$$\frac{\Lambda^i_{t+\Delta}}{\Lambda^i_t} = a - \sum_{l=0}^{L} b^l \left(f^l_{t+\Delta} - E\left[f^l_{t+\Delta} | I_t \right] \right) \tag{17}$$

where f^l is the risk factor l and $E\left[f^l_{t+\Delta}|I_t\right]$is the conditional expectation of the factor given the information set available at time t. Cochrane calls b^l the factor loading for the lth risk factor. When we use asset returns as mimicking factors, $f^l_{t+\Delta} = R^l_{t+\Delta} = \left(S^l_{t+\Delta} + D^l_{t+\Delta}\right)/S^l_t$, the linear factor model of the stochastic discount factor links to the more familiar beta representation of asset returns. In the beta representation, the expected excess return of an asset over the risk-free interest rate, $R^{ij,e}_t = R^{ij}_t - r^i_t$; is equal to sum of the factor risk premium λ^l times the $\beta^{ij,l}$ exposure of asset to the corresponding risk factor

$$E\left[R^{ij,e}_{t+\Delta} | I_l \right] = \sum_{l=0}^{L} \lambda^l \beta^{ij,l} \tag{18}$$

where $R^{ij,e}_t$ is the excess return of for investing in currency of country j. The beta $\beta^{ij,l}$, which is specific to the currency, captures how the return of the jth currency reacts to shocks on the corresponding risk factor l. The factor risk premium λ^l, which does not depend on the asset, reflects the compensation on the expected excess currency return of any asset for its exposure to the lth risk. In chapter 6 of his book Cochrane (2005) [8] describes how we can go from the SDF representation to the beta representation of excess returns and shows that factor risk premiums are linear in the factor loading. Empirically, this link allow us to go from estimates of the factor loading to estimates of the factor risk premium.

To estimate the model I am going to use the efficient Generalized Method of Moments (GMM) since we have a moment condition for every currency of portfolio, setting $a = 1$ in equation 17. The expectation for this equation is conditional on the information available to the investor at time t which is captured by the information set I_t. To deal with the fact that the expectation is conditional I will assume that the econometricians information set is generated by a vector of instrumental variables Z_t. The information set available to the econometrician is contained in the agents information set I_t. These instrumental variables affect the investment opportunity set for investors and are observable at time t. I incorporate this instrumental variables by multiplying them to currency returns. Cochrane [8] refers to this approach as scaling returns. We can interpret the scaling returns as the returns on managed portfolios for which the investor adjust her position given the observation of Z_t. Under this approach the parameters of the model are time invariant. If the model is correctly specified we expect the pricing errors to be zero. Hansen's test of over-identifying

[3] The statistics for the CT portfolio are in line with those from Lustig et al. (2011)

restrictions tests for the null hypothesis that the pricing errors are jointly zero. The GMM estimation is carried out in two stages. In the first stage, we estimate the factor loading's b from equation 17 setting the weighting matrix equal to the identity matrix $\hat{W} = I$. In the second stage, we estimate the factor loading's setting the weighting matrix equal to the inverse of the Newey-West (1987) [22] estimate for the co-variance matrix of the pricing errors in the first stage $\hat{W} = S\hat{^{-1}}$. Finally, with the factor loading estimates from the second stage, we compute the pricing errors to test how well our model fits the data.

I am also going to estimate the model with the Fama-MacBeth methodology in which we first run for each asset a time series regression to estimate the vector of β from equation 18 and then for every period we estimate a cross-sectional regression to estimate the prices of risk λ_t at time t finally we estimate the prices of risk as the average of λ_t. Covariance matrices are estimated by Newey-West to account for auto-correlation.

