Carry Trades and Currency Crashes

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Just My Views...

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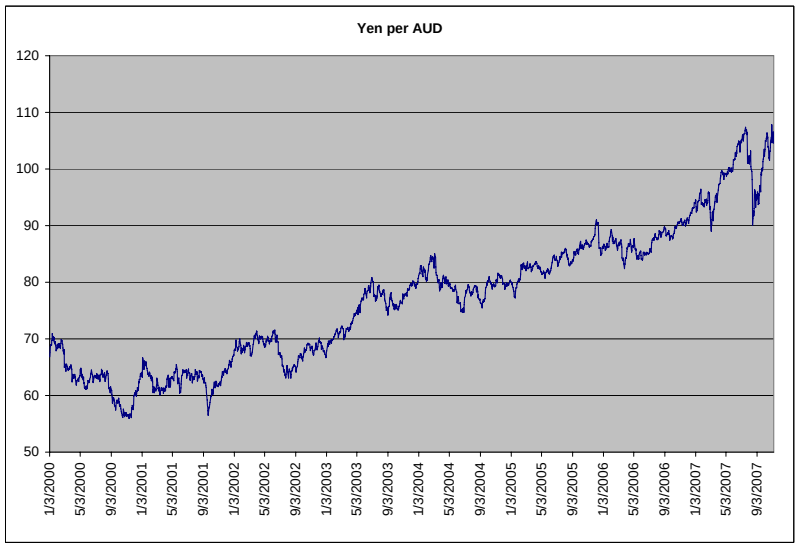
Carry Trades and Currency Crashes: Motivation

We study the drivers of risk (and return) in FX markets:

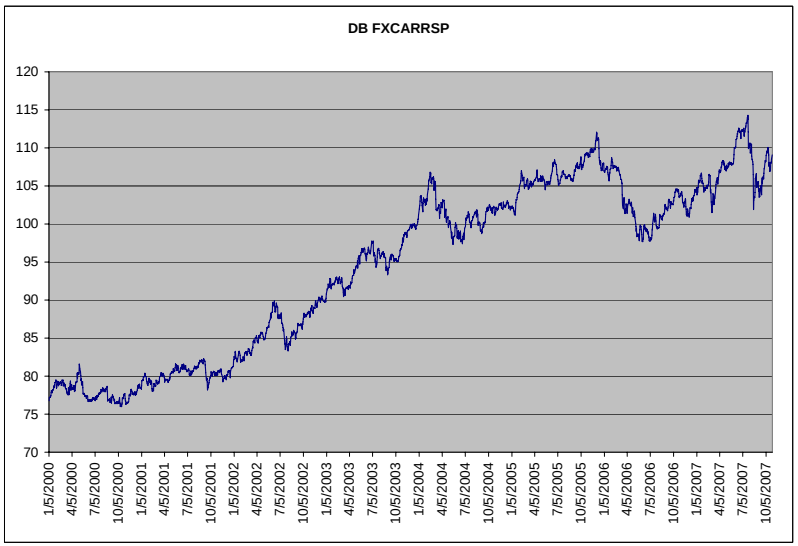
- "Up by the stairs and down by the elevator"
- Forecasting currency crashes: drivers of conditional FX skewness
- Pricing currency crashes: option price of FX insurance
- Co-movement of currencies: what makes FX rates move together?
- Key drivers:
  - Carry traders
  - Global volatility and/or risk aversion
  - Funding liquidity and unwinding of carry trades

What is the Carry Trade?

- Example: Yen-Aussie carry trade (Nov. 8, 2007)
  - **Borrow** at 0.87% 3m JPY LIBOR ("funding currency")
  - **Invest** at 7.09% 3m AUD LIBOR ("investment currency")
  - **Hope** that AUD doesn't depreciate much vs. JPY



Yen per AUD



DB FXCARRSP

Background: Uncovered Interest Parity (UIP)

- Uncovered interest rate parity, with $s_t =: \log(AUD/JPY)$, states:

$$\begin{aligned} E_t\left[\Delta s_{t+1}\right] &= r_{AUD,t} - r_{JPY,t} \\ \text{equivalently:} \quad E_t(x_t) &= 0 \\ \text{where } x_t &= r_{AUD,t} - r_{JPY,t} - \Delta s_{t+1} \end{aligned}$$

