Realized Semibetas in Currency Markets and Other Asset Classes

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Background

- The forward premium puzzle, i.e., the failure of the uncovered interest rate parity (UIP) condition, has been one of the most profound puzzles in the foreign exchange market. (Fama,1984)
- Currency carry trades, which exploit the failure of UIP, have earned a higher return and Sharpe ratio relative to the U.S. equity market index for the past several decades (Lustig et al., 2011; Burnside et al., 2011b).
- The risk-based explanation argues that excess returns from the currency carry trade is a compensation for bearing systematic risk.
- Carry trade return contains little risk premium for classical asset pricing factors, including Fama–French equity factors (Burnside et al., 2011) and bond market factors (Daniel et al.,2014).
- Successful factors known to provide some explanatory power for carry trade returns include dollar and HML factors (Lustig et al.,2011), the global FX volatility factor (Menkhoff et al., 2012), foreign exchange market liquidity risk (Mancini et al., 2013), and the equity downside risk (Ang et al.,2012) (Lettau et al., 2014).

Background

- Downside risk refers to the risk of an asset or portfolio in case of an adverse economic scenario, which can be measured by negative market returns or higher market volatility. Upside uncertainty is the analogue if the scenario is favorable.
- The asymmetric treatment of downside risk versus upside uncertainty by investors has long been accepted among practitioners and academic researchers (see, e.g., Roy, 1952; Markowitz, 1959)
- Rational investors place greater weights on adverse market conditions in their utility functions. These include the loss aversion of Kahneman and Tversky (1979) in their prospect theory, and the disappointment aversion of Gul (1991) , which has been generalized by Routledge and Zin (2010) .
- Ang et al. (2006) find that the downside beta version of the CAPM does a better job than the traditional CAPM in terms of explaining the cross-sectional variation in U.S. equity returns.
- Lettau et al. (2014) confirm the better performance of the downside beta version of the CAPM in the currency market and across other asset classes.

Motivation

- Realized semi beta
  - Bollerslev et al. (2020) propose a new decomposition of the traditional market beta into four semibetas that depend on the signed covariation between the market and individual asset returns.
  - They show that semibetas stemming from negative market and negative asset return covariation predict significantly higher future returns, while semibetas attributable to negative market and positive asset return covariation predict significantly lower future returns. The two semibetas associated with positive market return variation do not appear to be priced.
- The role of volatility in pricing currency returns
  - Fargo and T´edongap (2018) emphasized the role of volatility risk in a downside risk version ICAPM model and find volatility risk is time varying.
  - Lu et al (2023) find volatility risk is only compensated during “volatile” period- in “non-volatile” period it is not compensated using both a conditional ICAPM setting and a Markov regime-switching model.

Research Design

- Decompose market beta into four components based on the signed corelation between market return and currency portfolio return.
- Test the pricing power of the semibetas under CAPM framework.
- Decompose volatility beta into four components based on the signed corelation between market return and currency portfolio return.
- Test the pricing power of the semibetas under ICAPM framework.

Structure of the presentation

- Data
- Methodology on realized semibetas
- Results and Findings
- Limitation and further direction

Data

High Frequency (daily)

- Daily spot and forward rate for 48 currencies from 1st October 1983 to 31st May 2022.
    - Daily currency/portfolio returns are calculated
    - Daily FX market volatility across 48 currencies is calculated
- We use daily US stock market index (all stocks with CRSP from Kenneth French's Library) as a proxy of FX market risk. (Lettau et al., 2014)

Low Frequency (monthly)

- End of month spot and forward exchange rate per unit of US dollar for 48 currencies. (Menkhoff et al., 2012)
- We sort the currencies to 10 portfolios following the interest rate differentials.
- We increased the number of portfolios from 5 as in Menkhoff et al. (2012) to 10 to ensure a decent degree of freedom in the cross-sectional regression.
- Portfolios are adjusted monthly