5 Empirical Findings.

5.1 Validating the data set.

As mention in section 3 there are some restriction on the data for African and Latin American countries that prevent us from constructing the regional portfolio from 1971. To check that the limitation on the data is not driving results first I estimate the LRV model on the full sample from 1971 to 2018 and then contrast the results with those from a sub sample ranging from 2000 to 2018. LRV model estimates the cross section of 6 interest rate sorted currency portfolios on two factors: the carry trade (CT) and the dollar factor ($Average$). The LRV model is not affected by the restriction on the sample since their portfolios are sorted based on interest rate differentials. I choose the sub sample to begin in 2000 because first I want each regional portfolio to have at least 2 currencies in the portfolio and second it coincides with the introduction of the Euro when many European countries began to share a single currency.

Table 2 presents the GMM and Fama-MacBeth results for the LRV model on the full sample and the sub sample. In both samples the carry trade factor and the average factor help to explain the cross-section of currency returns as indicated by their significant loading's. Loading estimates significance level are quite similar across samples and across estimation method. The prices of risk are closely in line with the mean of the factors as theory suggests, with mean carry trade return and average return begin a little higher in the sub sample. In the second stage of the Fama-MacBeth regression I do not include a constant since as stated by LRV the average factor is basically acting a as constant- These estimates do not include instrumental variables since by construction these are managed portfolios. Panel a. of table 4 presents the portfolio betas for the full sample where beta on carry trade increases as we move from low interest rate portfolios to high interest rate portfolio and with betas on the average portfolio that are close to a unity. The results of these estimations are in line with those of LRV and Verdelhan (2018) [25] and are robust to the sample period therefore I will continue the analysis working with the sub sample given the restrictions that I face on the data.

Table 2: Portfolios sorted on interest rate differential.

	1970-2018		2000-2018	
GMM	CT	Average	CT	Average
Loading	14.91*	6.65*	33.32*	12.66*
[se_load]	2.63	2.99	4.62	6.08
Price Risk	9.48*	2.43	11.97*	3.59
[se_Price]	1.72	1.58	1.64	2.47
p-value	18.5%		21.7%	
Adjusted r^2	0.85		0.74	
Fama-MacBeth				
Loading FMB	13.65*	6.12*	31.28*	11.16*
[se_Loading FMB]	1.89	2.29	4.40	4.24
Price Risk FMB	8.67*	2.24	11.28*	3.07
[se_Price FMB]	1.25	1.33	1.65	1.85
Adjusted r^2	0.86		0.77	
Mean	**8.75**	**2.26**	**10.89**	**3.29**

Table reports the results from the efficient GMM and Fama-MacBeth regression for the 6 interest rate sorted portfolios of currency returns. Risk factors are the carry trade return and the average excess return. No constant is included in the second stage of the Fama-MacBeth procedure. Standard error are as in Newey-West with the optimal number of lags as in Andrews (1991). * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

5.2 Regional Portfolios

We check whether the carry trade and the average portfolio factor can explain the cross-section of the 5 regional portfolios. Panel a. of table 3 presents the unconditional GMM and Fama-MacBeth estimates for a sample the begins in march 1994, this is the earliest date for which we have at least one currency in all regional portfolios, nor the carry trade nor the average portfolio can explain the dispersion in regional currency returns for the full sample. Panel b. presents the results for the sub sample that begins in January 2000 and results are similar with nor the factor loading nor the prices of risk being statistically significant, this suggests that regional factors are not driven by the same risks as the carry trade and average factor. Panel b. of table 4 reports the estimated betas, for all regions average betas are statistically significant and fluctuate around one, though not as closely as for the LRV portfolios. The carry trade beta is only significant for Europe and it is negative which is consistent with portfolios with low interest rates and could potentially link to the trade centrality of European countries as suggested by Richmond (2019) [23]. Figure 1 depicts the pricing errors for the LRV currency portfolios and the Regional portfolios when we use the carry trade and the average portfolio as factors. This factors can explain the cross-section of portfolios sorted based on interest rate differentials but are not good at explaining regional currency return portfolios.

