Carry Trades and Currency Crashes

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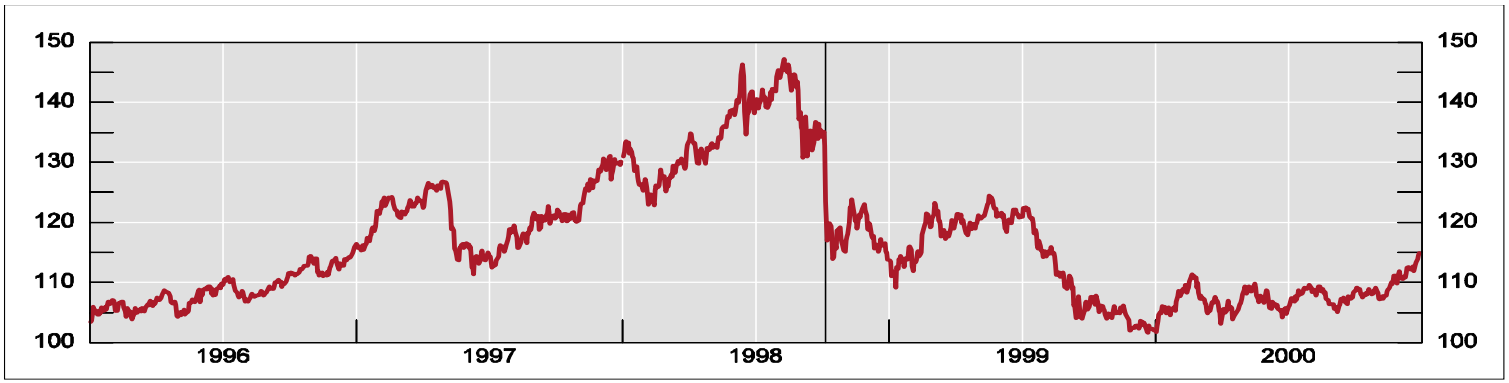
Motivation

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

- "Up by the stairs and down by the elevator"
- Forecasting currency crashes: drivers of conditional FX skewness
- Pricing of currency crashes: option prices
- Co-movements of currencies
- Key drivers:
  - Carry trades
  - Global volatility and/or risk aversion
  - Funding liquidity and unwinding of carry trades

Carry Trade

1. Violation of UIP - "Forward Premium Puzzle"
   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 JPY doesn't appreciate much **(UIP violation)**
2. Large exchange rate movements without news
   Example: October 7th/8th, 1998



Background: Literature

- Macro: near-random walk of FX
  (Messe & Rogoff 1983, Engel & West)
- 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
  - 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 decrease with price of insurance (risk reversals)
- The price of FX crash insurance increases after crash
- An increase in VIX (cf. global risk and risk aversion) leads to unwinding of carry trades
- Investment currencies move together, funding currencies ditto
- Carry trade exposed to – and may lead to – crash risk
  limits correcting arbitrage $\Rightarrow$ "Forward premium puzzle"

