Currencies

Empirical Asset Pricing

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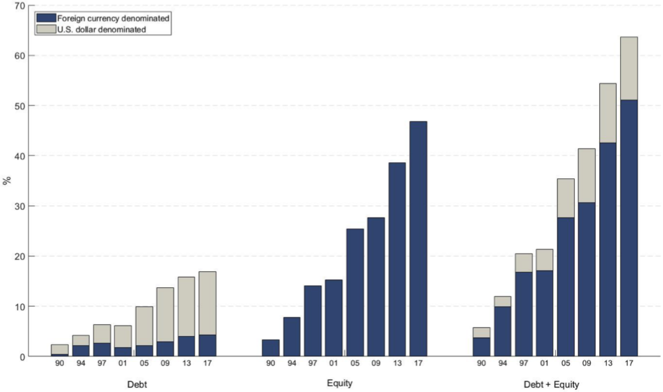
Currencies

- Portfolio sorting and return predictability are not unique to stocks, but the method is equally applicable to pretty much any asset with a return
- In the previous years, the projects have been mainly related to (US) stocks
- To (hopefully) avoid 32 projects on stocks, I will give you a proper introduction to currencies as an asset

Why bother about the currency?

- The currency exposure arising from international investments can substantially affect the underlying assets' overall risk-return profile
- As you can see below, the foreign investments as a share of GDP has been growing rapidly (Opie and Riddiough, 2020)



An extremely liquid market

"The foreign exchange (FX) market is enormous: On average, $6.6 trillion is traded each day by a diverse set of key market participants, ranging from corporations to mutual funds, and from central banks to hedge funds, making FX volume over ten times larger than global equity market volume (BIS, 2019)." (Cespa et al., 2021)

An extremely liquid market

- As a consequence, currencies are relatively cheap to leverage and, hence, attractable for speculation
- Even private investors have access to highly geared futures FX products which the screenshot from Nordnet below suggests:

		Navn	Retning	Underliggende	Gearing
Køb	Sælg	MINI L EURUSD NORDNET D02	Lang	EUR/USD	15,3
Køb	Sælg	MINI S EURUSD NORDNET D01	Kort	EUR/USD	18,6
Køb	Sælg	LONG EURUSD NORDNET F02	Lang	EUR/USD	18,0
Køb	Sælg	LONG USDJPY NORDNET F19	Lang	USD/JPY	19,0
Køb	Sælg	MINI L EURNOK NORDNET N02	Lang	EUR/NOK	21,3
Køb	Sælg	MINI L EURUSD NORDNET 08	Lang	EUR/USD	15,9
Køb	Sælg	MINI L USDJPY NORDNET 19	Lang	USD/JPY	15,7
Køb	Sælg	MINI S EURSEK NORDNET 13	Kort	EUR/SEK	27,4
Køb	Sælg	MINI S USDJPY NORDNET 05	Kort	USD/JPY	18,6
Køb	Sælg	MINI S USDSEK NORDNET 05	Kort	USD/SEK	30,0

Currencies as asset class

Determination of the exchange rate

- We have different approaches to determine the exchange rate
- For instance, the PPP propose that national price levels should be equal when expressed in a common currency
- We will, however, focus on how to determine using Stochastic Discount Factors, i.e., the asset market view of exchange rates

The asset market view of exchange rates

- Remember from the SDF lecture for a foreign investor:

$$1 = \mathbb{E}_t(\tilde{R}_{t+1}\tilde{M}_{t+1}) \tag{1}$$

- For a domestic investor investing in the same asset, no-arbitrage also implies

$$1 = \mathbb{E}_t(\tilde{R}_{t+1}\frac{S_{t+1}}{S_t}M_{t+1}) \tag{2}$$

- Meaning that

$$\mathbb{E}_t(\tilde{R}_{t+1}\frac{S_{t+1}}{S_t}M_{t+1}) = \mathbb{E}_t(\tilde{R}_{t+1}\tilde{M}_{t+1}) \tag{3}$$

A suffient condition

- A sufficient condition for the eq. (3) is

$$\frac{S_{t+1}}{S_t} M_{t+1} = \tilde{M}_{t+1} \tag{4}$$

- Under no-arbitrage and completeness (uniqueness of the SDFs), the exchange rate is determined by

$$\frac{S_{t+1}}{S_t} = \frac{\tilde{M}_{t+1}}{M_{t+1}}, \tag{5}$$

  where S_t is measured as foreign prices per unit of domestic prices (by far the worst part of working with currencies)

