

Volatility Risk Premia and Exchange Rate Predictability

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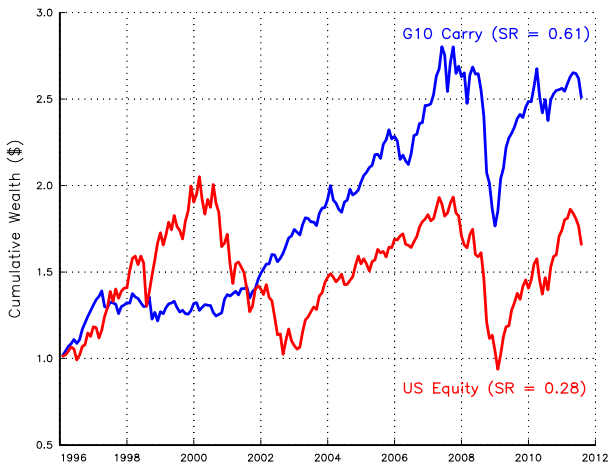
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- **A growing interest in currency strategies**
 - carry, momentum and value are typically profitable
 - excess returns can be understood as compensation for risk
 - Lustig, Roussanov, and Verdelhan (2011), Menkhoff *et al.* (2012), Della Corte, Sarno and Riddiough (2013).
- **Little progress, however, in understanding exchange rate returns**
 - carry is not informative about future exchange rate changes,
 - weak evidence for momentum over the past 10 years.
- ★ **Exchange rate returns remain difficult to predict**
 - Meese and Rogoff (1983), Mark (1995),
 - Bacchetta and van Wincoop (2004), Engel and West (2005).

Carry Strategy



- A carry investor **buys high and sells low-yielding currencies** every month.

Simple Decomposition

● Excess Return

- buy the foreign currency at time t in forward market, and offset the position at time $t + 1$ in the spot market

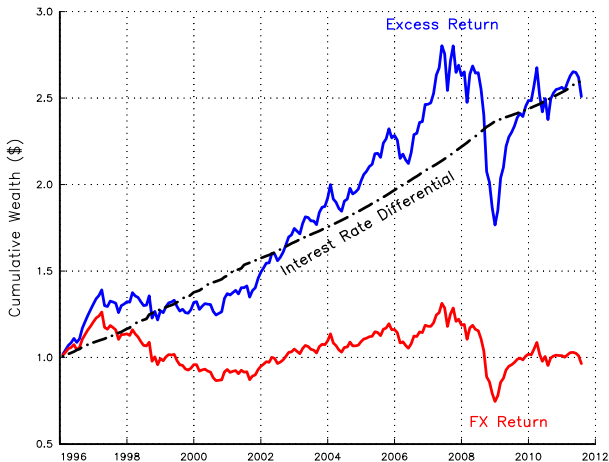
$$RX_{t+1} = \frac{S_{t+1} - F_t}{S_t}$$

- decomposed into exchange rate return and forward premium

$$\begin{aligned} RX_{t+1} &= \frac{S_{t+1} - S_t}{S_t} - \frac{F_t - S_t}{S_t} \\ &\simeq \frac{S_{t+1} - S_t}{S_t} + i_t^* - i_t \end{aligned}$$

- S_t is the spot rate defined as US dollar price of foreign currency,
- F_t is the forward rate defined as US dollar price of foreign currency,
- i_t is the domestic riskless rate,
- i_t^* is the foreign riskless rate.

Carry Trade Strategy



- Carry excess returns decomposed into **exchange rate returns** and **interest rate differential**.

Contribution

- A novel currency strategy based on **volatility risk premia**
 - simply $\text{time-}t$ realized volatility minus model-free implied volatility,
 - the model-free implied volatility is based on options (Britten-Jones and Neuberger, 2001),
 - the volatility risk premium - typically negative - interpreted as the cost of insurance against volatility fluctuations.
- Our strategy - **VRP strategy** - is a long-short strategy that
 - buys currencies with cheap insurance cost and sells currencies with expensive insurance cost,
 - is rebalanced at the end of the month from Jan 1996 to Aug 2011,
 - involves the top 10 (or top 20) most liquid currencies.