5.3 Currency pair regression.

Now we move to the currency pair analysis. First we test the model's ability to explain the time series of currency returns, I run a time series regression for each currency pair of the form

Table 3: Portfolios sorted by geographical region

	1994-2018		2000-2018	
GMM	CT	Average	CT	Average
Loading	6.50	7.74	8.05	7.63
[se_load]	6.87	4.46	8.79	5.35
Price Risk	3.99	2.86	2.65	2.80
[se_Price]	4.40	1.71	3.23	2.12
Fama-MacBeth				
Loading FMB	2.18	7.04	7.77	8.09
[se_Loading FMB]	6.45	3.83	8.26	4.36
Price Risk FMB	1.22	2.70	2.52	3.01
[se_Price FMB]	4.29	1.57	3.09	1.84
Mean	**11.97**	**3.00**	**10.89**	**3.29**

Table reports the results from the efficient GMM and Fama-MacBeth regression for the 5 regional portfolios of currency returns: Americas, Europe, Asia, Australia and Africa. Risk factors are the carry trade return and the average excess return. No constant is included in the second stage of the Fama-MacBeth procedure. Standard error are as Newey-West with the optimal number of lags as in Andrews (1991). * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

$$r_t^{e,j} = \alpha^j + \sum_{l=1}^{L} \beta^{lj} f_t^l + \varepsilon_t^j \tag{19}$$

where $l = [Americas, Europe, Asia, Australia, Africa, CT]$ I exclude the average factor since by construction the average factor is a weighted average of the 5 regional portfolios. It is also worth highlighting that when running the regression for currency i I exclude from the regional currency portfolios such currency to avoid spurious regressions. Table 5 presents the currency betas by country, for each country the estimation is carried out from March 1993 or the longest sample available for each country after this date. The first feature to highlight is that except for Uruguay and the African currencies all betas for the home regional factor are positive and highly statistically significant with some dispersion on the betas for the countries within that region, this tell us that when the US dollar is appreciating against the currencies from the home region, the home currency appreciates as well and that currencies from the same region could be driven by a common factor which seem to support the thesis that regional factors are important at explaining currency returns. A second feature is that the carry trade factor is statistically significant only for a set of currencies and that this currencies are mainly from Europe. Usually developed countries have a carry trade beta that is negative and developing countries a carry trade that is positive, this result is consistent with the findings in Verdelhan (2018) [25]. The model's fit is better for Europe and Australia with average adjusted r-squared that are higher in Europe (0.70) and Australia (0.71) , Asian and the Americas adjusted r-square are (0.34) and (0.35) respectively. For Africa the average adjusted r-square is the lowest. Fit is best describe by region rather than by if the currency is from a developed country, the Japanese fit(0.22) is actually the lowest in the Asia region and the Canadian fit (0.5) is lower than Brazil's in the Americas

Table 6 presents the time series estimates for the LRV model with the carry trade and average

Table 4: Portfolio Betas in the LRV model

Panel a: Portfolios sorted based on interest rate differentials

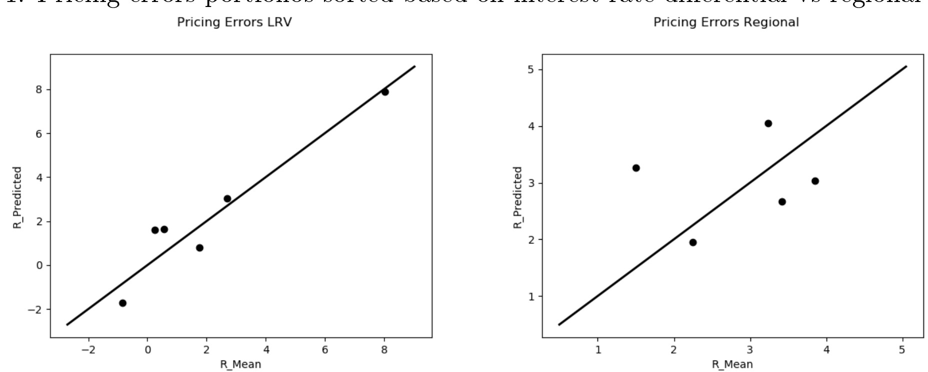
	alfa	CT	Average
1	0.000	-0.422*	1.015*
2	0.001	-0.181*	1.110*
3	-0.001	-0.067*	0.991*
4	-0.001	-0.046	0.887*
5	0.000	0.071	1.030*
6	0.000	0.578*	1.015*