Let us gain some intuition

Consider a continuous-time framework, such that

$$dM_t = -r_{f,t} M_t dt - \lambda_t M_t dW_t, \tag{6}$$

$$d\tilde{M}_t = -\tilde{r}_{f,t} \tilde{M}_t dt - \tilde{\lambda}_t \tilde{M}_t dW_t, \tag{7}$$

$$\tag{8}$$

Applying Ito's lemma to log exchange rate

$$ds_t = (r_{f,t} - \tilde{r}_{f,t} - \frac{1}{2}(\tilde{\lambda}_t{}' \tilde{\lambda}_t - \lambda_t' \lambda_t))dt + (\tilde{\lambda}_t - \lambda_t) dW_t \tag{9}$$

A simple decomposision of log spot changes

- A simple Euler-discretization of the dynamics of the log exchange rate reveals

$$\mathbb{E}(\Delta s_{t+1}) \approx (r_{f,t} - \tilde{r}_{f,t} - \frac{1}{2}(\tilde{\lambda}_t{}' \tilde{\lambda}_t - \lambda_t' \lambda_t)) \tag{10}$$

➜ Expected short-term exchange-rate movements can be decomposed into two components:

  - The difference in interest rates
  - A function of the difference in market-price of risk (risk compensation per unit of risk)
    ➜ If risk compensation is different between two countries, the exchange rate must reflect that!

➜ Expected short-term currency risk premium is a function of the latter

Excess return of a currency

- The **excess return** of a **currency**

$$RX_{t,t+1,i} = \frac{S_{t+1,i} - F_{t,t+1,,i}}{S_{t,i}} = \frac{S_{t+1,i} - S_{t,i}}{S_{t,i}} - \frac{F_{t,t+1,i} - S_{t,i}}{S_{t,i}} \tag{11}$$

- The excess return is hence given as the return of spot exchange rates minus the forward premium

Interest rate parities

In international finance we have two different interest rate parity: the covered (CIP) and uncovered interest rate parity (UIP)

- Under **CIP**, the **forward premium** is equal to the **interest rate difference**

$$\frac{F_{t,i} - S_{t,i}}{S_{t,i}} \approx r_{f,t} - \tilde{r}_{f,t} \tag{12}$$

- Under **UIP**, the expected return of the **spot exchange rate** is the **interest rate difference** :
  - The expected excess return is **0**
  - requires risk neutrality (market-price of risk is equal to 0) or market-price of risk is equal for all t in the two countries
    ➜ The most rejected hypothesis in international finance!

The failure of the UIP

- Rejections of UIP goes all the way back to Hansen and Hodrick (1980)
- Under UIP (in terms of log) $\Delta s_{t+1} = r_{f,t} - \tilde{r}_{f,t}$ or in terms of the forward premium $\Delta s_{t+1} = f_{t,t+1} - s_t$
- Fama (1984) run the following regression

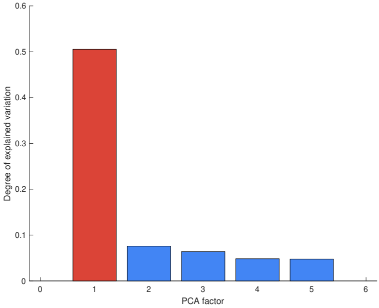
$$\Delta s_{t+1} = \alpha + \beta(f_{t,t+1} - s_t) + \varepsilon_{t+1} \tag{13}$$

  ➜ UIP implies $\beta = 1$. Estimates of β are often negative. This is known as the forward puzzle bias.
- $\beta_{EUR} = -1.57$ and $\beta_{GBP} = -1.28$. Both significantly different from 1 (sample from 2000 to 2020).
- High-interest rate currencies tend to appreciate while UIP predicts a depreciation!