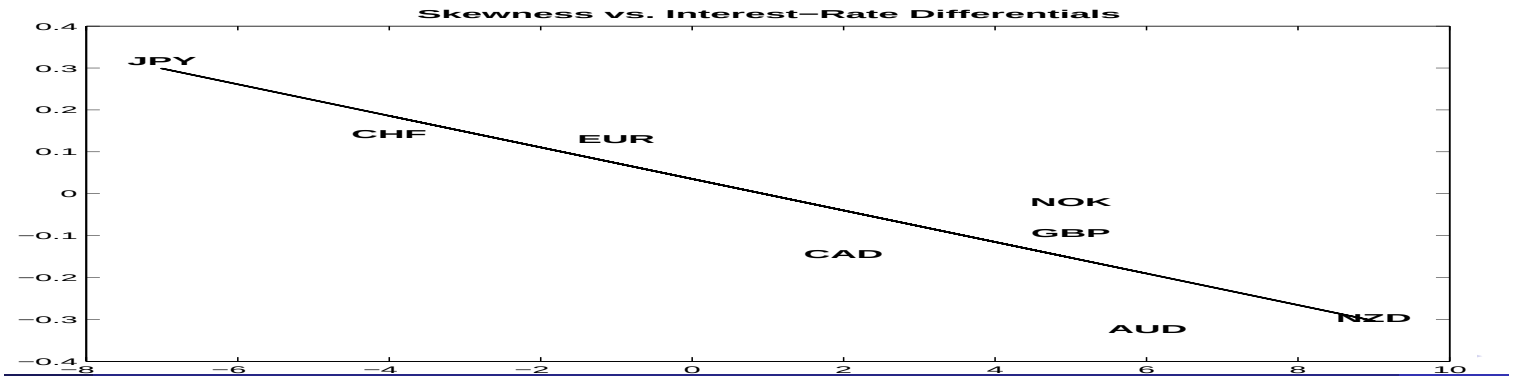
Data and Definitions

- FX rates (1986-2006): s_t (in logs) [Datastream]
  - AUD, CAD, JPY, NZD, NOK, CHF, GBP, EUR per USD
- Interest rate differentials (1986-2006): $i^* - i$ (in logs) [Datastream] 3m-LIBOR
- Foreign currency excess return: $z_t \equiv \left(i^*_{t-1} - i_{t-1}\right) - \Delta s_t$
  - Return from a carry trade where foreign currency is investment currency
  - UIP: $E_t\left[z_{t+1}\right] = 0$
- Futures positions of non-commercial traders on the CME (1986-2006): Futures_t [CFTC]
- Risk Reversals (1998-2006): RiskRev_t [JP Morgan]

Summary Statistics

Table 1: 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
z_t	0.009	0.004	-0.004	0.013	0.007	-0.001	0.009	0.003
$i^*_{t-1} - i_{t-1}$	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
z_t	0.050	0.029	0.064	0.053	0.053	0.064	0.049	0.060
$i^*_{t-1} - i_{t-1}$	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 $i_t^* - i_t$ to predict

- FX excess return $z_{t+\tau}$ during quarter $t + \tau$
  - Positive coefficient: carry trade pays off (UIP violation)
- Futures positions at end of quarter $t + \tau$
  - Positive coefficient: consistent with carry trade activity
- Skewness of daily z_t within quarter $t + \tau$
  - Negative coefficient: Carry trades are exposed to crash risk

Predicting Crash Risk

Table 2: z, futures positions, and skewness regressed on $i_t^* - i_t$

	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: z, futures positions, and skewness regressed on $i_t^* - i_t$

	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)