Table 1 – Annualized excess Returns from Currency portfolios

	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	DOL	HML
Mean	-20.10	-1.95	-2.27	0.16	2.38	1.81	1.86	2.81	1.93	12.82	-0.06	32.91
Std	14.08	8.32	8.61	8.64	7.70	7.75	8.24	9.02	10.38	12.40	7.37	17.59
skew	-0.85	-0.07	-0.19	-0.09	0.12	0.00	-0.39	-1.03	-1.54	-0.90	-0.25	0.40
SR	-1.43	-0.23	-0.26	0.02	0.31	0.23	0.23	0.31	0.19	1.03	-0.01	1.87

This table reports the descriptive statistics of the annualized excess returns from currency portfolios from October 1983 to May 2022. DOL is “the dollar risk factor” and is the mean across all 10 portfolios. HML is “the carry trade portfolio” constructed by borrowing P1 and investing P10.

Realized Semi-betas: a four-way decomposition

- Bollerslev et al. (2022) decompose the traditional beta into four semibetas that depend on the signed covariation between the market and individual asset returns.

$$\widehat{\beta}_{t,i} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i} f_{t,k}}{\sum_{k=1}^{m} f_{t,k}^2} = \widehat{\beta}_{t,i}^{N} + \widehat{\beta}_{t,i}^{p} + \widehat{\beta}_{t,i}^{M^+} + \widehat{\beta}_{t,i}^{M^-}$$

- Let $r_{t,k,i}$ denote the "high-frequency" return on asset *i* over the k^{th} time interval within some fixed time period *t*, with the concurrent "high-frequency" return for the aggregate market factors denoted by $f_{t,\mathrm{k}}$.
- In accordance with the discussed below, think about *k* as a day and *t* as a month.

$$\widehat{\beta}_{t,i}^{\mathcal{N}} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i}^{-} f_{t,k}^{-}}{\sum_{k=1}^{m} f_{t,k}^2}, \quad \widehat{\beta}_{t,i}^{\mathcal{P}} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i}^{+} f_{t,k}^{+}}{\sum_{k=1}^{m} f_{t,k}^2}$$

$$\widehat{\beta}_{t,i}^{\mathcal{M}^-} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i}^{+} f_{t,k}^{-}}{\sum_{k=1}^{m} f_{t,k}^2}, \quad \widehat{\beta}_{t,i}^{\mathcal{M}} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i}^{-} f_{t,k}^{+}}{\sum_{k=1}^{m} f_{t,k}^2}$$

Realized Semi-betas: a two-way decomposition

- The downside betas proposed in the widely-cited study by Ang et al. (2006) and Farago and T´edongap (2018) have also been found to improve upon the traditional CAPM. Realized versions of the betas are naturally defined as:

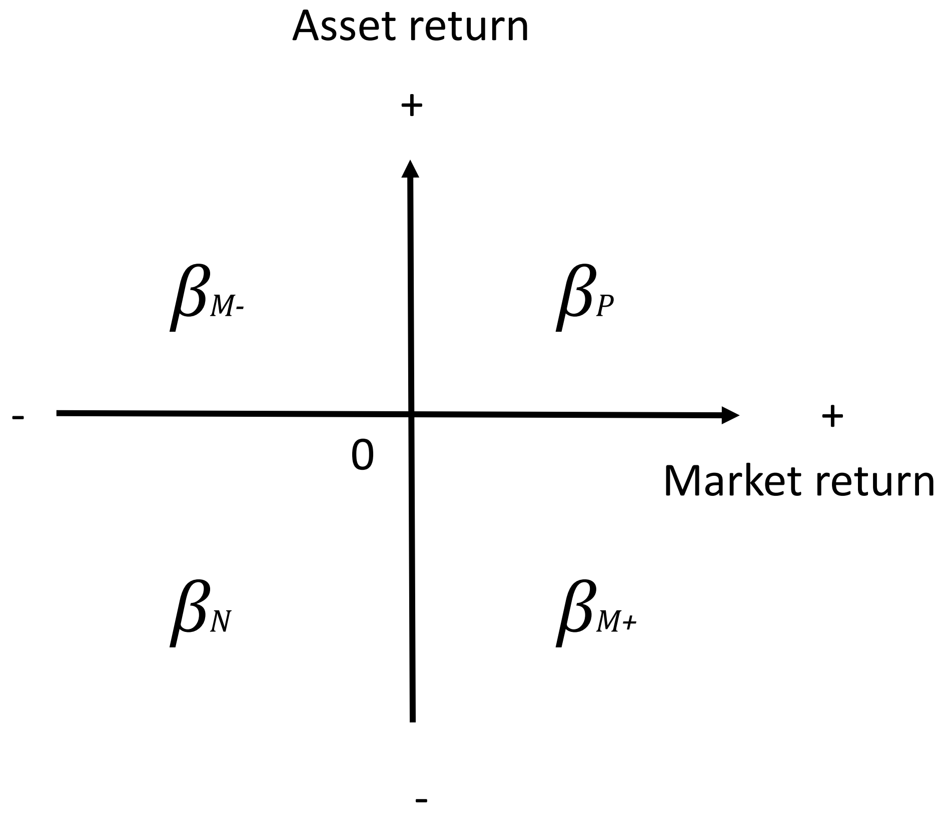
$$\hat{\beta}^{+}_{t,i} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i} f^{+}_{t,k}}{\sum_{k=1}^{m} \left(f^{+}_{t,k}\right)^2}, \quad \hat{\beta}^{-}_{t,i} \equiv \frac{\sum_{k=1}^{m} r_{t,k,i} f^{-}_{t,k}}{\sum_{k=1}^{m} \left(f^{-}_{t,k}\right)^2}$$