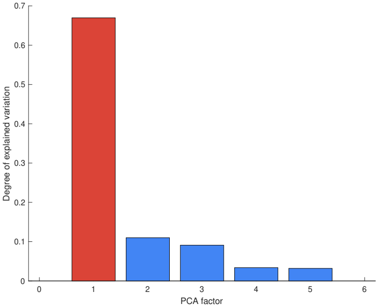
Return predictability of currencies

- A long-standing issue in international finance is the disconnection between economic fundamentals and exchange rates, especially at short horizons (Meese and Rogoff, 1983)
- As a consequence, individually exchange rates follow a random walk closely (Engel and West, 2005, Della Corte and Tsiakas, 2012, Verdelhan, 2018)
- So for some reason, a random walk with drift has been introduced as benchmark even though a random walk without drift performs better (Rossi, 2013)
- And the overall conclusion to whether exchange rates are predictable, it depends... (Rossi, 2013)

Common factors in the cross-section of currencies



(a) All countries



(b) Developed countries

➜ A strong common factor structure in currencies!

Dollar factor predictability

- The Dollar factor has a correlation of 99% with the first PCA factor (Lustig et al., 2011)
- We will now examine whether we have (in-sample) predictability of the Dollar factor
- For now, we will try to examine the paper Lustig et al. (2014)
- Lustig et al. (2014) also examine bilateral (individual) currencies which you can (try) to replicate yourself!
- We will only focus on excess returns. The dataset also contains spot changes so you can try to replicate the results yourself
- We will ignore transaction costs

Countercyclical currency risk premia

Motivation

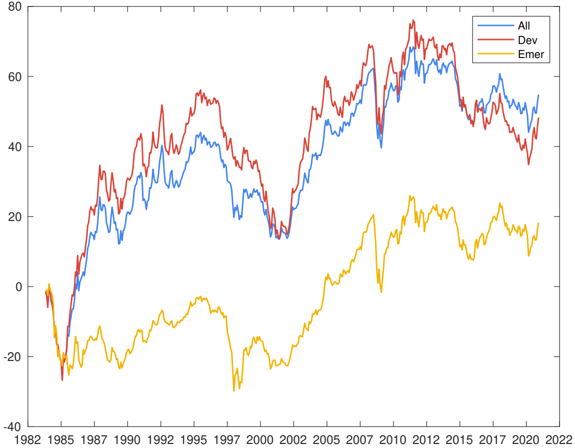
- (10) suggest that when the SDF volatility of the US is higher than the rest of the world, the USD should depreciate
- They consider a link between the SDF volatility (market-price of risk) and the US interest rate and the rest of the world
- When the volatility of the SDF is high, US interest rates seems to be low relative to the rest of the world (at least historically) due to an argument of precautionary savings

  $\rightarrow$ we can use the AFD to time the Dollar

Data

- We will consider currency data for the 48 currencies from 1984 to 2020 obtained from Barclays and Reuters
- We consider end-of-month observations
- The cross-section is divided into three baskets: all, developed and emerging
- The Dollar factor is simply defined as the cross-sectional average of excess returns for the currencies in each basket

The Dollar factor

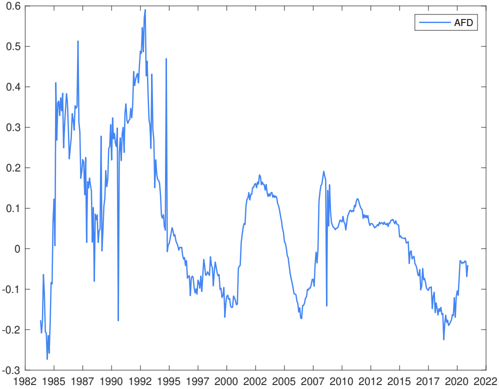


- The USD seems to provide positive returns against the other currencies during periods of high turbulence $\rightarrow$ Safe haven property

The average forward discount

- As predictor, Lustig et al. (2014) consider the (log) average forward discount for developed countries

$$AFD_{t,t+h} = \frac{1}{N_{dev}} \sum_{i \in dev} f_{i,t,t+h} - s_t \tag{14}$$



In-sample evidence

	All		Develop		Emerging	
Horizon	Coef	R^2	Coef	R^2	Coef	R^2
1	1.81	2.18	2.31	2.51	0.85	0.62
	(2.46)		(2.70)		(1.57)	
2	1.51	5.47	2.00	6.88	0.63	1.28
	(2.70)		(3.11)		(1.61)	
3	1.88	5.38	2.40	6.47	0.84	1.41
	(2.24)		(2.51)		(1.35)	
6	1.85	8.27	2.39	10.30	0.75	1.80
	(2.18)		(2.49)		(1.15)	
12	1.59	10.43	2.09	13.39	0.84	3.79
	(1.95)		(2.28)		(1.27)	