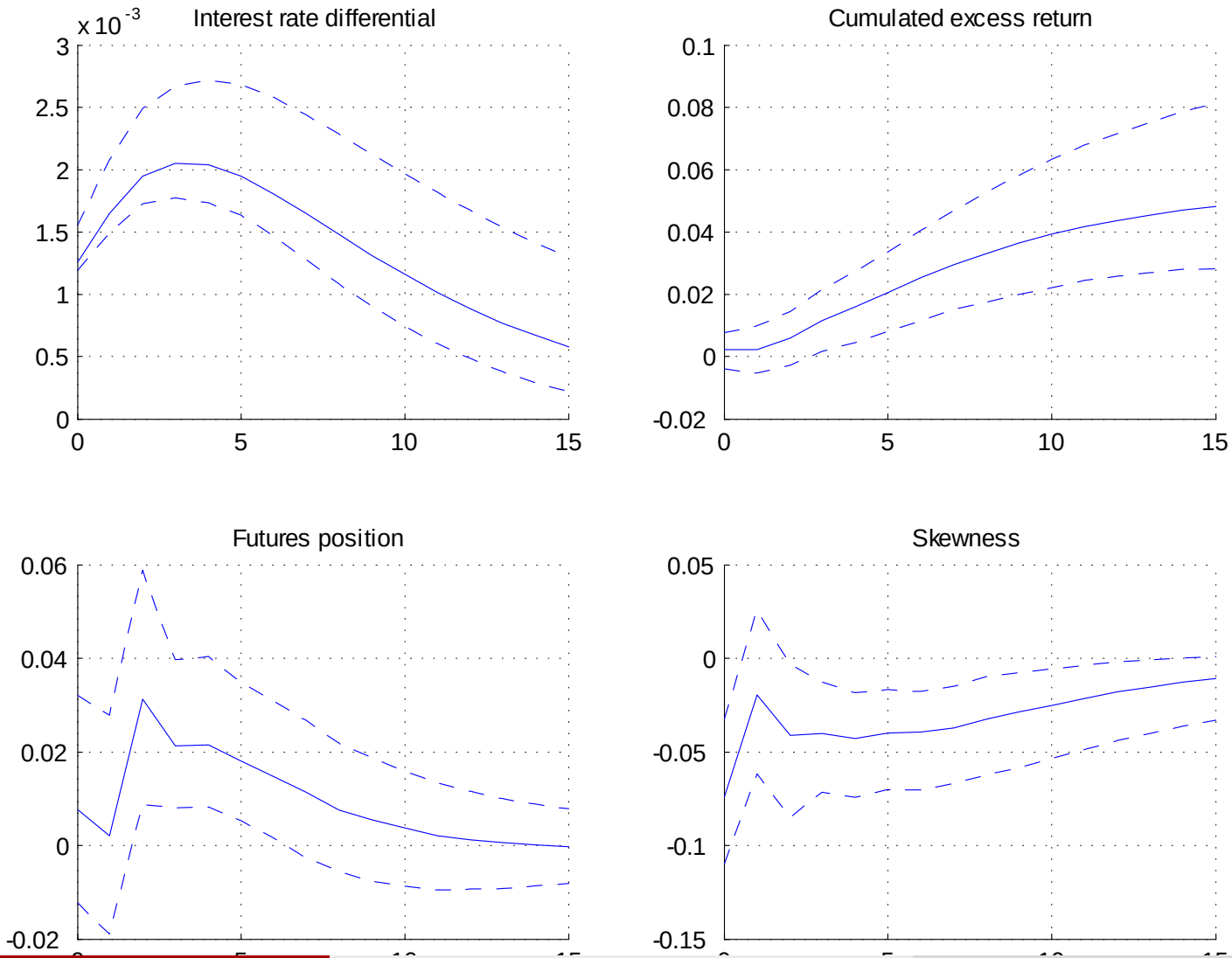
Notes: Panel regressions (1986-2006) with country-fixed effects and quarterly data. Standard errors in parentheses are robust to within-time period correlation of residuals and are adjusted for serial correlation with a Newey-West covariance matrix with 10 lags.