- Notice that the upside and downside betas can be obtained as a weighted sum of the four semi betas:

$$\hat{\beta}^{+}_{t,i} = \left(\widehat{\beta}^{P}_{t,i} - \widehat{\beta}^{\mathcal{H}^+}_{t,i}\right) \frac{\sum_{k=1}^{m} f^{2}_{t,k}}{\sum_{k=1}^{m} \left(f^{+}_{t,k}\right)^2},$$

$$\hat{\beta}^{-}_{t,i} = \left(\widehat{\beta}^{\mathcal{N}}_{t,i} - \widehat{\beta}^{\mathcal{M}^-}_{t,i}\right) \frac{\sum_{k=1}^{m} f^{2}_{t,k}}{\sum_{k=1}^{m} \left(f^{-}_{t,k}\right)^2}$$

Four-way decomposition



Two-way decomposition

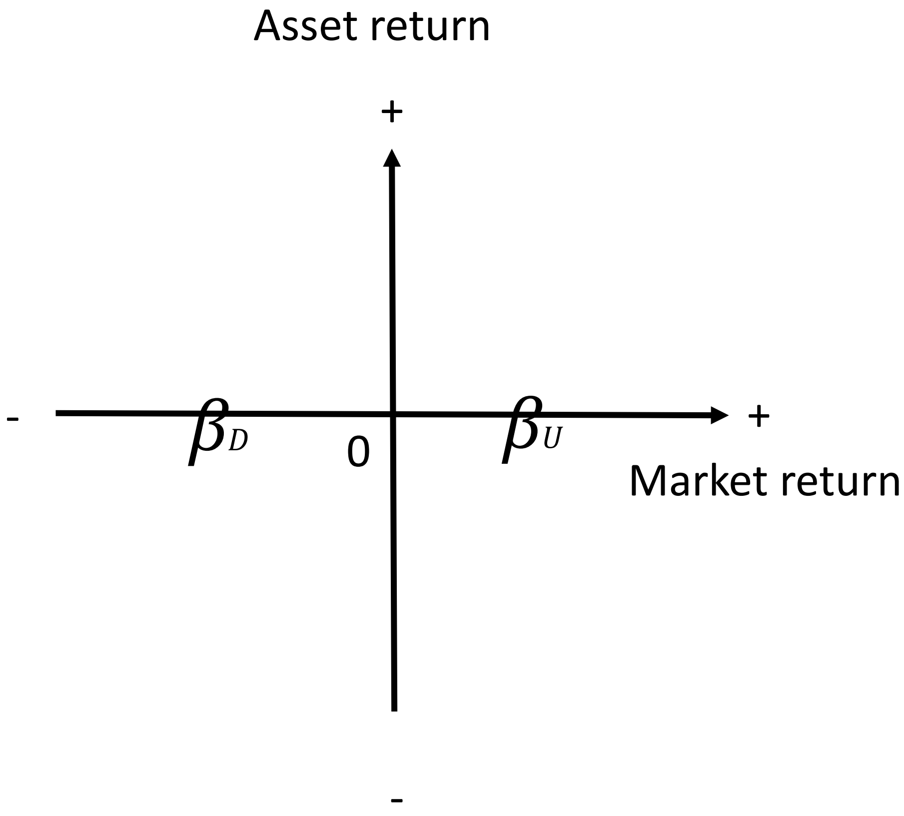


Table 2 – Time series average of betas

	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10
β	-0.317	-0.029	-0.014	-0.005	0.011	0.034	0.049	0.076	0.121	0.239
β_N	0.692	0.127	0.108	0.099	0.077	0.068	0.058	0.052	0.041	0.02
β_P	0.055	0.074	0.098	0.105	0.115	0.133	0.164	0.217	0.306	0.831
β_{M+}	-1.015	-0.172	-0.146	-0.128	-0.09	-0.074	-0.062	-0.051	-0.033	-0.024
β_{M-}	-0.049	-0.058	-0.075	-0.082	-0.091	-0.093	-0.111	-0.142	-0.192	-0.587
β_D	1.754	0.181	0.087	0.048	-0.037	-0.057	-0.145	-0.235	-0.406	-1.46
β_U	-1.687	-0.178	-0.087	-0.037	0.046	0.107	0.187	0.307	0.501	1.471

This table reports the time series average of betas for all 10 portfolios. All betas are monthly realized betas constructed from daily returns. The estimates are based on all 48 currencies from October 1983 to May 2022.

Table 3 – Summary Statistics of betas (CAPM)

	β	β_N	β_P	β_{M+}	β_{M-}	β_D	β_U
Panel A: summary statistics							
Mean	0.020	0.130	0.210	0.180	0.150	-0.030	0.060
Median	-0.840	0.000	0.020	0.010	0.010	-1.520	-1.240