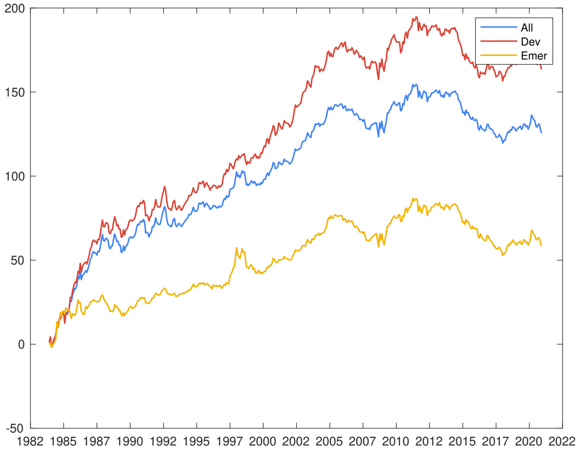
The Dollar carry

- To examine the value of timing the Dollar factor, Lustig et al. (2014) propose the following simple timing strategy:
  - If $AFD_t > 0$, buy the Dollar factor
  - If $AFD_t < 0$, sell the Dollar factor
- Meaning that investors will be buy in the USD when US interest rates are higher than the cross-sectional average among developed economies

The Dollar carry

	All	Developed	Emerging
		Dollar Carry	
Mean	3.39	4.41	1.57
	(2.84)	(3.19)	(1.50)
SR	0.48	0.53	0.25
		Difference to no Timing	
Mean	1.87	3.07	1.05
	(1.25)	(1.92)	(0.65)

The Dollar carry



A sample specific result?

- The performance of the Dollar Carry strategy seems to be remarkable worse since the mid-2000s
- So let's examine whether the ADF is useful for timing the Dollar after the transition to the new millennium

	All	Developed	Emerging
		Dollar Carry	
Mean	1.39	2.36	0.73
	(0.97)	(1.31)	(0.57)
SR	0.20	0.28	0.12
		Difference to no Timing	
Mean	0.02	1.62	-0.86
	(0.02)	(0.75)	(-0.51)

$\rightarrow$ both returns and Sharpe ratios have halved....

A sample specific result?

- Is the degree in performance of the Dollar Carry as result of a decrease in the predictive ability of the ADF?

	All		Develop		Emerging	
Horizon	Coef	R^2	Coef	R^2	Coef	R^2
1	1.32	0.54	2.29	1.04	0.66	0.16
	(1.30)		(1.70)		(0.75)	
2	1.06	1.33	1.77	2.45	0.56	0.45
	(1.36)		(1.80)		(0.81)	
3	0.95	0.70	1.91	1.87	0.27	0.07
	(0.71)		(1.16)		(0.22)	
6	0.69	0.63	1.60	2.32	0.03	0.00
	(0.44)		(0.85)		(0.02)	
12	0.65	1.11	1.64	4.72	-0.01	0.00
	(0.44)		(0.93)		(-0.01)	

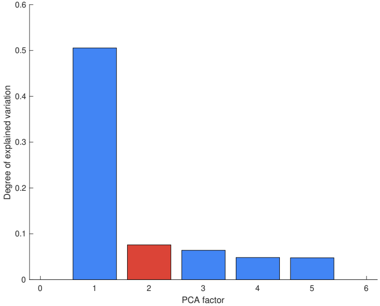
- This seems to be the case...

Conclusion

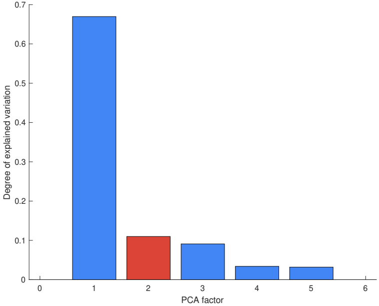
- The average forward discount is related to the average difference in interest rates between the US and the countries in the basket
- The average forward discount seem to contain predictive information about future USD movements at least against the cross-section of developed countries (prior the transition to the new millennium)
- This information can be exploited for an investor in a timing strategy that delivers (very) close to significant higher returns (for the first part of the sample...)