Panel b: Portfolios sorted based on geographical region

	alfa	CT	Average
Americas	-0.001	0.185	0.807*
Europe	0.002	-0.176*	1.181*
Asia	-0.003	0.196	0.873*
Australia	-0.001	-0.034	1.465*
Africa	0.000	0.009	0.671*

Table reports betas from the efficient GMM regression. Panel a. reports the betas for the 6 interest rate sorted portfolios of currency returns. Panel b. reports the betas for the 5 regional portfolios of currency returns. Risk factors are the carry trade return and the average excess return. Standard error are as in Newey-West with the optimal number of lags as in Andrews (1991). * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg. Sample for panel a. is from January 1971 to September 2018. Sample for panel b. is from March 1993 to September 2018.

Figure 1: Pricing errors portfolios sorted based on interest rate differential vs regional portfolios



Pricing errors from the efficient GMM regression. Panel a. depicts the pricing errors for the 6 interest rate sorted portfolios of currency returns. Panel b. depicts the pricing errors for the 5 regional currency portfolios. Risk factors are the carry trade return and the average excess return. Data on exchange rates and money market interest rates from bloomberg. Sample for panel a. is from January 1971 to September 2018. Sample for panel b. is from March 1993 to September 2018.

portfolios as factors, carry trade betas are very similar in the two specifications of the model indicating that regional factors are capturing dimensions of risk different from the carry trade factor. Average factors are mostly positive and highly significant. Table 10 on the appendix shows that the correlation between the regional portfolios and the Average factor is not that strong except for the Africa portfolio for which is -0.41 so the average factor might be in fact aggregating the common regional factors. Adjusted r-squared follow the same patter as in the full model with average adjusted r-squared higher in Europe and Australia and lowest in Africa, Japanese and Canadian adjusted r-square are low relative to other developed nations. Compared to the regional model the average increase in the fit is more notorious in Australia ($0.6\, vs\, 0.71$) and the Americas ($0.6\, vs\, 0.71$) and virtually not existing in Africa.

Notice that European factor betas are close to the unity for most European currencies that belong to the Euro except for Italy. For Spain, Germany, France, Finland, Belgium, Italy and

Figure 2: Pricing errors currency pair

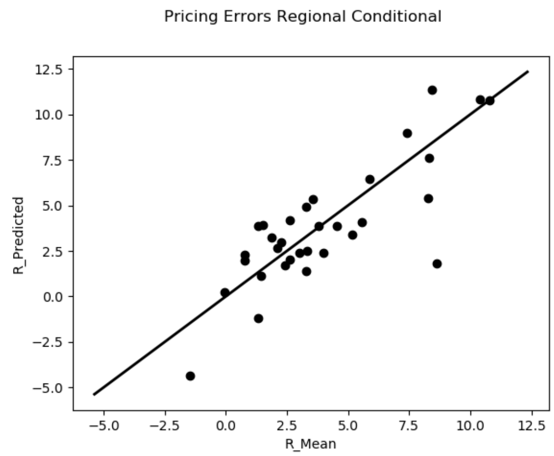


Figure depicts pricing errors from the conditional Fama-MacBeth regression for currency returns. Risk factors are the carry trade return and regional portfolios. Instruments are interest rate differentials. No constant is included in the second stage of the Fama-MacBeth procedure. Data on exchange rates and money market interest rates from bloomberg.