Main Findings

- **Volatility risk premia**
 - provide significant forecasting power for exchange rate returns.
- Excess returns to the **VRP strategy** are
 - driven by spot return predictability,
 - negatively correlated with carry and uncorrelated with momentum,
 - not replicable with known strategies or canonical risk factors.
- We consider two possible explanations
 - excess returns are driven by global volatility risk,
 - ★ excess returns arise from the interaction of hedgers and speculators with time-varying limits to arbitrage.

● Volatility swap

- a forward contract on the volatility of the underlying asset 'realized' over the life of the contract,
- it pays the difference between the actual volatility measured ex-post and a fixed amount quoted at the inception date.

● Payoff

- the buyer of a swap written at time t and maturing at time $t + \tau$ receives per \$1 notional amount

$$RV_{t,t+\tau} - SW_{t,t+\tau}$$

- $RV_{t,t+\tau}$ is the realized volatility known at time $t + \tau$,
- $SW_{t,t+\tau}$ is the swap rate agreed on at time t ,
- $RV_{t,t+\tau}$ and $SW_{t,t+\tau}$ are both defined over $[t, t + \tau]$.

● Volatility Risk Premium

- the ex-ante payoff to a volatility swap contract

$$VRP_{t,t+\tau} = E_t [RV_{t,t+\tau}] - SW_{t,t+\tau}$$

- $E_t [\cdot]$ denotes the conditional expectation at time t ,
- $E_t [RV_{t,t+\tau}] = RV_{t-\tau,t}$ as in Bollerslev, Tauchen and Zhou (2009).

● Volatility Swap Rate

- we use the model-free approach of Britten-Jones and Neuberger (2000), Jiang and Tian (2005), and Carr and Wu (2009),
- $SW_{t,t+\tau}$ is based on the cross-section of call and put options across different strike prices.

Volatility Swap Rate

- The variance swap rate is the expected value of the average variance

$$SW_{t,\tau}^2 = E_t^Q [RV_{t,\tau}^2].$$

- Britten-Jones and Neuberger (2000) show that

$$SW_{t,\tau}^2 = \frac{2e^{i_t \cdot \tau}}{\tau} \left\{ \int_0^{F_{t,\tau}} \frac{1}{K^2} P_{t,\tau}(K) dK + \int_{F_{t,\tau}}^{\infty} \frac{1}{K^2} C_{t,\tau}(K) dK \right\}.$$

- Jiang and Tian (RFS, 2007)
 - model-free implied variance can be computed using a limited number of strikes
 - the approximation error turns out to be small for a limited range of strikes.

Volatility Swap Rate

- We synthetically construct the strike price as

$$SW_{t,\tau} = \sqrt{SW_{t,\tau}^2}$$

- This approach is subject to a convexity bias as

$$E_t^Q \left[\sqrt{RV_{t,\tau}^2} \right] \leq \sqrt{E_t^Q [RV_{t,\tau}^2]}.$$

- The convexity bias using a second-order Taylor expansion as in Brockhaus and Long (2000) tends to be empirically small.

VRP Portfolios

- At the end of each month t
 - sort currencies into 5 baskets using the 1-year volatility risk premia,
 - *First Portfolio* (P_C): currencies with cheap volatility insurance (or high volatility risk premia),
 - *Last Portfolio* (P_E): currencies with expensive volatility insurance (or low volatility risk premia).
- At time $t + 1$
 - currencies are equally-weighted within portfolios,
 - *VRP* is a strategy that is long cheap volatility insurance currencies, and short expensive volatility insurance currencies (i.e., $VRP = P_C - P_E$).

Constructing Other Currency Portfolios

● Carry Portfolios

- *CAR* is a portfolio which is long high interest rate and short low interest rate currencies.

