Carry Trades and Currency Crashes

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Motivation

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

- Interest-rate differential an important driver of currency crash risk, i.e. conditional FX skewness
- "Up by the stairs and down by the elevator"
- Pricing of currency crashes: option prices
- Co-movements of currencies
- Examine the importance of
  - Carry trades
  - Global volatility and/or risk aversion
  - Funding liquidity and unwinding of carry trades

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, 2007)
- Rare disasters (Farhi and Gabaix (2008))
- Consumption growth risk (Lustig and Verdelhan (2007))

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 or TED (cf. global risk and risk aversion) associated with unwinding of carry trades
- Investment currencies move together, funding currencies ditto
- Carry trade exposed to – and may lead to – crash risk, this limits arbitrage, contributing to the "forward premium puzzle"

Data and Definitions

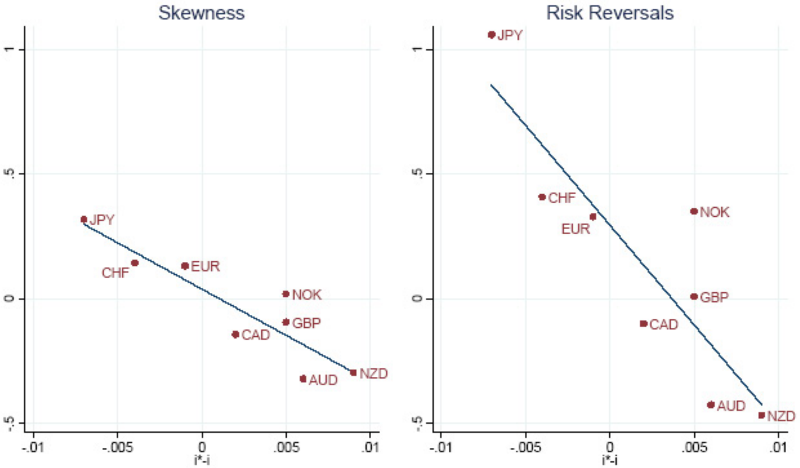
- FX rates (1986-2006): s_t (in logs) [Datastream]
  - AUD, CAD, JPY, NZD, NOK, CHF, GBP, EUR per USD
- Interest rate differentials (1986-2006): $i^* - i$ (in logs) [Datastream] 3m-LIBOR
- Foreign currency excess return: $z_t \equiv \left(i^*_{t-1} - i_{t-1}\right) - \Delta s_t$
  - Return from a carry 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

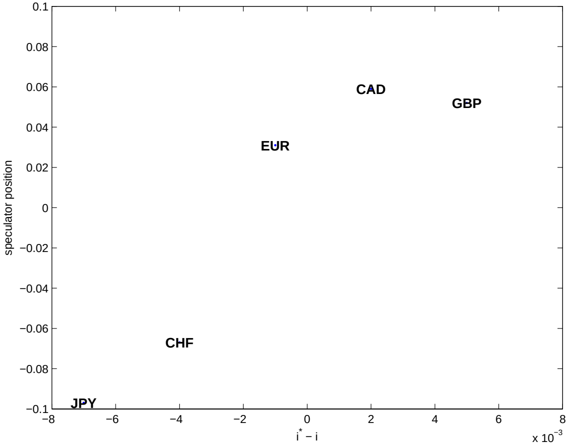
	AUD	CAD	JPY	NZD	NOK	CHF	GBP	EUR
				Panel A: Means				
Δs_t	-0.003	-0.002	-0.003	-0.005	-0.002	-0.004	-0.004	-0.004
z_t	0.009	0.004	-0.004	0.013	0.007	-0.001	0.009	0.003
$i^*_{t-1} - i_{t-1}$	0.006	0.002	-0.007	0.009	0.005	-0.004	0.005	-0.001
Futures pos	-	0.059	-0.097	-	-	-0.067	0.052	0.031
Skewness	-0.322	-0.143	0.318	-0.297	-0.019	0.144	-0.094	0.131
Risk rev	-0.426	-0.099	1.059	-0.467	0.350	0.409	0.009	0.329