Back to the common factors

Common factors in the cross-section of currencies



(a) All countries



(b) Developed countries

Common factors in the cross-section of currencies

- Lustig et al. (2011) define a HML factor (the return of a Carry) which has a correlation of 94% with the second PCA factor
- Lustig et al. (2011) propose a two-factor model for the cross-section of currency risk premia:

$$RX_{i,t} = \beta_{DOL}\lambda_{DOL,t} + \beta_{HML}\lambda_{HML,t} \tag{15}$$

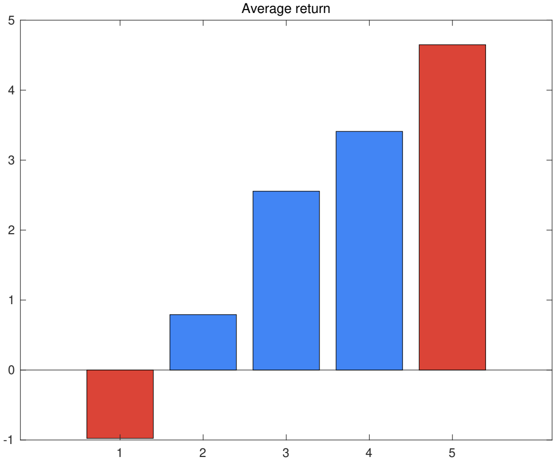
- For their sample, the two factors account for 82.3% (88.4%) of the variation in all (developed) currency returns

The Carry Strategy

- The carry strategy is a simple approach to exploit UIP deviations by the forward premium bias.
- More specifically, we construct currency portfolios by a univariate sort on forward discounts
- This implies that the strategy is (US) Dollar neutral and given CIP the strategy is buying high-interest rate currencies and selling low
- Due to the relatively low number of assets in the cross-section, we follow Menkhoff et al. (2012a) and split our cross-section into five portfolio

The Carry Strategy

- The Carry strategy delivers the following average annualized returns



The Carry Strategy

	1	2	3	4	5	HML
Mean	-0.98	0.79	2.56	3.41	4.65	5.63
	(-0.69)	(0.63)	(1.70)	(2.28)	(2.54)	(3.74)
Std	7.77	7.07	7.82	8.09	9.72	8.64
SR	-0.13	0.11	0.33	0.42	0.48	0.65

- The HML is highly significant!

Predictability of the HML factor

- Predictability of the HML factor is widely examined relative to the Dollar factor:
  - Commodity returns (Bakshi and Panayotov, 2013, Ready et al., 2017)
  - Global variance innovations (Bakshi and Panayotov, 2013)
  - Credit risk (Della Corte et al., 2021)
  - Liquidity related (such as the TED spread) (Brunnermeier et al., 2008)

Volatility innovations and carry trades

Menkhoff et. al. (2011)

- We will now go through the article of Menkhoff et al. (2012a) which provides a nice example of how you can test for a specific risk factor is priced in the cross-section
- The article, furthermore, provides an example of to test whether a non-traded factor is priced in the cross-section of some asset (in this case currencies)
- Said simple: the authors examine whether global exchange volatility can explain the cross-section of portfolios sorted on interest rates

Why consider Volatility?

- The relation between risk and return is at the core of empirical asset pricing
- Time-varying market volatility induced changes in the investment opportunity set by changing expected returns and/or the risk-return trade-off (again think of the ICAPM model)
- Ang et al. (2006) documents that stocks with high sensitivities to innovations in aggregate volatility have low average returns - consistent with risk-based asset pricing
- Menkhoff et al. (2012a) essentially copy-paste the analysis of Ang et al. (2006) into the currency framework
- The findings of the paper is similar: high-interest rate currencies have a negative relation to aggregated FX vol and, hence, deliver a negative return due to increases in volatility
- The profitability of the Carry trade is, hence, compensation for risk

Initial comments for the analysis

- To ease the analysis (and avoid confusion), we will ignore transaction costs
- We will, furthermore, consider discrete returns instead of $\log$ returns (and do the analysis without approximations)
- We follow Lustig et al. (2011) and exclude currencies in which the CIP has been documented to be violated
- We will consider the same Carry returns as from before