● Momentum Portfolios

- *MOM* is a portfolio which is long winner and short loser currencies (3-month FX return).

● Value Portfolios

- *VAL* is a portfolio which is long undervalued ($RER < 1$) and short overvalued ($RER > 1$) currencies according to PPP.

● Risk Reversal Portfolios

- *RR* is a portfolio which is long more negative-skewness (negative risk reversal) and short less negative-skewness currencies (positive risk reversal).

Dataset

- The **'Developed & Emerging Countries'** sample (20):
 - Australia, Brazil, Canada, Czech Republic, Denmark, Euro Area, Hungary, Japan, Mexico, New Zealand, Norway, Poland, Singapore, South Africa, South Korea, Sweden, Switzerland, Taiwan, Turkey, United Kingdom.
- The **'Developed Countries'** sample (10):
 - highlighted in blue.
- Time period:
 - monthly data from January 1996 to August 2011.

- **Foreign exchange data**

- monthly spot and forward rates relative to USD from Datastream.

- **Over-the-Counter Currency Option Data**

- 1-year implied volatility data from JP Morgan,
- five deltas: ATM, 10 Δ Calls & Puts, 25 Δ Calls & Puts.

- **Hedger Position Data**

- the net position of traders in exchange rate futures on the CME,
- US Commodity Futures Trading Commission (CFTC).

- **Hedge Fund Flows**

- hedge funds and funds-of-funds data consolidated from HFR, CISDM, TASS, Morningstar and Barclay-Hedge databases.

Volatility Risk Premia

	$RV_{t,t+\tau} \times 100$	$SW_{t,t+\tau} \times 100$	$VRP_{t,t+\tau} \times 100$
	<i>Developed</i>		
<i>Mean</i>	10.68	11.31	-0.62
<i>Sdev</i>	2.88	2.75	1.58
<i>Skew</i>	1.85	1.42	0.54
<i>Kurt</i>	6.86	5.29	5.97
AC_{τ}	0.33	0.53	-0.19
	<i>Developed & Emerging</i>		
<i>Mean</i>	10.82	11.74	-0.92
<i>Sdev</i>	3.10	3.22	1.78
<i>Skew</i>	2.12	2.07	-0.31
<i>Kurt</i>	7.85	8.06	7.88
AC_{τ}	0.27	0.46	-0.17

Currency Strategies

Developed Countries

	<i>CAR</i>	<i>MOM</i>	<i>VAL</i>	<i>RR</i>	<i>VRP</i>
Excess Returns					
<i>Mean</i>	6.49	2.58	5.78	5.30	4.03
<i>Sdev</i>	10.66	9.55	9.38	11.40	8.33
<i>Skew</i>	-0.92	0.35	-0.26	-0.72	0.28
<i>Kurt</i>	5.65	3.86	3.50	6.58	3.47
<i>SR</i>	0.61	0.27	0.62	0.46	0.48
<i>MDD</i>	-0.37	-0.16	-0.14	-0.37	-0.18
FX Returns					
<i>Mean</i>	0.34	2.03	2.95	1.42	4.40
<i>Sdev</i>	10.66	9.57	9.44	11.48	8.35
<i>Skew</i>	-0.93	0.42	-0.29	-0.75	0.28
<i>Kurt</i>	5.82	4.17	3.51	6.83	3.61
<i>SR</i>	0.03	0.21	0.31	0.12	0.53
<i>MDD</i>	-0.43	-0.20	-0.24	-0.40	-0.19