Austria the sample starts in 1993 and ends in December 1998 since by this date they officially fixed their currencies to the Euro[4]. A regional beta close to one to this set of countries indicate that the European regional factor is acting as a level in the currency premium, much like the dollar factor in LRV, this could be associated with the fact that the previsions to form the monetary union date back to 1992 with the Maastricht Treaty and therefore for the period 1993-1999 the currencies might be already behaving as a single one, for this reason, plus the restriction on data for African and Latin American countries, I run the cross-sectional analysis from 2000 onward.

Table 7 presents the conditional Fama-MacBeth estimation from currency pair from January 2000 to September 2018. As instruments I consider the interest rate differential, since by the forward premium anomaly interest rate differentials are know to be linked with currency returns. I'm only reporting Fama-MacBeth estimates because I am working with an unbalanced panel. In the second stage I don´t include a constant since by construction the weighted average of the regional factors is equal to the average portfolio which acts as a constant. Loading's for regional portfolios are statistically significant for Europe, Asia, Australia and the Carry Trade. The Carry trade factor loading and price of risk is similar in magnitude to the LRV estimates on interest rate based portfolios indicating that the carry trade factor is robust and that the additional regional portfolios are not driven by the same risk factors as the carry trade. Figure 2 depicts the pricing errors. Table 8 presents the conditional estimates for the LRV model[5], carry trade and average factors loading's are significant, however the fit of the model with regional factor is better as indicated by its higher adjusted r^2 and its lower mean square error. Tables 12 and 11 in the appendix present the unconditional estimates and show the results are robust.

[4]Greece did it on June 2000

[5]I don´t include a constant in the second stage

6 Conclusions

This paper presents a continuous-time model of currency return processes for an integrated global economy in a multi-currency framework. If all arbitrage opportunities have been eliminated, markets are complete and all assets are expressed in a common currency, then there is a unique stochastic discount factor process that prices all assets. However the representation of the stochastic discount factor depends on the currency used to express assets. In the model the SDFs and the exchange rate process are linked. If there is a stochastic exchange rate process, then investments in foreign assets expressed in the domestic currency are exposed to currency risk. In this paper, I derive explicit formulas that express the impact of currency risk on currency returns. The model yields a continuous time analog of the uncovered interest rate parity condition, where there is an exchange rate premium. I demonstrate that the foreign exchange risk premium can only emerge if exchange rates are driven by dimensions of risk that also drive the SDF and identify two sources of currency risk that helps explain cross-variations in currency returns: Global and Regional risk.

In the empirical section using a linear factor model for both the time series and the cross-section of currency returns I provide evidence that exchange rates are driven by global and regional risk factors and I demonstrate that foreign exchange risk can be best capture by a portfolio of investments in foreign currencies. More precisely, the returns on regional portfolios are factors for currency returns in the conditional estimation with monthly observations of the returns.