- Empirically UIP is violated: High-yield currencies tend to appreciate, not depreciate
  - Large literature on "forward premium puzzle"
  - Source of carry trade profitability
- Possible causes
  - Underreaction to interest rate shocks?
    - Suggests insufficient carry trade activity
  - Bubbles?
    - Carry trade activity could be self-reinforcing

Background: Literature

- Macro: little/no predictability of FX (e.g. Meese and Rogoff 1983)
- Large literature on UIP
- Funding liquidity constraints of speculators
  (Brunnermeier and Pedersen 2007; Plantin and Shin 2007)
  - Unwinding of carry trades when funding liquidity dries up
  - Endogenous negative skewness of carry trade returns
    - Losses are amplified: funding problems$\rightarrow$unwind$\rightarrow$funding problems...
    - Gains are not amplified
  - Excess co-movement of funding currencies (investment currencies)
- Transaction costs (Burnside et al. 2006)

Our Main Results

- FX crash risk increases with
  - Interest rate differential (i.e. carry)
  - Past FX carry returns
  - Speculator carry futures positions
  - and decreases with price of insurance (risk reversal)
- The price of FX crash insurance behaves "perversely"
- An increase in VIX (cf. global risk or risk aversion) associated with carry unwind
- Investment currencies move together, funding currencies ditto
- Carry trade exposed to – and may lead to – crash risk
- Speculators trade carry, partly "correcting" UIP, but face crash risk due to their own funding liquidity constraints

Overview of Talk

1. Data, definitions, and summary statistics
2. Does carry predict currency (return and) crash risk?
3. Document the behavior of speculators: do they trade carry?
4. What else predicts currency crashes?
5. Pricing of crash risk
6. Comovement of currencies

Data and Definitions

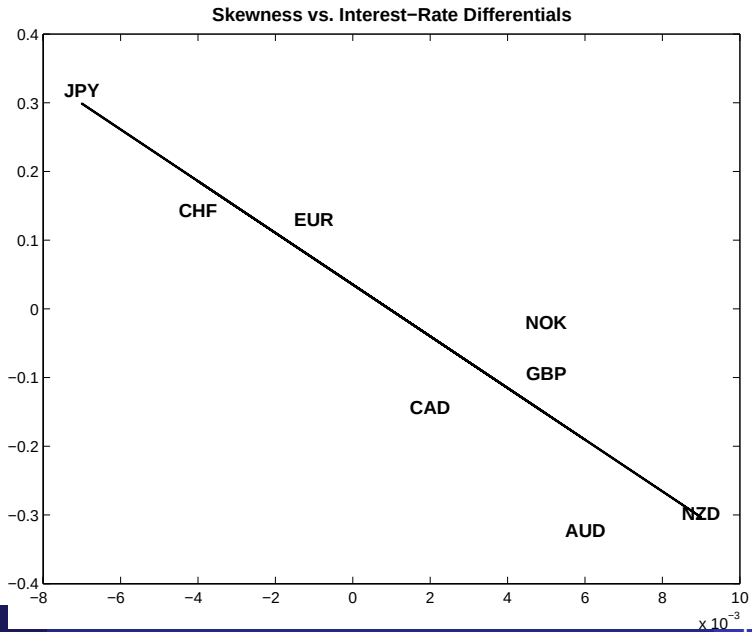
- FX rates (1986-2006): s_t (in logs) [Datastream]
  - AUD, CAD, JPY, NZD, NOK, CHF, GBP, EUR (DEM)
  - Units of foreign currency per USD
- Interest rate differentials (1986-2006): $r_f - r_d$ (in logs) [Datastream]
  - 3m-LIBOR minus USD 3m-LIBOR
- Foreign currency excess return: $x_t \equiv r_{f,t-1} - r_{d,t-1} - \Delta s_t$
  - Return from a carry trade where foreign currency is investment currency
  - Recall UIP: $E_t[x_{t+1}] = 0$

Data and Definitions

- Futures positions of non-commercial traders on the CME (1986-2006): Futures_t [CFTC]
  - Proxy for carry trade activity
  - CAD, JPY, CHF, GBP, EUR (DEM)
    - Example: Taking a long futures position in AUD $\approx$ Buying AUD, investing at AUD LIBOR, financed by borrowing in USD at USD LIBOR
  - Scaled by total open interest
- Risk Reversals (1998-2006): RiskRev_t [JP Morgan]
  - Implied volatility of 1m foreign currency call option minus implied volatility of 1m foreign currency put option (both at 25Δ)
  - Negative value implies negatively skewed risk-neutral distribution of x_t, i.e., risk of foreign currency crash and/or risk premium for foreign currency crash