Currency Strategies

Developed & Emerging Countries

	<i>CAR</i>	<i>MOM</i>	<i>VAL</i>	<i>RR</i>	<i>VRP</i>
Excess Returns					
<i>Mean</i>	7.42	2.22	3.55	5.38	2.34
<i>Sdev</i>	9.97	8.30	8.90	10.60	8.18
<i>Skew</i>	-0.92	-0.03	-0.15	-0.14	0.12
<i>Kurt</i>	4.53	2.95	3.17	4.43	3.26
<i>SR</i>	0.74	0.27	0.40	0.51	0.29
<i>MDD</i>	-0.21	-0.13	-0.14	-0.24	-0.18
FX Returns					
<i>Mean</i>	-0.65	1.45	0.06	0.22	3.72
<i>Sdev</i>	9.99	8.16	8.89	10.60	8.17
<i>Skew</i>	-1.05	-0.02	-0.16	-0.21	0.12
<i>Kurt</i>	4.84	3.13	3.19	4.74	3.50
<i>SR</i>	-0.07	0.18	0.01	0.02	0.46
<i>MDD</i>	-0.35	-0.15	-0.27	-0.29	-0.18

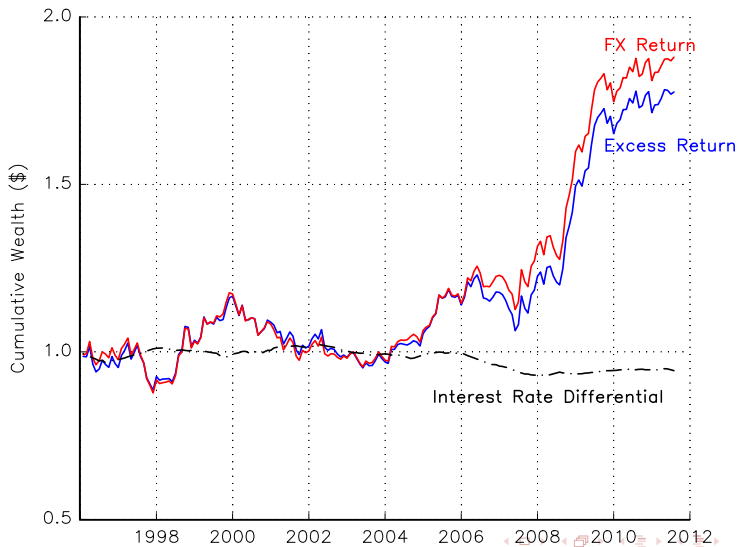
Currency Strategies

FX Returns: Sub-Samples

NBER Recession Periods										
	CAR	MOM	VAL	RR	VRP	CAR	MOM	VAL	RR	VRP
	<i>Developed</i>					<i>Developed & Emerging</i>				
Mean	-9.59	11.32	4.62	-7.96	11.54	-7.97	7.07	0.10	-4.80	6.50
SR	-0.56	0.74	0.38	-0.42	1.14	-0.54	0.67	0.01	-0.32	0.69
MDD	-0.40	-0.16	-0.12	-0.41	-0.09	-0.32	-0.07	-0.18	-0.29	-0.09
non-NBER Recession Periods										
Mean	2.09	0.40	2.65	3.08	3.14	0.64	0.46	0.05	1.11	3.23
SR	0.23	0.05	0.30	0.32	0.39	0.07	0.06	0.01	0.12	0.41
MDD	-0.31	-0.21	-0.22	-0.15	-0.16	-0.31	-0.20	-0.22	-0.20	-0.16
Pre-Crisis Period										
Mean	1.91	0.81	3.00	2.94	2.18	1.09	0.71	0.58	1.28	3.04
SR	0.23	0.10	0.31	0.31	0.27	0.12	0.09	0.06	0.13	0.36
MDD	-0.31	-0.16	-0.24	-0.15	-0.19	-0.31	-0.14	-0.23	-0.18	-0.18
Crisis Period										
Mean	-3.34	4.88	2.81	-2.13	9.61	-4.73	3.17	-1.15	-2.25	5.30
SR	-0.23	0.38	0.32	-0.14	1.06	-0.40	0.34	-0.14	-0.19	0.73
MDD	-0.43	-0.16	-0.12	-0.40	-0.08	-0.31	-0.13	-0.15	-0.29	-0.10