SD	0.220	0.140	0.160	0.230	0.120	0.530	0.460
Min	-1.020	0.000	0.010	0.000	0.000	-1.910	-1.740
Max	1.070	0.900	1.130	1.550	1.130	3.390	1.560
Panel B: Correlations							
β	1.000	-0.060	0.430	-0.510	-0.300	-0.110	0.520
β_N		1.000	-0.040	0.680	-0.050	0.710	-0.650
β_P			1.000	0.090	0.330	-0.250	0.490
β_{M+}				1.000	-0.050	0.650	-0.740
β_{M-}					1.000	-0.510	0.350
β_D						1.000	-0.680
β_U							1.000

Panel A reports the time series averages of the cross-sectional means, medians, and standard deviations of the monthly realized semibetas constructed from daily returns. Panel B reports the time series averages of the cross-sectional correlations. The estimates are based on all 48 currencies from October 1983 to May 2022.

Table 4 – Time series average of betas of (VOL)

	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10
β	2.830	0.214	0.094	0.030	-0.146	-0.259	-0.470	-0.584	-0.864	-2.144
β_N	1.238	0.129	0.082	0.104	0.049	0.033	0.007	-0.017	0.009	-0.031
β_P	-0.111	-0.102	-0.165	-0.161	-0.196	-0.250	-0.350	-0.381	-0.601	-1.248
β_{M+}	-1.728	-0.291	-0.216	-0.139	-0.093	-0.053	-0.030	-0.055	-0.015	-0.036
β_{M-}	0.024	0.104	0.040	0.053	0.092	0.094	0.158	0.241	0.287	0.901
β_D	9.913	0.449	0.212	0.178	-0.260	-0.419	-0.831	-1.330	-1.956	-6.522
β_U	3.346	0.731	0.267	0.107	-0.161	-0.383	-0.736	-0.693	-1.406	-2.955

This table reports the time series average of *vol* betas for all 10 portfolios. All *vol* betas are monthly realized betas constructed from daily average of absolute returns across 48 currencies. The estimates are based on all 48 currencies from October 1983 to May 2022.