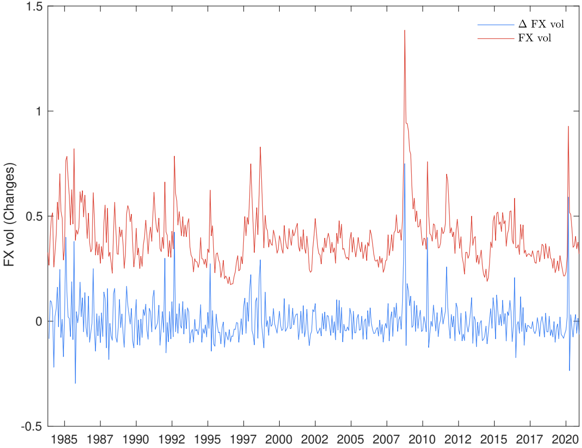
Global Foreign Exchange Volatility

- To proxy the volaility Menkhoff et al. (2012a)

$$\sigma_t^{FX} = \frac{1}{T_t} \sum_{\tau \in T_t} \left[\sum_{k \in K_\tau} \frac{| r_\tau^k |}{K_\tau} \right] \tag{16}$$

- They consider absolute returns instead of realized volatility to minimize the impact of outliers
- Menkhoff et al. (2012a) focus on volatility innovations which they define as residuals from an AR(1) process

Global Foreign Exchange Volatility



Motivational evidence for volatility

- Let's first examine a motivating plot on the relationship between carry returns and vol innovations:

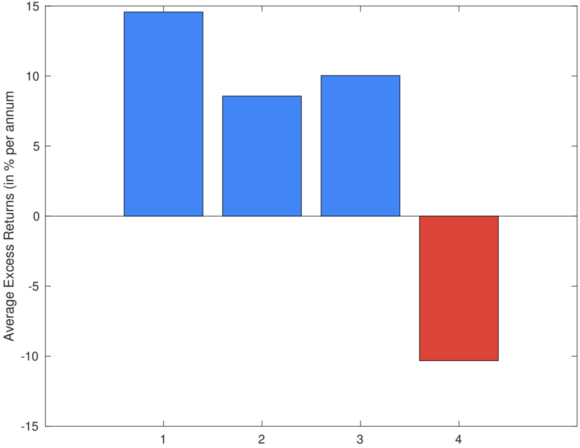


Fig. 3: Carry performace across Δ vol quartiles

A linear SDF

- To test for whether vol innovations can explain the variation in Carry portfolios, Menkhoff et al. (2012a) consider the following linear SDF

$$M_t = (1 - b_{Dol}(DOL_t - \mu_{Dol}) - b_{VOL}\Delta\sigma_{FX,t}) \tag{17}$$

- where the DOL factor is now defined as the cross-sectional average of Carry portfolios
- To estimate the parameters, they apply GMM

Moment conditions

- Denote $z_t = (rx_t, h_t)$ where $h_t = (DOL_t, \sigma_{FX,t})$
- More specifically, they consider the following moment conditions

$$g(z_t, \theta) = \begin{bmatrix} [1 - b'(h_t - \mu)]\, rx_t \\ h_t - \mu \\ vec((h_t - \mu)(h_t - \mu)') - vec(\Sigma_h) \end{bmatrix} \tag{18}$$

- As weighting matrix, they consider the identity matrix for the SDF and a large weight (I have set it to 1000) for the additional
- They consider a HAC estimator for the long-run covariance matrix with Andrews (1991) lag length

From SDF loading to risk premium

- Remember that the risk premium λ is given as

$$\lambda = \Sigma_h b \tag{19}$$

- We can then apply the delta method to conduct inference on the risk premium estimates
- Denote

$$\theta = \begin{bmatrix} vec(b) \\ vec(\Sigma_h) \end{bmatrix} \tag{20}$$

- The delta method state that if

$$\hat{\theta} \sim^d \mathcal{N}(\theta, \Sigma_\theta) \tag{21}$$

then

$$g(\hat{\theta}) \sim^d \mathcal{N}(g(\theta), g'(\theta)\Sigma_\theta (g'(\theta))^\intercal) \tag{22}$$

In our case

- In our case

$$g'(\theta) = \begin{bmatrix} \Sigma_{1,1} & \Sigma_{1,2} & b_{1,1} & b_{2,2} & 0 & 0 \\ \Sigma_{2,1} & \Sigma_{2,2} & 0 & 0 & b_{1,1} & b_{2,2} \end{bmatrix} \tag{23}$$

- and Σ_θ is the covariance matrix of our estimates

Asset pricing test

- We are now ready to test whether vol innovations can explain cross-sectional variation in Carry portfolios. The table below provides the results