VRP Strategy

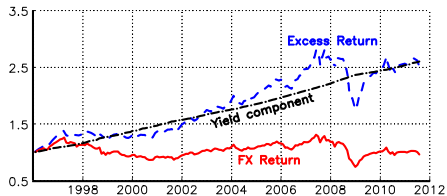
Developed Countries



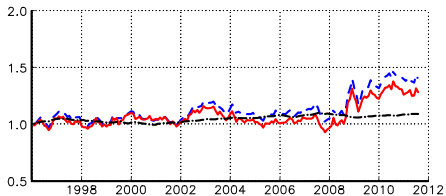
Other Strategies

Developed Countries

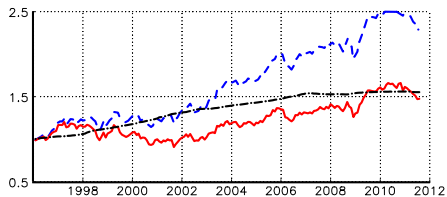
Carry



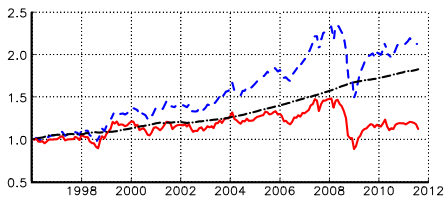
Momentum



Value



Risk Reversal



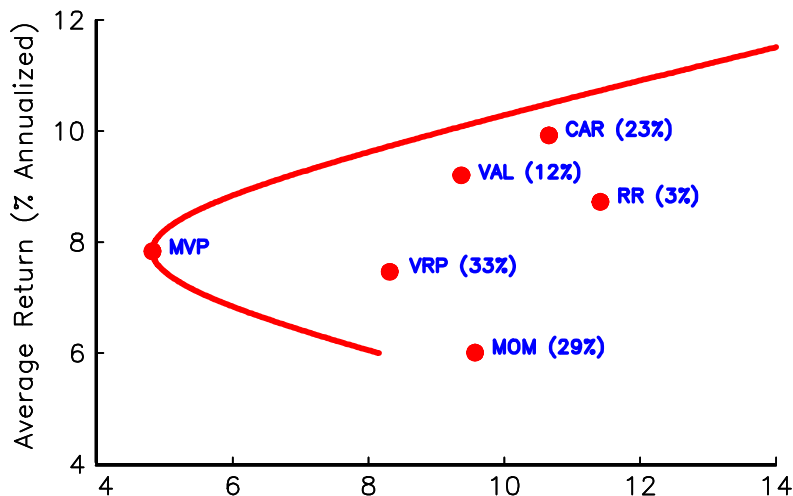
Currency Strategy: Correlations

Developed Countries					
	<i>CAR</i>	<i>MOM</i>	<i>VAL</i>	<i>RR</i>	<i>VRP</i>
<i>CAR</i>	1.00				
<i>MOM</i>	-0.17	1.00			
<i>VAL</i>	0.44	-0.17	1.00		
<i>RR</i>	0.68	-0.17	0.49	1.00	
<i>VRP</i>	-0.18	0.09	0.23	-0.01	1.00

Developed & Emerging Countries					
	<i>CAR</i>	<i>MOM</i>	<i>VAL</i>	<i>RR</i>	<i>VRP</i>
<i>CAR</i>	1.00				
<i>MOM</i>	-0.03	1.00			
<i>VAL</i>	0.54	-0.14	1.00		
<i>RR</i>	0.57	-0.15	0.64	1.00	
<i>VRP</i>	-0.21	0.10	-0.10	-0.12	1.00