Summary Statistics, Graphically



Summary Statistics, Graphically

Speculator positions and interest-rate differentials



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

Qtr	z	Futures	Skewness
$t+1$	2.17	8.26	-23.92
	(0.78)	(5.06)	(3.87)
$t+2$	2.24	8.06	-23.20
	(0.70)	(5.08)	(3.71)
$t+3$	1.87	5.96	-23.65
	(0.66)	(4.68)	(3.87)
$t+4$	1.50	6.41	-23.28
	(0.63)	(4.44)	(4.65)
$t+5$	1.11	5.87	-23.49
	(0.52)	(3.47)	(5.05)
$t+6$	0.76	4.72	-22.24
	(0.48)	(2.52)	(5.00)
$t+7$	0.68	4.27	-21.23
	(0.49)	(1.91)	(4.09)
$t+8$	0.44	2.81	-16.96
	(0.55)	(2.12)	(4.03)
$t+9$	0.27	0.46	-12.90
	(0.63)	(2.41)	(3.45)
$t+10$	-0.04	-0.96	-11.14
	(0.78)	(3.26)	(3.74)

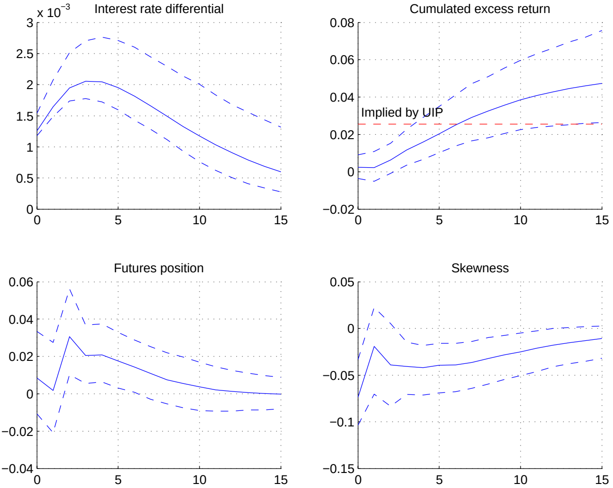
Notes: Panel regressions (1986-2006) with country-fixed effects and quarterly data. Standard errors in parentheses are robust to within-time period correlation and are NW adjusted.

Predicting Crash Risk

- We confirm these findings in a VAR
- 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)
  - The usual caveats apply (sensitivity to specification etc.)

Predictable Return and Crash Risk of Carry Trades

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



Predicting Crash Risk

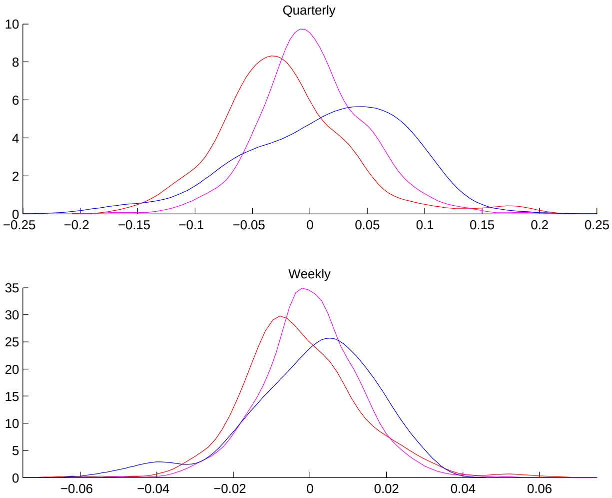


Figure 1: Kernel density estimates of distribution of foreign exchange excess returns conditional on interest rate differential. Interest rate differential groups quarterly: < -0.005 (red), -0.005 to 0.005 (magenta), > 0.005 (blue);

Price of Crash Risk

Table 3: Forecasting crashes and the price of crash risk

	Skewness_{t+1}	Skewness_{t+1}	Skewness_{t+1}	RiskRev_t	RiskRev_t
$i_t^* - i_t$	-28.51	-22.18	-27.34	-15.51	-30.70
	(11.59)	(12.59)	(11.52)	(29.20)	(25.91)
z_t		-3.34	-2.11		7.87
		(0.60)	(0.69)		(1.39)
Futures_t	-0.26	0.13	0.18	1.16	0.27
	(0.12)	(0.15)	(0.14)	(0.19)	(0.12)
Skewness_t	0.12	0.18	0.17	0.10	-0.02
	(0.05)	(0.05)	(0.05)	(0.09)	(0.10)
RiskRev_t			-0.16		
			(0.04)		
R^2	0.12	0.18	0.21	0.20	0.41

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.