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Table 5: Currency betas

	Constant	Americas	Europe	Asia	Australia	Africa	CT	Ad_R2
United Kingdom	-0.001	-0.064	0.506*	-0.027	0.126	0.041	-0.058	0.407
Sweden	-0.002	0.060	0.863*	0.079	0.184*	0.007	-0.164*	0.760
Spain	-0.001	0.270*	0.908*	0.099**	-0.045	-0.010	-0.125*	0.827
Serbia	0.002	-0.307**	1.386*	0.104	0.099	0.088	0.395**	0.775
Romania	0.000	-0.174	1.254*	-0.061	0.156	-0.389	0.625**	0.364
Portugal	0.001	0.082	0.932*	0.108*	-0.032	0.033	-0.183*	0.923
Poland	-0.001	0.379*	1.064*	-0.188	0.073	0.115	0.029	0.701
Norway	0.000	0.205**	0.827*	0.127*	0.030	0.072	-0.253*	0.706
Moldova	0.003	0.055	0.494*	-0.346	-0.052	0.043	0.138	0.120
Italy	0.000	-0.008	0.683*	-0.020	0.174	-0.114	0.096	0.357
Greece	0.012*	-0.253	0.868*	-0.009	0.382*	0.003	-0.553*	0.699
Germany	-0.001	0.063	1.035*	0.147*	-0.125*	0.098**	-0.256*	0.952
Georgia	0.002	0.209	0.428*	-0.068	-0.148**	-0.103	0.310*	0.163
France	0.000	-0.039	0.983*	0.145*	-0.089	0.024	-0.236*	0.921
Finland	-0.001	0.237**	0.978*	0.140*	-0.144	0.139	-0.227*	0.857
Euro	-0.001**	-0.148*	0.978*	0.061**	0.067	0.137*	-0.154*	0.886
Denmark	-0.001	-0.139**	0.986*	0.080*	0.048	0.136*	-0.169*	0.886
Czech Republic	0.000	-0.056	1.178*	0.081	0.029	0.036	-0.066	0.729
Belgium	-0.001	0.066	1.043*	0.144*	-0.110*	0.110**	-0.242*	0.957
Austria	-0.001	0.020	1.018*	0.149*	-0.131*	0.090	-0.238*	0.952
New Zealand	0.000	0.082	0.262*	0.132*	0.616*	0.106	0.010	0.695
Australia	0.000	0.434*	0.145	0.094	0.512*	0.126	-0.110**	0.731
Thailand	-0.002	-0.177	0.120	0.789*	0.036	0.038	0.230	0.472
South Korea	0.000	0.217	0.202	0.408*	0.356*	-0.361	-0.011	0.294
Philippines	0.000	0.084	-0.110	0.403*	0.142**	-0.015	0.064	0.351
Japan	0.003	-0.091	-0.006	0.391*	0.003	0.177	-0.577*	0.226
Indonesia	-0.010	-0.482	0.217	2.062*	-0.044	0.021	1.237*	0.379
India	0.001	0.265*	0.019	0.086**	0.111**	0.144*	-0.026	0.319
Uruguay	-0.001	0.478	0.178	0.028	0.033	-0.165	0.629*	0.250
Peru	0.001	0.265*	0.061	0.086*	-0.040	0.042	-0.021	0.257
Paraguay	0.001	0.295*	0.021	-0.174*	0.094	0.115	-0.073	0.087
Mexico	-0.002	0.473*	0.145	-0.049	0.261*	-0.171	0.406*	0.313
Colombia	0.000	0.888*	-0.021	0.460*	0.066	-0.097	-0.087	0.438
Chile	-0.001	0.685*	-0.139	0.060	0.147	0.358*	-0.101	0.414
Canada	-0.001	0.277*	0.088	0.014	0.303*	0.093	-0.088	0.507
Brazil	-0.002	1.551*	0.059	0.326	0.163	-0.336**	0.652*	0.550
South Africa	-0.002	0.384**	0.137	0.183	0.474*	-0.008	0.026	0.340
Mozambique	0.000	-0.087	0.251	-0.014	-0.001	-0.021	0.130	0.006
Mauritius	0.000	0.219*	0.393*	0.048	-0.078	0.089	-0.170*	0.365
Madagascar	0.000	-0.218	0.555*	-0.067	0.217	-0.051	0.165	0.172
Ghana	-0.001	-0.257	0.526*	0.118	-0.098	-0.258*	0.796*	0.155

Table reports the results from the time series regression for currency returns. Risk factors are the carry trade return and Americas, Europe, Asia, Australia and Africa excess return. Currency return that is being regressed is excluded from the regional portfolio . Standard error are as Newey West 3 lags. * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