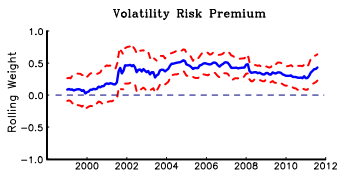
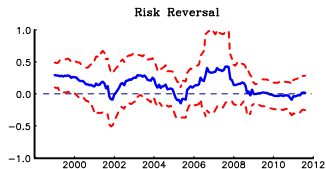
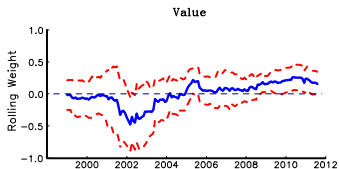
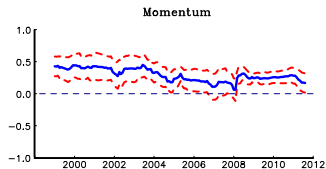
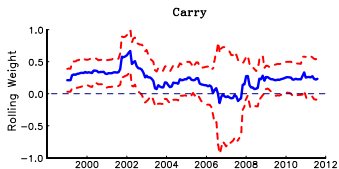
Global Minimum Variance Portfolio

Average Weights: Developed Countries



Global Minimum Variance Portfolio

3-year Rolling Weights: Developed Countries



Volatility Spread Strategies

	L_{M6}	L_{M9}	L_{M12}	L_{M18}	L_{M24}	L_{M6}	L_{M9}	L_{M12}	L_{M18}	L_{M24}
	<i>Developed (G10)</i>					<i>Developed & Emerging (G20)</i>				
<i>Sharpe Ratios: Excess Returns</i>										
S_{M1}	0.60	0.41	0.39	0.58	0.45	0.64	0.38	0.45	0.39	0.38
S_{M2}	0.59	0.45	0.49	0.34	0.45	0.53	0.45	0.49	0.31	0.21
S_{M3}	0.53	0.52	0.45	0.24	0.31	0.43	0.40	0.17	0.20	0.32
S_{M6}		0.19	0.12	0.02	0.02		0.04	0.07	0.01	0.08
<i>Sharpe Ratios: FX Returns</i>										
S_{M1}	0.60	0.44	0.43	0.60	0.47	0.59	0.34	0.41	0.35	0.34
S_{M2}	0.60	0.47	0.49	0.36	0.47	0.53	0.41	0.43	0.27	0.17
S_{M3}	0.54	0.53	0.47	0.27	0.32	0.44	0.37	0.15	0.17	0.28
S_{M6}		0.22	0.15	0.04	0.04		0.04	0.09	0.01	0.07
<i>Correlation with VRP: Excess Returns</i>										
S_{M1}	0.20	0.30	0.26	0.23	0.16	0.00	0.03	0.02	0.02	-0.08
S_{M2}	0.28	0.30	0.30	0.19	0.09	0.13	0.18	0.09	0.02	-0.09
S_{M3}	0.32	0.39	0.38	0.23	0.09	0.12	0.17	0.11	-0.05	-0.13
S_{M6}		0.14	0.11	0.04	-0.10		0.01	0.03	-0.06	-0.13

Time-Series: Risk Factors

Developed Countries

Currency Factors						
α	<i>DOL</i>	<i>CAR</i>	<i>MOM</i>	<i>VAL</i>	<i>RR</i>	R^2
0.05^b	0.14	-0.22^b	0.11	0.10	-0.04	0.05
(0.02)	(0.09)	(0.09)	(0.08)	(0.13)	(0.12)	

Equity Factors					
α	R_m^e	<i>SMB</i>	<i>HML</i>	<i>MOME</i>	R^2
0.05^b	-0.07	-0.05	-0.09^a	-0.05	0.01
(0.02)	(0.06)	(0.05)	(0.05)	(0.03)	

Hedge Fund Factors								
α	<i>Bond Trend</i>	<i>Curr Trend</i>	<i>Comm Trend</i>	<i>Equity Market</i>	<i>Size Spread</i>	<i>Bond Market</i>	<i>Credit Spread</i>	R^2
0.05^b	0.14	-0.17	0.09	-0.04	-0.05	-0.09	0.07	0.01
(0.02)	(0.12)	(0.11)	(0.17)	(0.05)	(0.05)	(0.11)	(0.21)	

Two Possible Explanations

- *VRP* returns capture fluctuations in aversion to volatility risk
 - currencies with high (low) volatility insurance deliver high (low) returns at times of high global volatility
 - currencies must load differently on global volatility shock.
- Time-varying capital constraints for providers of volatility insurance (speculators), and risk-averse currency hedgers happier holding currencies with cheaper volatility insurance
 - returns from *VRP* strategy should be temporary; reversion once capital constraints are relaxed
 - returns from *VRP* strategy should correlate with funding liquidity and hedger risk aversion
 - order flow in spot currency market should line up as predicted in *VRP* portfolios.