Summary Statistics

	AUD	CAD	JPY	NZD	NOK	CHF	GBP	EUR
				Panel A: Means				
Δs_t	-0.003	-0.002	-0.003	-0.005	-0.002	-0.004	-0.004	-0.004
x_t	0.009	0.004	-0.004	0.013	0.007	-0.001	0.009	0.003
$r_{f,t-1} - r_{d,t-1}$	0.006	0.002	-0.007	0.009	0.005	-0.004	0.005	-0.001
Futures	-	0.059	-0.097	-	-	-0.067	0.052	0.031
Skewness	-0.322	-0.143	0.318	-0.297	-0.019	0.144	-0.094	0.131
Risk reversals	-0.426	-0.099	1.059	-0.467	0.350	0.409	0.009	0.329



Summary Statistics

Table 1: Summary Statistics (cont.)

	AUD	CAD	JPY	NZD	NOK	CHF	GBP	EUR
				Panel B: Standard deviations				
Δs_t	0.049	0.028	0.062	0.050	0.053	0.063	0.049	0.059
x_t	0.050	0.029	0.064	0.053	0.053	0.064	0.049	0.060
$r_{f,t-1} - r_{d,t-1}$	0.006	0.004	0.005	0.007	0.008	0.006	0.005	0.006
Futures	-	0.248	0.242	-	0.000	0.296	0.272	0.202
Skewness	0.712	0.585	0.627	0.685	0.472	0.438	0.528	0.510
Risk reversals	0.436	0.343	1.204	0.466	0.515	0.550	0.391	0.534

Predicting Crash Risk

Use $r_{f,t} - r_{d,t}$ to predict

- FX excess return x_{t+j} during quarter $t + j$
  - Positive coefficient: carry trade pays off
- Futures positions at end of quarter $t + j$
  - Positive coefficient: consistent with carry trade activity
- Skewness of daily x_t within quarter $t + j$
  - Negative coefficient: Carry trades are exposed to crash risk

Predicting Crash Risk

Table 2: Future FX excess returns, futures positions, and skewness regressed on $r_{f,t} - r_{d,t}$

	FX excess return	Futures	Skewness
$t+1$	2.17	8.30	-23.98
	(0.77)	(5.06)	(3.80)
$t+2$	2.24	8.09	-23.22
	(0.69)	(5.09)	(3.65)
$t+3$	2.24	6.07	-23.59
	(0.69)	(4.69)	(3.82)
$t+4$	1.50	6.47	-23.26
	(0.62)	(4.47)	(4.60)
$t+5$	1.11	5.92	-23.40
	(0.52)	(3.47)	(5.04)

Notes: Panel regressions (1986-2006) with country-fixed effects and quarterly data. Standard errors in parentheses are robust to within-time period correlation of residuals and are adjusted for serial correlation with a Newey-West covariance matrix with 10 lags.

Predicting Crash Risk

Table 2: Future FX excess returns, futures positions, and skewness regressed on $r_{f,t} - r_{d,t}$

	FX excess return	Futures	Skewness
$t+6$	0.76	4.75	-22.10
	(0.48)	(2.50)	(4.97)
$t+7$	0.68	4.15	-21.20
	(0.48)	(1.83)	(4.05)
$t+8$	0.44	2.74	-16.95
	(0.55)	(2.04)	(4.02)
$t+9$	0.27	0.44	-12.88
	(0.63)	(2.35)	(3.44)
$t+10$	-0.04	-0.90	-11.08
	(0.77)	(3.21)	(3.72)