Table 6: Betas currency pair LRV

	Constant	CT	Average	Ad_R2
United Kingdom	0.000	-0.168*	0.784*	0.381
Sweden	0.000	-0.286*	1.411*	0.720
Spain	0.002	-0.200*	1.123*	0.760
Serbia	0.003	0.032	1.578*	0.681
Romania	0.002	0.311	1.377*	0.328
Portugal	0.003*	-0.283*	1.185*	0.862
Poland	0.000	-0.047	1.704*	0.680
Norway	0.001	-0.327*	1.353*	0.693
Moldova	0.005*	-0.023	0.410*	0.067
Italy	0.002	-0.041	0.783*	0.348
Greece	0.008	-0.651*	1.284*	0.526
Germany	0.001	-0.357*	1.330*	0.877
Georgia	0.003	0.236**	0.410*	0.147
France	0.002	-0.339*	1.268*	0.841
Finland	0.001	-0.302*	1.276*	0.805
Euro	0.000	-0.330*	1.273*	0.761
Denmark	0.001	-0.339*	1.277*	0.765
Czech Republic	0.002	-0.258*	1.454*	0.635
Belgium	0.001	-0.347*	1.344*	0.883
Austria	0.001	-0.341*	1.311*	0.867
New Zealand	0.000	-0.024	1.518*	0.601
Australia	-0.001	-0.049	1.492*	0.614
Thailand	-0.004	0.313	0.841*	0.284
South Korea	-0.002	0.041	1.152*	0.275
Philippines	-0.002	0.173**	0.548*	0.222
Japan	0.002	-0.456*	0.497*	0.200
Indonesia	-0.013	1.223**	1.636*	0.290
India	0.000	0.037	0.613*	0.307
Uruguay	-0.002	0.634*	0.739*	0.268
Peru	0.001	0.024	0.363*	0.224
Paraguay	0.001	-0.034	0.439*	0.069
Mexico	-0.002	0.405*	0.845*	0.270
Colombia	-0.002	0.108	1.222*	0.381
Chile	-0.003	0.173	1.101*	0.392
Canada	-0.001	-0.046	0.885*	0.439
Brazil	-0.005	0.846*	1.752*	0.472
South Africa	-0.003	0.095	1.474*	0.350
Mozambique	0.001	0.071	0.297	0.015
Mauritius	0.000	-0.179*	0.645*	0.363
Madagascar	0.001	0.005	0.825*	0.174
Ghana	0.000	0.601*	0.128	0.114

Table reports the results from the time series regression for currency returns. Risk factors are the carry trade return and the average return. Currency return that is being regressed is excluded from the regional portfolio . Standard error are as Newey West 3 lags. * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

Table 7: Conditional FMB estimation

	Americas	Europe	Asia	Australia	Africa	CT
Loading FMB	-732	16.9**	26.86**	-18.26**	16.66	31.36*
[se_Loading FMB]	9.86	7.0	13.0	7.44	13.98	9.6
Price Risk FMB	2.63	4.47	3.42	-0.94	7.95	8.98*
[se_Price FMB]	2.48	2.39	2.31	3.70	4.11	3.11
Mean	**3.61**	**3.82**	**1.56**	**4.22**	**3.41**	**10.89**
Adjusted r^2	0.512					
mse	10.21					

Table reports the results from the conditional Fama-MacBeth regression for currency returns. Risk factors are the carry trade return and regional portfolios. Instruments are interest rate differentials. No constant is included in the second stage of the Fama-MacBeth procedure. Standard error are as in Newey West with 3 lags. * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

Table 8: Conditional FMB for LRV model

	CT	Average
Loading FMB	32.12**	18.46**
[se_Loading FMB]	14.32	8.46
Price Risk FMB	5.62**	3.06
[se_Price FMB]	2.59	1.75
Mean	**10.89**	**3.29**
Adjusted r^2	0.402	
mse	14.41	

Table reports the results from the conditional Fama-MacBeth regression for currency returns. Risk factors are the carry trade return and average portfolios. Instruments are interest rate differentials. No constant is included in the second stage of the Fama-MacBeth procedure. Standard error are as in Newey West with 3 lags. * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