Predicting Crash Risk

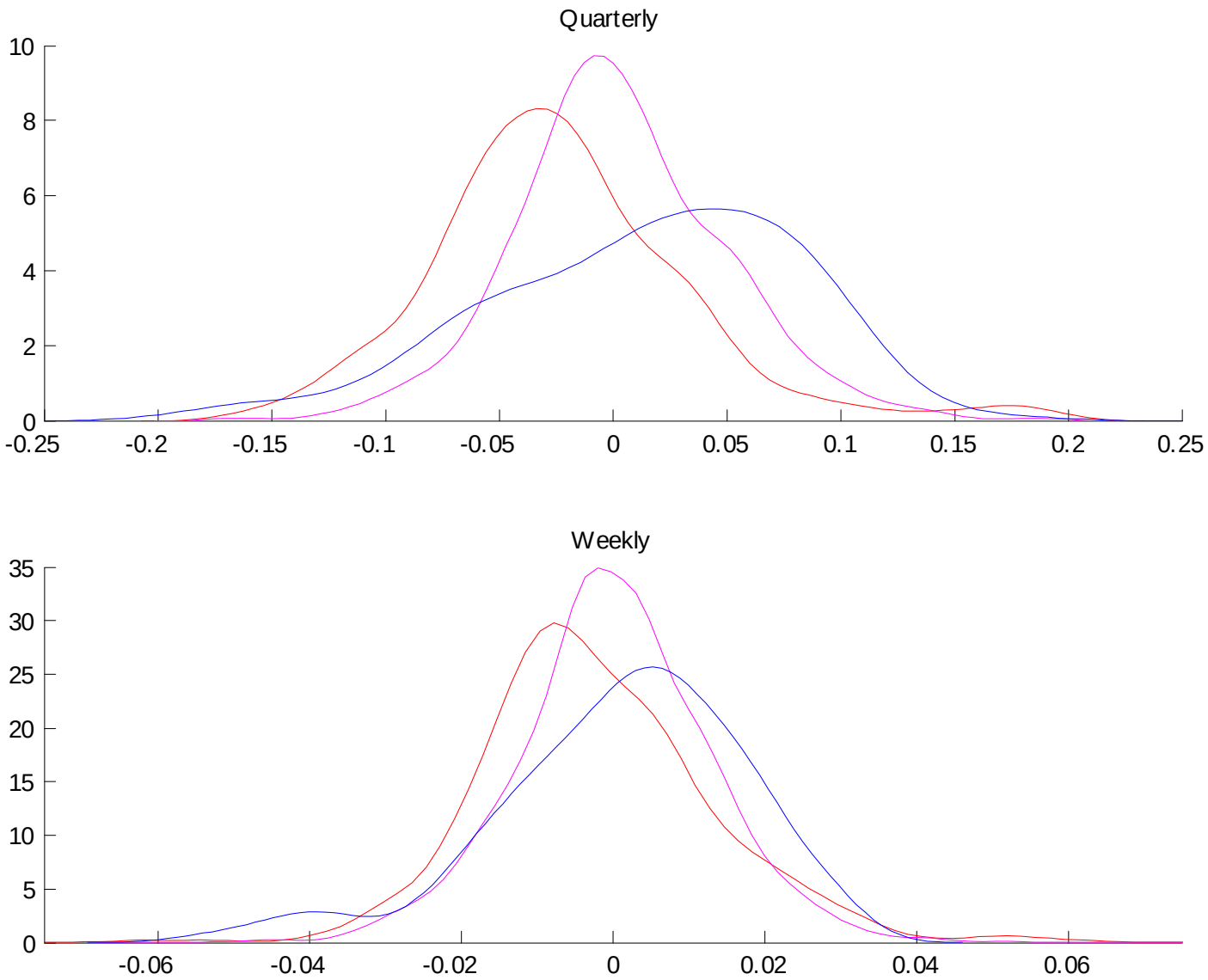
- Consider dynamic relationships between FX excess returns, futures positions, skewness, and interest rate differentials: Vector-Autoregressions
- VAR(3) with $i_t^* - i_t$, z_t, Skew_t, Futures_t
  - 1986-2006, quarterly
  - Impulse responses for shocks to $i_t^* - i_t$ with Choleski decomposition with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

Predictable Return and Crash Risk of Carry Trades

Impulse responses for shocks to $i_t^* - i_t$



Predicting Crash Risk



Price of Crash Risk

Table 3: Forecasting crashes and the price of crash risk

	Skewness_{t+1}	Skewness_{t+1}	RiskRev_t
$i_t^* - i_t$	-24.74	-29.33	-25.49
	(11.47)	(11.87)	(28.21)
z_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

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 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: $z_t \times \text{sign}(i^*_{t-1} - i_{t-1})$
    - Negative = Losses on carry trade
  - ΔCFut_t: $\Delta\text{Futures}_t \times \text{sign}(i^*_{t-1} - i_{t-1})$
    - Negative = unwinding of carry trades
  - $\Delta\text{CRiskRev}_t$: $\Delta\text{RiskRev}_t \times \text{sign}(i^*_{t-1} - i_{t-1})$,
    - Negative = Insurance against carry trade losses gets more expensive