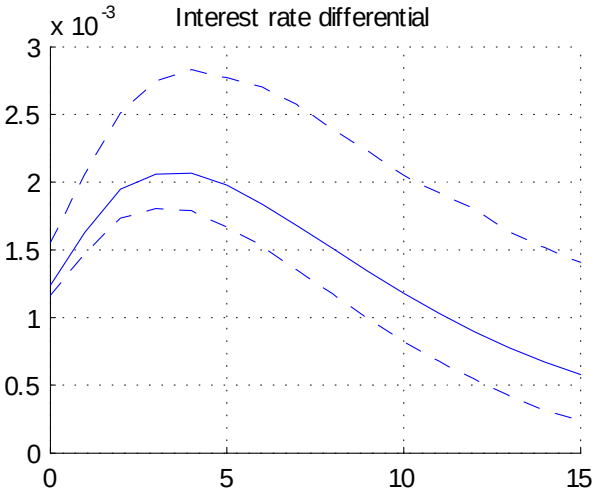
Notes: Panel regressions (1986-2006) with country-fixed effects and quarterly data. Standard errors in parentheses are robust to within-time period correlation of residuals and are adjusted for serial correlation with a Newey-West covariance matrix with 10 lags.

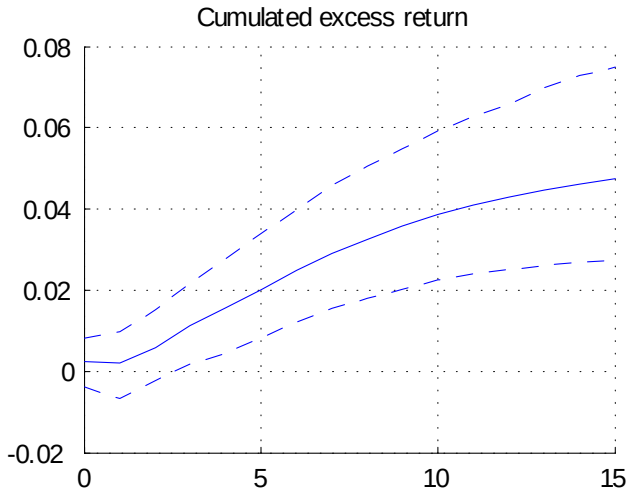
Predicting Crash Risk

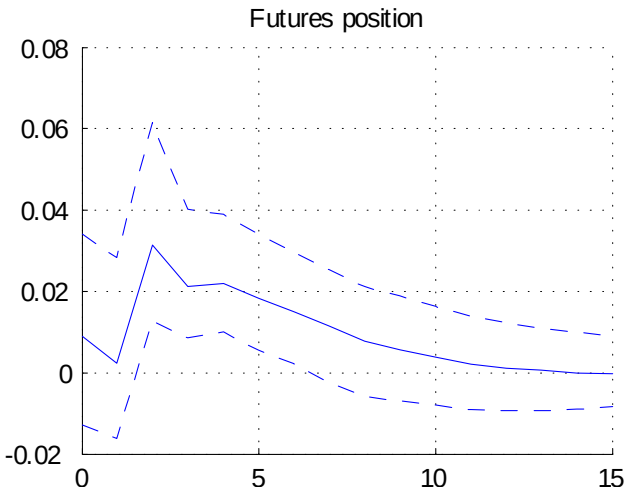
- Consider dynamic relationships between FX excess returns, futures positions, skewness, and interest rate differentials: Vector-Autoregressions
- VAR(3) with $r_{f,t} - r_{d,t}$, x_t, Skew_t, Futures_t
  - 1986-2006, quarterly
  - Impulse responses for shocks to $r_{f,t} - r_{d,t}$ with Choleski decomposition with ordering $r_{f,t} - r_{d,t}$, x_t, Skew_t, Futures_t
  - Bootstrap-after-bootstrap bias-adjusted confidence intervals for impulse response function (Kilian 1998)