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

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

	ΔFut_t	ΔFut_{t+1}	ΔRiskR_t	ΔRiskR_{t+1}	z_t	z_{t+1}
$\Delta VIX_t \times sign(i^*_{t-1} - i_{t-1})$	-1.47	-1.29	-5.33	-2.74	-0.43	-0.03
	(0.77)	(0.57)	(2.64)	(3.39)	(0.11)	(0.11)
Futures_{t-1}	-0.09	-0.10				
	(0.01)	(0.01)				
RiskRev_{t-1}			-0.16	-0.11		
			(0.02)	(0.02)		
R^2	0.04	0.06	0.08	0.04	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.

- CBOE VIX index and TED spread:
  Proxies for global volatility and funding liquidity:
  Prior evidence that funding liquidity "dries up" when VIX / TED spikes

Unwinding of Carry Trades

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

	ΔFut$_t$	ΔFut$_{t+1}$	ΔRiskR$_t$	ΔRiskR$_{t+1}$	z_t	z_{t+1}
$\Delta TED_t \times sign(i^*_{t-1} - i_{t-1})$	-0.48	-1.92	-0.71	-25.05	-0.27	-0.57
	(2.27)	(1.85)	(10.02)	(13.89)	(0.35)	(0.31)
Futures$_{t-1}$	-0.09	-0.10				
	(0.01)	(0.01)				
RiskRev$_{t-1}$			-0.16	-0.11		
			(0.02)	(0.02)		
R^2	0.04	0.06	0.08	0.04	0.00	0.00

Funding Liquidity and Violations of UIP

Table 6: Future excess FX return regressed on $i_t^* - i_t$ and its interaction

	Forecast with VIX		Forecast with TED	
Qtr	$i_t^* - i_t$	$\text{VIX}_t \times \text{sign}(i_{t-1}^* - i_{t-1})$	$i_t^* - i_t$	$\text{TED}_t \times \text{sign}(i_{t-1}^* - i_{t-1})$
$t+1$	1.35	0.29	2.58	-0.62
	(1.36)	(0.26)	(1.01)	(0.45)
$t+2$	1.37	0.35	2.27	-0.04
	(1.17)	(0.18)	(0.91)	(0.50)
$t+3$	0.75	0.53	1.40	0.72
	(1.20)	(0.23)	(0.90)	(0.58)
$t+4$	0.63	0.53	0.96	0.84
	(1.22)	(0.23)	(0.90)	(0.59)
$t+5$	0.93	0.31	1.04	0.11
	(0.82)	(0.16)	(0.58)	(0.29)
$t+6$	0.63	0.29	0.18	0.88
	(0.65)	(0.11)	(0.48)	(0.30)
$t+7$	0.23	0.34	0.23	0.70
	(0.90)	(0.16)	(0.57)	(0.28)
$t+8$	0.05	0.31	0.46	-0.03
	(0.83)	(0.17)	(0.64)	(0.40)
$t+9$	0.28	0.09	0.41	-0.21
	(0.79)	(0.18)	(0.68)	(0.34)
$t+10$	0.30	0.02	-0.25	0.33
	(0.87)	(0.17)	(0.77)	(0.40)

Currency Co-movement

- If carry trades affect FX, it should also affect covariance matrix:
  - funding currencies move together, and so do investment currencies
  - i.e., the lower the interest rate differential, the more their FX rates co-move
- Variables
  - Dependent variable: pairwise correlation of daily log FX changes within 13-week (non-overlapping) windows, mapped to real line by 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 $\rho(\Delta s_1, \Delta s_2)$ = 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