Testing First Explanation

Cross-Sectional Tests

- The Euler condition

$$E[M_t R X_t^j] = 0$$

- $R X_t^j$: excess return on portfolio j
 - $M_t = 1 - b' f_t$: linear stochastic discount factor
 - b : vector of factor loadings
 - f_t : demeaned risk factors
- The β -pricing model

$$E[R X^j] = \underbrace{\frac{\text{Cov}(R X_t^j, f_t)}{\text{Var}(f_t)}}_{\beta^j} \times \underbrace{b \text{Var}(f_t)}_{\lambda}$$

- λ : market price of risk
- β^j : regression coefficient of $R X_{t+1}^j$ on f_{t+1} .

Testing First Explanation

Risk Factors

- The **dollar factor** (DOL)
 - Essentially acts as constant that allows for a common mispricing.
- The **slope factor** (CAR)
 - The long/short portfolio on high/low interest rate currencies.
- The **illiquidity factor** (BAS_{FX})
 - Innovations to the cross-sectional average of FX bid-ask spreads.
- The **volatility factor** (VOL_{FX})
 - Innovations to the cross-sectional average of FX realized volatilities.
- **Bottom line:** None of these factors helps to price VRP portfolios.

Testing First Explanation

Asset Pricing Test: FX Volatility Factor

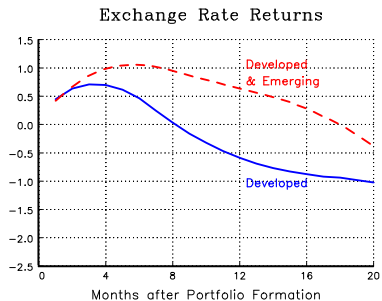
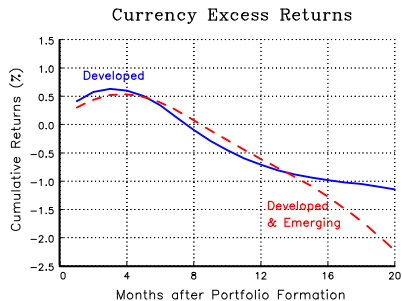
Factor Prices								
	b_{DOL}	b_{VOL}	λ_{DOL}	λ_{VOL}	R^2	$RMSE$	χ^2	HJ
GMM_1	0.52 (0.32)	1.25 (0.81)	0.02 (0.02)	0.16 (0.11)	0.26	2.74	3.02 [0.39]	0.13 [0.44]
GMM_2	0.44 (0.32)	1.01 (0.78)	0.02 (0.02)	0.15 (0.11)	0.27	2.75	2.91 [0.41]	
FMB	0.52 (0.36)	1.24 (0.81)	0.02 (0.02)	0.16 (0.11)	0.26	2.74	3.02 [0.39]	
(sh)	(0.33)	(0.92)	(0.02)	(0.13)			[0.37]	
Factor Betas								
	α	β_{DOL}	β_{VOL}	R^2	$\chi^2_{(\alpha)}$			
P_C	0.03 (0.01)	0.90 (0.06)	0.08 (0.06)	0.62	10.01 [0.07]			
P_2	0.00 (0.01)	0.94 (0.08)	-0.07 (0.05)	0.71				
P_3	-0.01 (0.01)	1.02 (0.06)	0.03 (0.07)	0.71				
P_4	-0.01 (0.01)	1.10 (0.06)	0.01 (0.04)	0.78				
P_E	-0.02 (0.01)	1.04 (0.04)	-0.06 (0.04)	0.78				