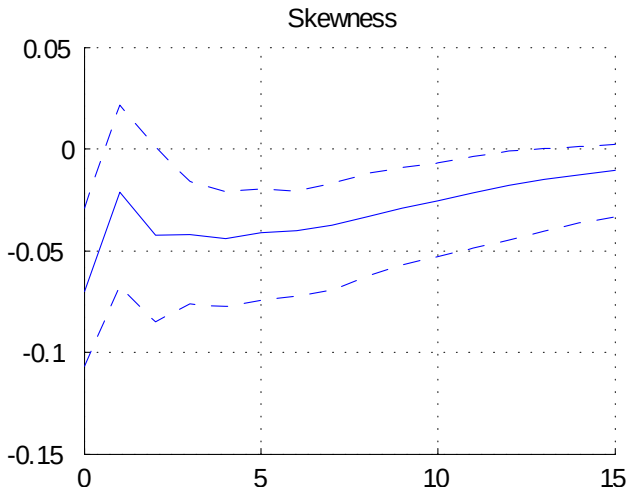
Predicting Crash Risk

Impulse responses for shocks to $r_{f,t} - r_{d,t}$









Crash Risk

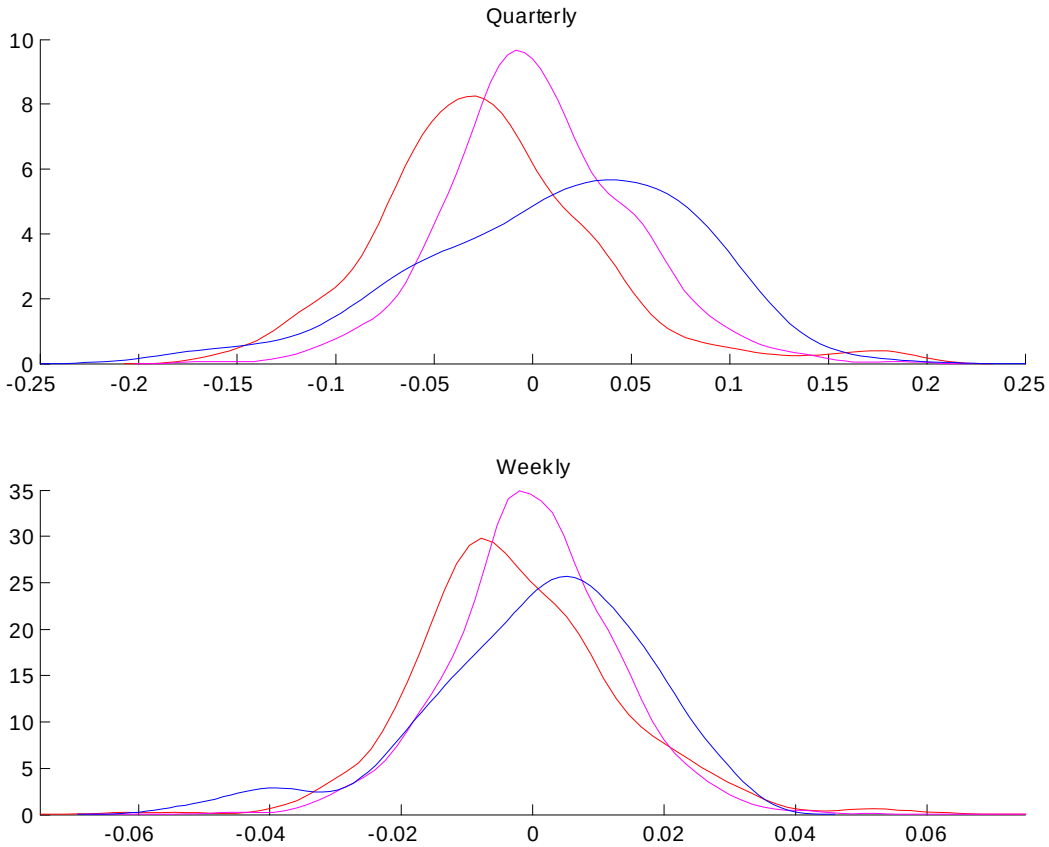


Figure 1: Kernel density estimates of distribution of foreign exchange excess returns conditional on interest rate di erential. Interest rate differential groups quarterly: $<$ -0.005 (red), -0.005 to 0.005 (magenta), $>$ 0.005 (blue); weekly: $<$ -0.01 (red), -0.01 to 0.01 (magenta), $>$ 0.01 (blue).

The Price of Crash Risk

Table 3: Forecasting crashes and the price of crash risk

	Skewness_{t+1}	Skewness_{t+1}	RiskRev_t
$r_{f,t} - r_{d,t}$	-24.74	-29.33	-25.49
	(11.47)	(11.87)	(28.21)
x_t	-2.98	-1.57	8.47
	(0.79)	(0.73)	(1.62)
Futures_t	0.08	0.14	0.32
	(0.11)	(0.11)	(0.16)
Skewness_t	0.20	0.21	0.05
	(0.05)	(0.05)	(0.12)
RiskRev_t		-0.17	
		(0.05)	
R^2	0.21	0.24	0.43

Notes: Panel regressions (1998-2006) with country-fixed effects and quarterly data. Standard errors in parentheses are robust to within-time period correlation of residuals and are adjusted for serial correlation with a Newey-West covariance matrix with 10 lags.