Table 5 – Summary Statistics of betas (of VOL)

	β	β_N	β_P	β_{M+}	β_{M-}	β_D	β_U
Panel A: summary statistics							
Mean	-0.130	0.160	-0.356	0.266	-0.199	-0.057	-0.188
Median	-6.038	-2.699	-5.473	-2.902	-4.050	-13.886	-8.982
St Dev	2.486	1.141	1.191	1.938	1.025	5.693	3.489
Min	-10.385	-5.863	-6.607	-7.267	-7.742	-57.219	-11.779
Max	31.680	13.053	2.863	23.772	8.455	48.531	36.222
Panel B: Correlations							
β	1.000	0.548	0.199	0.713	0.235	0.409	0.789
β_N		1.000	-0.141	0.389	-0.356	0.438	0.294
β_P			1.000	-0.386	0.209	0.045	0.255
β_{M+}				1.000	-0.146	0.073	0.683
β_{M-}					1.000	0.314	-0.001
β_D						1.000	0.115
β_U							1.000

Panel A reports the time series averages of the cross-sectional means, medians, and standard deviations of the monthly realized semibetas for *vol* constructed from daily average of absolute returns across 48 currencies. Panel B reports the time series averages of the cross-sectional correlations. The estimates are based on all 48 currencies from October 1983 to May 2022.

Table 6 – Fama-Macbeth Regressions (CAPM)

	Estimated risk prices (λ)		R^2
β	4.626		0.937
	(9.64)		
β_D, βU	-1.733	-0.884	0.963
	(2.16)	(1.10)	
βD	-0.855		0.963
	(10.83)		
βN, $\beta M-$	-2.486	1.99	0.974
	(29.17)	(16.92)	

The table reports the estimated annualized risk premium and Newy-West robust *t*-statistics from Fama-Macbeth cross-sectional regressions. The monthly semibetas are calculated from daily data. The estimates are based on all 48 currencies from October 1983 to May 2022.

Table 7 – Fama-Macbeth Regressions (ICAPM)

	Estimated risk prices (λ)			R^2
DOL, β	-0.079	-0.527		0.972
	(2.67)	(26.50)		
DOL, βD, βU	-0.023	-0.155	-0.026	0.973
	(0.66)	(3.56)	(0.23)	
DOL, βD	-0.018	-0.165		0.976
	(0.68)	(48.62)		
DOL, βN, βM−	-0.008	-1.362	-1.107	0.978
	(0.09)	(9.48)	(6.55)	

The table reports the estimated annualized risk premium for *vol* and decomposed *vol* and Newy-West robust *t*-statistics from Fama-Macbeth cross-sectional regressions. The monthly semibetas are calculated from daily data. The estimates are based on all 48 currencies from October 1983 to May 2022.

Findings

- We use the US stock market return as a proxy of the FX market risk.
- When the market return is negative, we have the “downside risk state” and when the market return is positive, we have the “upside uncertainty state”. Consistent with the literature, only “the downside risk” are priced.
- We further decompose the “downside risk state” into two states based on whether the individual portfolio/asset return is positive or negative. We find that under the “downside risk state” the two states are priced differently and by allowing the two states pricing separately, we can improve the pricing power of the models under both the CAPM and ICAPM settings.

Limitation and further direction

- Next step: currency trading strategies based on semibetas to access the economic significance of the semibeta pricing.
- Robustness test
  - across asset classes including stock portfolios, index options and currency returns
  - Use the global stock market index rather than the US stock market index: the MSCI All-Country World Index (ACWI) as a proxy for the market return. This index aggregates the stock market performance in forty-five countries.
  - Possible structure break after the 2008 global financial crisis as currency carry trade performance has been declining since(Fan et.al., 2020)
- Realized risk factors generated using high-frequency data provide better cross-sectional pricing power in the currency market, even under a CAPM setting. (another paper)