	DOL	VOL	J-test
b	-0.01	-4.71	1.38
	(-0.18)	(-2.31)	[0.71]
λ	0.15	-0.05	
	(1.60)	(-3.37)	

Asset pricing test, 2.0

- We can also examine whether the specified SDF delivers significant pricing errors (note a slightly different focus in Menkhoff et al. (2012a)):

Portfolio	α	β_{DOL}	β_{σ}	R^2
1	-0.25	0.98	4.24	76.90
	(-4.84)	(18.29)	(7.59)	
2	-0.09	0.89	1.01	77.72
	(-1.79)	(19.63)	(2.04)	
3	0.04	1.01	-0.01	84.89
	(0.87)	(24.13)	(-0.02)	
4	0.10	1.04	-0.81	83.93
	(1.98)	(24.11)	(-1.52)	
5	0.20	1.09	-4.43	70.68
	(2.51)	(19.79)	(-4.28)	

Factor mimicking portfolio

- To better measure ex post exposure to aggregate FX volatility risk at a monthly frequency, Menkhoff et al. (2012a) follow Breeden et al. (1989) and Ang et al. (2006) and build a factor-mimicking portfolio from the regression

$$\Delta\sigma_t^{FX} = c + b' rx_t + u_t \tag{24}$$

- So we construct a portfolio of the carry portfolios that maximize the correlation between the factor of interest and mimicking portfolio
- The factor-mimicking portfolio is then constructed as the fitted values (less the intercept c) from the regression in (24), i.e.,

$$rx_t^{FM} = \hat{b}' rx_t \tag{25}$$

- One could essentially use any set of assets with sufficient return dispersion to construct the mimicking portfolio

Factor mimicking portfolio

- In our case, the FM weights are given as

$$rx_t^{FM} = 0.25rx_t^1 - 0.07rx_t^2 - 0.08rx_t^3 - 0.05rx_t^1 - 0.13rx_t^5 \tag{26}$$

- The mimicking portfolio loads most heavily on the extreme deciles and is somewhat decreasing from portfolio 2 through 5
- This implies that portfolio 1 provides a hedge against FX vol increases

Asset pricing tests 2.0 with the factor mimicking portfolio

- We can then examine whether the factor mimicking portfolio is priced

	DOL	RX^{FM}	J-test
b	0.01	-0.39	1.38
	(-0.08)	(-1.07)	[0.71]
λ	0.46	-0.10	
	(3.44)	(-3.10)	

Vol exposure and the cross-section of currencies

- As in the case of Bali et al. (2017), we can also construct a portfolio sort based on vol innovation exposures
- Menkhoff et al. (2012a) consider a 36 rolling window of the following regression to measure the exposure

$$rx_{t,j} = \alpha + \beta_{DOL} DOL_t + \beta_{VOL} \Delta\sigma_t^{FX} + \eta_{t,j} \tag{27}$$

- Note, that they only rebalance every 6th month (nonstandard choice)
- Instead, we will follow the standard approach and rebalance every month

Vol exposure and the cross-section of currencies

	1	2	3	4	5	L-H
Mean	2.00	2.03	2.03	1.24	0.79	1.21
	(1.12)	(1.32)	(1.70)	(0.89)	(0.57)	(0.78)
STD	9.74	8.28	7.01	6.97	7.37	9.19
SR	0.21	0.24	0.29	0.18	0.11	0.13

- Not that convincing evidence!

Additional comments

Additional sorting signals

- Macro-economic difference: output gap (Colacito et al., 2020), momentum in economic fundamentals (Dahlquist and Hasseltoft, 2020), global imbalances (Corte et al., 2016)
- Traditional: Momentum(Menkhoff et al., 2012b), value (Menkhoff et al., 2017)
- Financial variables: currency volatility risk premia (Della Corte et al., 2016), Order flows (Menkhoff et al., 2016), Dollar beta Verdelhan (2018)

➜ In other words: see the website of Lucio Sarno...

Potential projects

- Many of the sorting variable from the slide before would make sense to consider in a predictability study
- For instance, Londono and Zhou (2017) consider the currency variance risk premium as Della Corte et al. (2016) consider in a cross-sectional study
- As long you find a variable that you can relate to the difference in market-price of risk between the two countries, we should expect the variable to predict currency risk premia'

References

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