The Price of Crash Risk

- Positive interest rate differential predicts negatively skewed physical and risk-neutral distributions of FX returns
  - Consistent with carry trades being exposed (lead to?) to crash risk
- After FX losses, the crash risk is *lower*, but the price of crash insurance is *higher.*
- Price of crash risk insurance is *high* when future skewness is *low*
- The price of insurance goes up after an "earthquake," although the risk of another "earthquake" is low
- Risk premium may be due to slow moving capital

Unwinding of Carry Trades

- Proxy for global volatility and funding liquidity: CBOE VIX index
  - Prior evidence that funding liquidity "dries up" when VIX spikes
- Carry trade variables
  - CRet_t: $x_t \times \text{sign}(r_{f,t-1} - r_{d,t-1})$
    - Negative = Losses on carry trade
  - ΔCFut_t: $\Delta\text{Futures}_t \times \text{sign}(r_{f,t-1} - r_{d,t-1})$
    - Negative = unwinding of carry trades
  - $\Delta\text{CRiskRev}_t$: $\Delta\text{RiskRev}_t \times \text{sign}(r_{f,t-1} - r_{d,t-1})$,
    - Negative = Insurance against carry trade losses gets more expensive

Unwinding of Carry Trades

Table 4: Sensitivity of weekly carry trade positions, price of skewness insurance, and carry trade returns to changes in VIX

	ΔCFut_t	ΔCFut_{t+1}	$\Delta \text{CRiskRev}_t$	$\Delta \text{CRiskRev}_{t+1}$	CRet_t	CRet_{t+1}
ΔVIX_t	-1.55	-1.29	-4.66	-3.48	-0.40	-0.01
	(0.79)	(0.58)	(2.80)	(3.79)	(0.11)	(0.11)
CFut_{t-1}	-0.09	-0.11				
	(0.01)	(0.01)				
CRiskRev_{t-1}			-0.14	-0.10		
			(0.02)	(0.01)		
R^2	0.05	0.06	0.07	0.03	0.00	0.00

Notes: Panel regressions with country-fixed effects and weekly data (1990. CAD, JPY, CHF, GBP, and EUR only (only currencies for which we have positions data since 1986). Standard errors in parentheses are robust to within-time period correlation of residuals and are adjusted for serial correlation with a Newey-West covariance matrix with 6 lags. The reported R^2 is an adjusted R^2 net of the fixed effects.