Table 9: Countries in the sample

	Start	End
Colombia	Sep-99	Oct-18
Brazil	Jan-99	Oct-18
Canada	Feb-75	Oct-18
Chile	Jan-00	Oct-18
Mexico	Dec-94	Oct-18
Paraguay	Jan-94	Oct-18
Peru	Nov-95	Oct-18
Uruguay	Jun-02	Oct-18
Euro	Feb-94	Oct-18
Georgia	Jan-97	Oct-18
Moldova	May-96	Oct-18
Norway	Jan-93	Oct-18
Poland	Apr-00	Oct-18
Romania	Feb-95	Oct-18
Serbia	Sep-05	Oct-18
Sweden	Nov-92	Oct-18
United Kingdom	Aug-92	Oct-18
India	Jan-93	Oct-18
Indonesia	Jan-97	Oct-18
Japan	Jan-71	Oct-18
South Korea	Jan-97	Oct-18
Philippines	Nov-91	Oct-18
Thailand	Jan-81	Oct-18
Australia	Jan-71	Oct-18
New Zealand	Mar-85	Oct-18
Ghana	May-03	Oct-18
Madagascar	Feb-98	Oct-18
Mauritius	Jun-93	Oct-18
Mozambique	Feb-98	Oct-18
South Africa	Jan-94	Oct-18
Austria	Jan-71	Dec-98
Belgium	Jan-71	Dec-98
Finland	Jan-78	Dec-98
France	Jan-71	Dec-98
Germany	Jan-71	Dec-98
Portugal	Jan-89	Dec-98
Spain	Feb-74	Dec-98
Czech Republic	Jun-93	Oct-18
Denmark	Feb-72	Oct-18
Greece	Feb-98	Dec-00
Italy	Feb-71	Dec-98

Table reports countries in the sample with its start and end date. Data on exchange rates and money market interest rates from bloomberg.

Table 10: Correlation across factors

	CT	Average	Americas	Europe	Asia	Australia	Africa
CT	1.00	-0.05	0.28	-0.38	0.25	-0.06	0.04
Average	-0.05	1.00	-0.24	0.31	-0.14	0.39	-0.41
Americas	0.28	-0.24	1.00	-0.54	-0.15	0.08	-0.01
Europe	-0.38	0.31	-0.54	1.00	-0.56	-0.07	-0.22
Asia	0.25	-0.14	-0.15	-0.56	1.00	-0.14	-0.12
Australia	-0.06	0.39	0.08	-0.07	-0.14	1.00	-0.17
Africa	0.04	-0.41	-0.01	-0.22	-0.12	-0.17	1.00

Table reports correlations across factors. Data on exchange rates and money market interest rates from bloomberg.

Table 11: Unconditional FMB by currency pair LRV

	CT	Average
Loading FMB	30.18	17.28
[se_Loading FMB]	12.68	8.36
Price Risk FMB	5.27	2.86
[se_Price FMB]	2.29	1.74
Mean	**10.89**	**3.29**
Adjusted r^2	0.33	
mse	10.66	

Table reports the results from the unconditional Fama-MacBeth regression for currency returns. Risk factors are the carry trade return and average portfolios. No constant is included in the second stage of the Fama-MacBeth procedure. Standard error are as in Newey West with 3 lags. * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.

Table 12: Unconditional FMB by currency pair

	Americas	Europe	Asia	Australia	Africa	CT
Loading FMB	-5.56	14.24*	21.78*	-14.86**	14.66	28.2*
[se_Loading FMB]	9.20	6.64	12.56	7.16	10.92	6.48
Price Risk FMB	2.78	3.98	2.86	-0.20	7.13*	8.32*
[se_Price FMB]	2.48	2.36	2.22	3.65	3.20	2.08
Mean	**3.61**	**3.82**	**1.56**	**4.22**	**3.41**	**10.89**
Adjusted r^2	0457					
mse	7.48					

Table reports the results from the unconditional Fama-MacBeth regression for currency returns. Risk factors are the carry trade return and regional portfolios. No constant is included in the second stage of the Fama-MacBeth procedure. Standard error are as in Newey West with 3 lags. * denotes significance at the 1% confidence level and ** significance at the 5% confidence level. Data on exchange rates and money market interest rates from bloomberg.