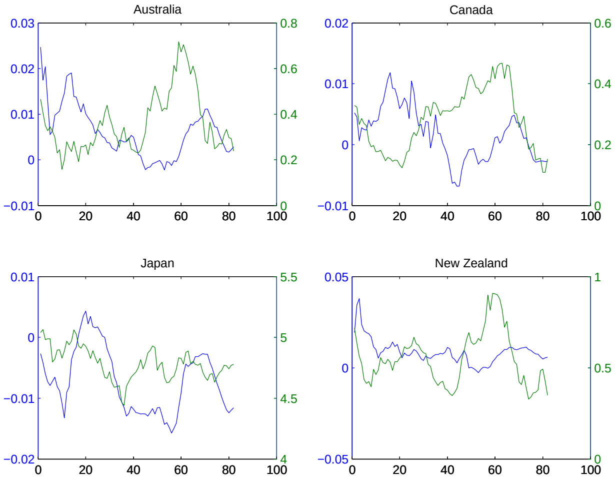
	(1)	(2)	(3)	(4)
$\lvert i_1^* - i_2^* \rvert$	-10.89	-6.62	-16.39	-13.41
	(3.81)	(3.62)	(4.05)	(6.41)
$\rho(i_1^*, i_2^*)$	0.63	0.28	0.70	0.32
	(0.16)	(0.08)	(0.17)	(0.08)
Average $\rho(\Delta s_1, \Delta s_2)$	2.54	2.56		
	(0.08)	(0.08)		
Time Fixed Effects			Yes	Yes
Country-Pair Fixed Effects				Yes
	0.18	0.36	0.05	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.

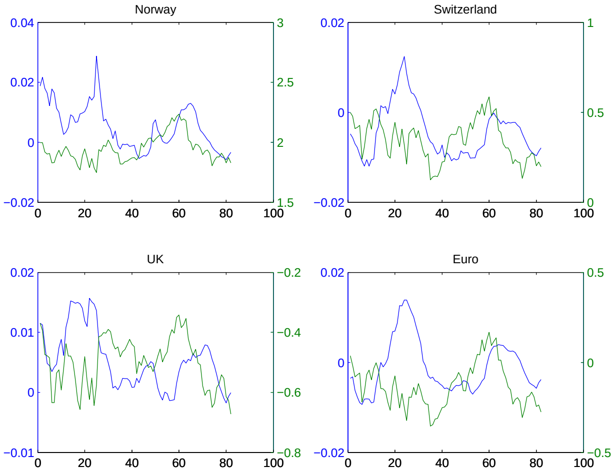
Conclusion

- 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"
- 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
- An increase in VIX associated with
  - carry losses, carry unwind (lower speculator positions)
  - price of insurance increases
- Funding currencies move together, funding currencies ditto

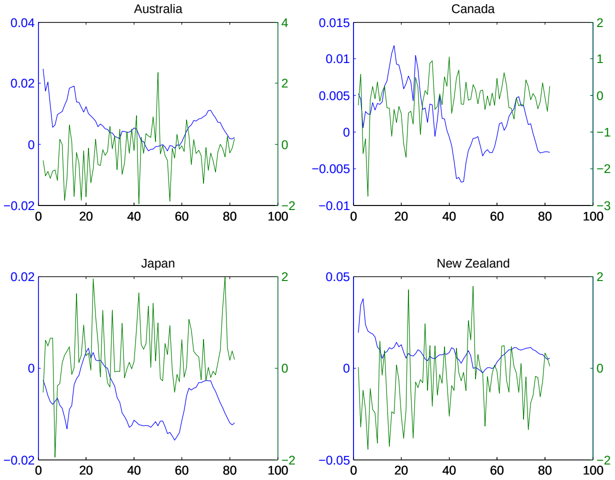
Log interest rate differentials (blue, left axis) and log FX rate (green, right axis)



Log interest rate differentials (blue, left axis) and log FX rate (green, right axis)



Lagged log interest rate differentials (blue, left axis) and quarterly skewness of daily log FX rate changes (green, right axis)



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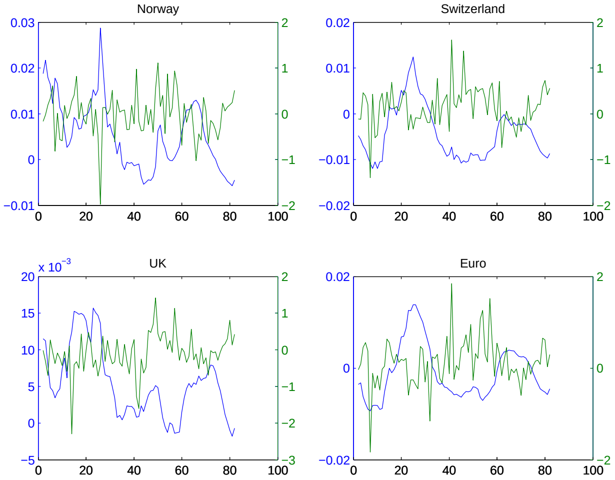

Log interest rate differentials (blue, left axis) and futures positions of non-commerical traders (green, right axis)