Unwinding of Carry Trades

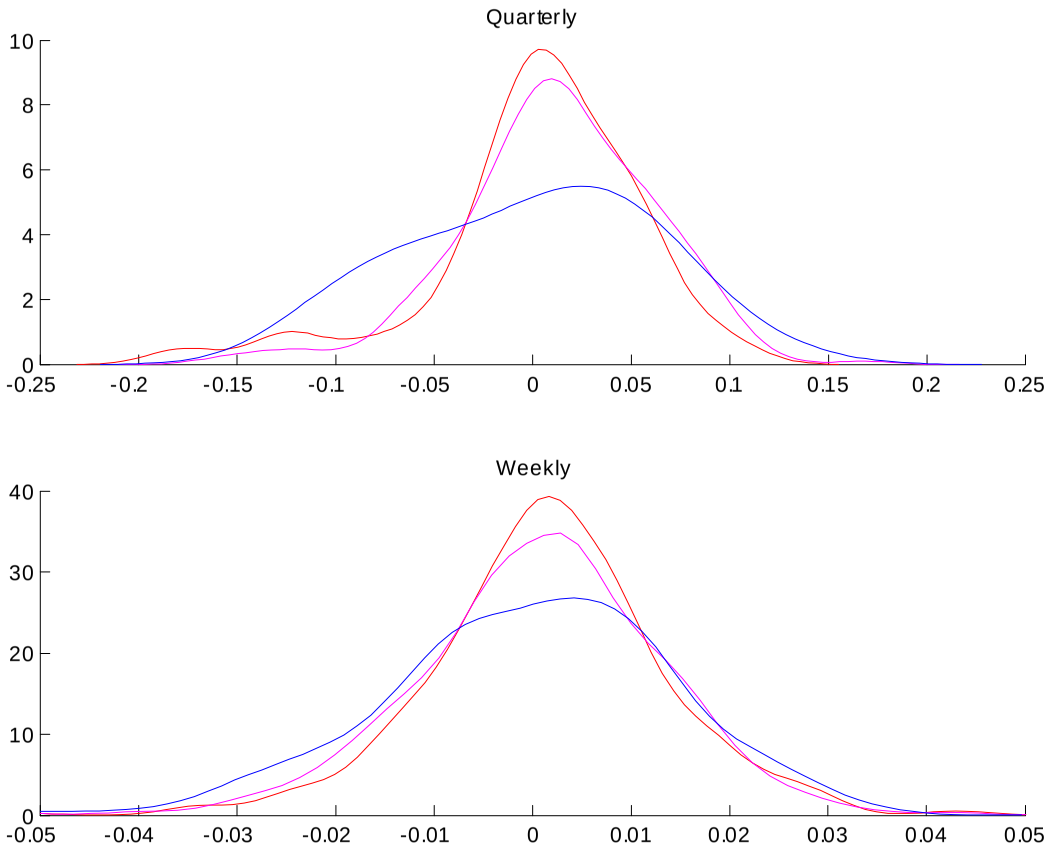


Figure 2: Kernel density estimates of distribution of carry trade returns conditional on contemporaneous change in VIX. Change in VIX groups quarterly: $<$ -0.25 (red), -0.25 to 0.25 (magenta), $>$ 0.25 (blue);weekly: $<$ -0.1 (red), -0.1 to 0.1 (magenta), $>$ 0.1 (blue).

Currency Co-Movement

- If FX rates are driven by carry trades, investment currencies should move with investment currencies and funding currencies with funding currencies
  - i.e., the lower the interest rate differential between a pair of currencies, the more their FX rates (relative to USD) should co-move
- Variables
  - Dependent variable is the pairwise correlation of daily log FX rate changes within 13-week (non-overlapping) windows mapped to real line by re-scaling and logistic transformation
  - $|r_1 - r_2|$ = absolute pairwise interest rate differential at the start of the 13-week period.
  - $\rho(r_1, r_2)$ = correlation of 5-day interest rate changes, estimated with overlapping windows, within each 13-week period.
  - Average $\rho(\Delta s_1, \Delta s_2)$ is the cross-sectional average of all pairwise correlations of daily FX rate changes within each non-overlapping 13-week periods.

Currency Co-Movement

Table 5: Correlation of FX rate changes and magnitude of interest rate differentials

	(1)	(2)	(3)	(4)
$\lvert r_1 - r_2 \rvert$	-10.49	-6.70	-15.73	-13.22
	(3.69)	(3.54)	(3.90)	(6.34)
$\rho(r_1, r_2)$	0.80	0.28	0.87	0.31
	(0.15)	(0.07)	(0.16)	(0.07)
$\overline{\rho(\Delta s_1, \Delta s_2)}$	2.53	2.55		
	(0.08)	(0.07)		
Time Fixed Effects			Yes	Yes
Country-Pair Fixed Effects				Yes
R^2	0.19	0.36	0.06	0.03

Note: The dependent variable is the pairwise correlation of daily FX rate changes, estimated within non-overlapping 13-week periods. The reported R^2 is an adjusted R^2 net of the fixed effects.

Conclusion

- FX crash risk increases with
  - Interest rate differential (i.e. carry)
  - Past FX carry gains
  - Speculator carry futures positions
  - and decreases with price of insurance, risk reversal
- The price of FX crash insurance increases with
  - Interest rate differential (i.e. carry)
  - Past FX carry losses
  - Speculator carry futures positions
- An increase in VIX (cf. global risk or risk aversion) contemporaneous with
  - carry unwind, i.e. reduced speculator futures positions
  - carry losses
  - price of insurance increases
- Investment currencies move together, funding currencies ditto

Conclusion, continued

- Carry trade
  - exposed to crash risk
  - payoff resembles that of selling put options
  - bad payoffs in low liquidity, high volatility states of the world
  - Unwinding of carry trades after losses and in these "bad" states
- Results consistent with idea that speculators
  - trade carry, partly "correcting" UIP, but only partly because they
  - face crash risk due to their own funding liquidity constraints and other "limits to arbitrage"