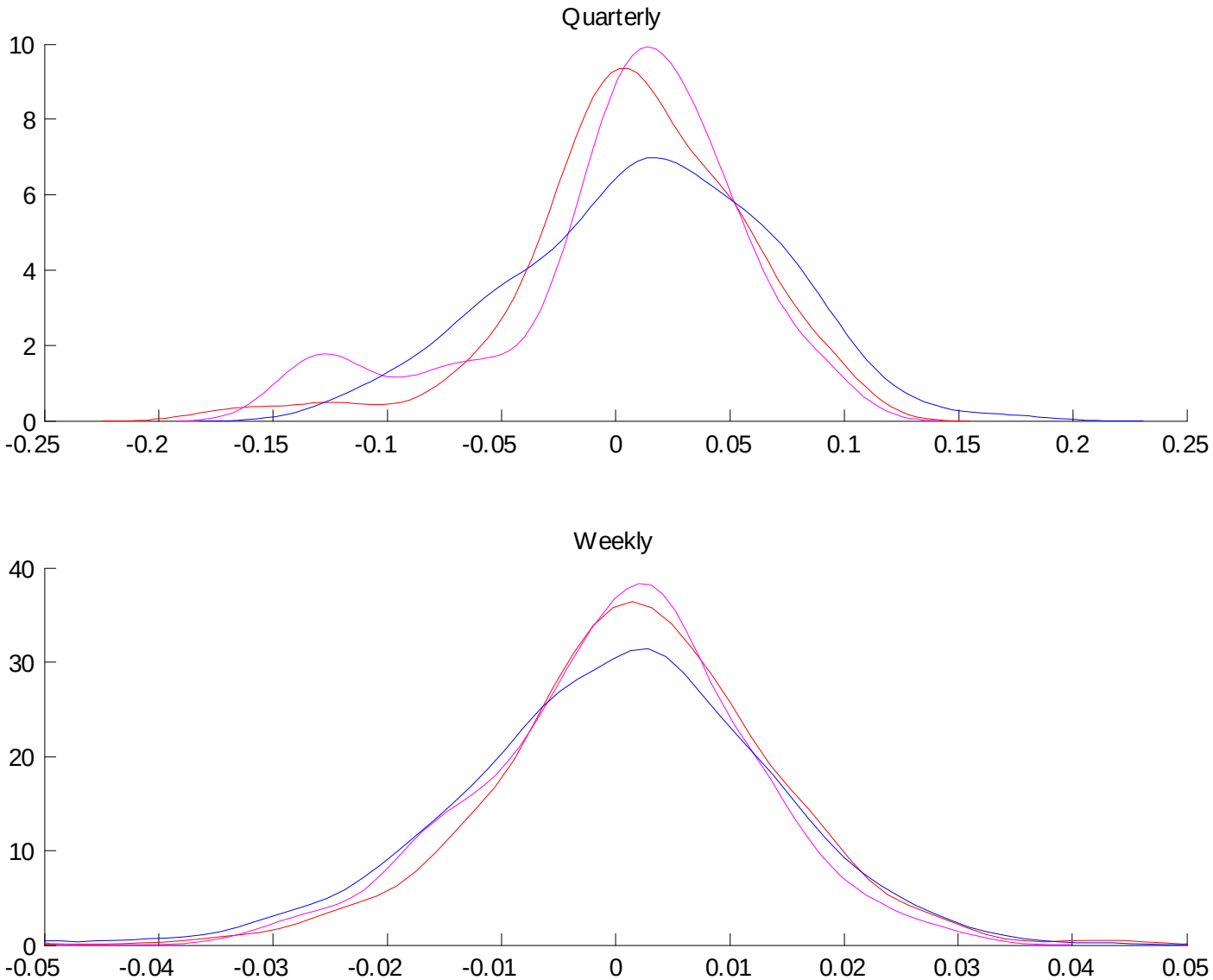
Unwinding of Carry Trades

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

	ΔCFut$_t$	ΔCFut$_{t+1}$	ΔCRiskRev$_t$	ΔCRiskRev$_{t+1}$	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. 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 - VIX



Currency Co-movement

- If FX rates are driven by carry trades, funding currencies move together, and so do investment 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
  - $|i_1 - i_2|$ = absolute pairwise interest rate differential at the start of the 13-week period.
  - $\rho(i_1, i_2)$ = 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)
$\lvert i_1 - i_2 \rvert$	-10.49	-6.70	-15.73	-13.22
	(3.69)	(3.54)	(3.90)	(6.34)
$\rho(i_1, i_2)$	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 decrease with price of insurance, risk reversal
- The price of FX crash insurance increases with
  - interest rate differential (i.e. carry)
  - past FX carry losses
  - speculators carry futures positions
- An increase in VIX (cf. global risk or risk aversion) contemporaneously leads to
  - carry unwind
  - carry losses
  - price of insurance increases
- Funding currencies move together, funding currencies ditto

Conclusion, ctd.

- 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"