Testing Second Explanation

Predictive Regressions for Developed Countries

α	TED	ΔVIX	TED \times ΔVIX	HED		Fund Flows	R ²
				AUDUSD	JPYUSD		
				<i>Developed</i>			
-0.04 (0.03)	0.16 ^b (0.07)						0.03
0.04 ^b (0.02)		0.05 ^a (0.03)					0.01
0.03 (0.02)			0.09 ^c (0.02)				0.05
0.05 ^b (0.02)				0.03 ^c (0.01)			0.01
0.05 ^b (0.02)					-0.02 (0.06)		0.00
0.05 ^b (0.02)						-1.50 ^b (0.72)	0.02
-0.01 (0.04)	0.12 (0.07)			0.02 ^b (0.01)		-0.93 (0.73)	0.04
0.05 ^b (0.02)		0.04 (0.03)		0.02 ^b (0.01)		-1.15 ^a (0.68)	0.03
0.04 ^a (0.02)			0.08 ^c (0.02)	0.02 ^b (0.01)		-0.93 (0.65)	0.06

Reversal



Testing Second Explanation

Data Definitions

● **Financial Customers**

- real money investors with long-term strategies (mutual funds and pension funds)
- levered traders and short-term/aggressive asset managers
- treasury units of nonfinancial corps with aggressive strategies

● **NonFinancial Customers**

- nonfinancial firms (export/import products and services)

Testing Second Explanation

Data Definitions

● Order Flow

- the difference between the value of purchase and sale orders for foreign currency initiated by traders against the bank quotes
- measures the trading decisions of the liquidity-consuming part to the transaction (pay bid-ask spread)
- **positive** order flow \implies foreign currency **purchases**
- **negative** order flow \implies foreign currency **sales**

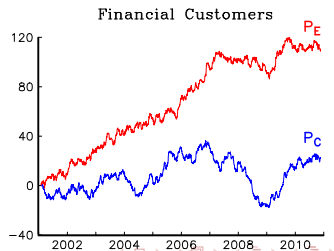
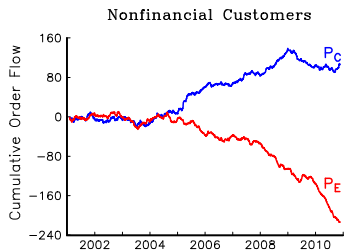
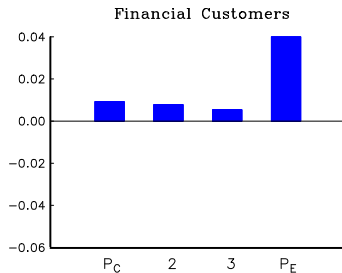
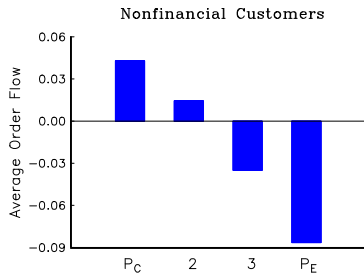
● Day- t order flow

$$x_t = \sum_i V_i \times \text{sign}(V_i)$$

- V_i is the dollar value of transaction i
- $\text{sign}(\cdot)$ is the sign of the trader-initiated order imbalances

Testing Second Explanation

The Behavior of Order Flow in VRP-sorted Portfolios



Conclusions

- The volatility risk premium (VRP) has strong predictive power for the cross-section of currency returns
 - economically valuable and statistically significant
 - VRP information relates purely to future spot exchange rate returns, not to interest differentials
- *VRP* returns are essentially uncorrelated with carry, momentum, value, risk reversal.
 - potential diversification gains from adding *VRP* strategy to those normally followed by currency managers.
- Evidence consistent with *VRP* returns driven by speculator-hedger interactions in the presence of time-varying capital constraints.