

# Market-Beta and Downside Risk

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Oct 2018

Seawell Boardroom (B400), Bass Center, 655 Knight Way, Stanford, CA, 8:00am

Our paper has three connected parts:

1. All-days market-beta is a good measure of stocks' hedging aspects for bear and crash markets.
2. A strong critique of downside beta in equities  
(Ang-Chen-Xing (2006), > 200 WoS > 800 Google)
  - ▶ Critique = Perspective. All results are replicable.
  - ▶ Definition: Down-beta is on days when  $R_M < 0$ .
3. A mild critique of downside beta in asset classes  
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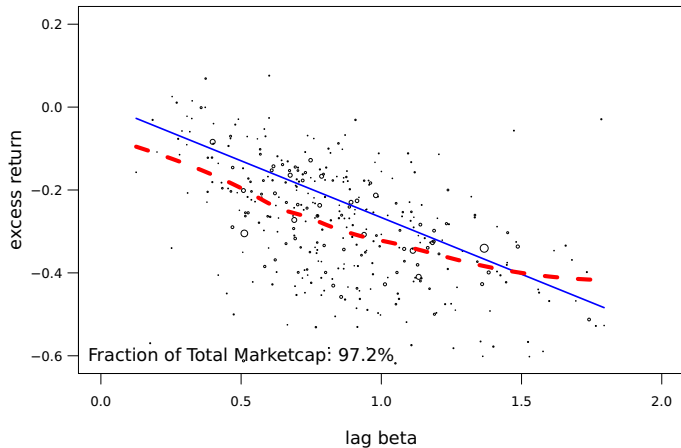
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# Part 1: Plain Beta As Hedge Metric

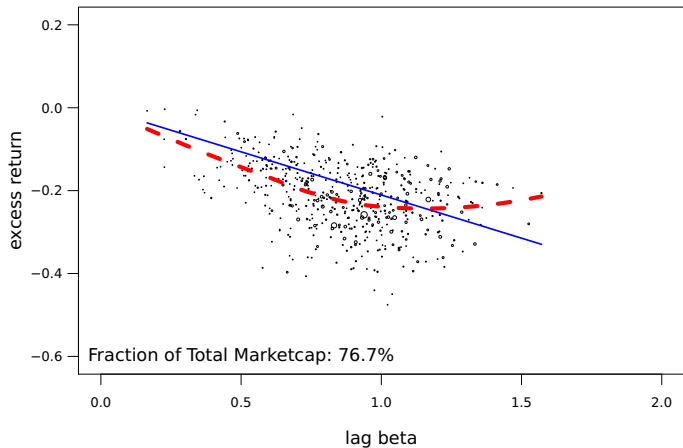
- ▶ Lots of detail (in the paper).
  - ▶ Daily-return “all-days” betas. OLS and/or others.
- ▶ Result: Plain=all-days beta is a good exposure measure also for down and crash markets.
- ▶ Will just show you the 3 extreme periods.
  - ▶ Betas are estimated ex-ante (all-days)
  - ▶ Market performance is realized in-time.
  - ▶ Select= Crash. Stocks. X-Axis is beta. Y-axis is returns.

# 1929: Oct 28, Oct 29, Nov 06

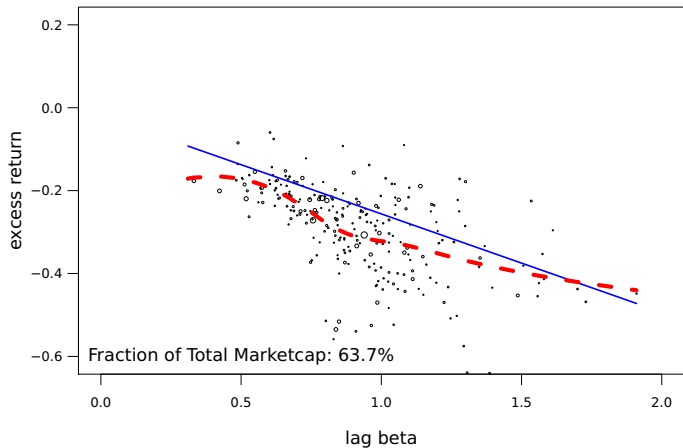


Blue = ex-ante OLS beta predicted slope  
Red = loess realized smoothed fit ex-ante

# 1987: Oct 16, Oct 19



# 2008: Oct 7, 9, 15 + Dec 1





## Part 2: Down-beta in Equities

- ▶ Can we improve (down-market) hedging?
- ▶ Estimate beta only on market **down**-days:  $\hat{\beta}_y^-$ 
  - ▶ Estimate beta on market **up**-days  $\hat{\beta}_y^+$ , too.
- ▶ **Is down-beta the relevant risk measure?**
  - ▶ Roy (1952), Markowitz (1959), etc.
- ▶ Is there a premium for down-beta bearing?
- ▶ **Most Prominent: Ang-Chen-Xing (2006)**

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# ACX Innovations

- ▶ Earlier tests used monthly betas and formed portfolios that destroyed variation in  $\hat{b}_y^-$ .
  - ▶ E.g., they may have sorted on  $\hat{b}_y$ .
  - ▶ it is better to work with individual stocks.
- ▶ ACX sometimes use set of low-volatility stocks.
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  - ▶ LV is ex-ante pre-identified. Good idea.

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# ACX Synopsis

1. Down-betas can forecast future down-betas.
2. Simultaneous Down-Beta Return Association.
  - ▶ The realized down-beta correlates strongly with **contemporaneous** average returns.
  - ▶ And this is also **not** mechanical. ✓
3. Some Down-Beta Future Return Evidence.
  - ▶ Down-betas can also predict quintile pfo returns.
  - ▶ (Plain, BkMkt+Sz+UMD adjusted)
4. Some significance in GMM on 25 FF pfios.

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# Still Relevant?

- ▶ ACX remains highly influential.
  - ▶ >200 Web of Science, >800 Google Scholar
  - ▶ Influence is not declining.
  - ▶ Will become “home run” paper.
  
- ▶ We critique ACX’s inference, **but**
  - ▶ All ACX results are replicable.
  - ▶ There are no mistakes.
  - ▶ Our paper “only” revisits interpretation of evidence.

# Descriptive Statistics

## Low-Volatility (LV) Subsample:

		Mean	Sd	#days
All-days-Beta	$\hat{b}_y$	0.67	0.54	253
Down-Beta	$\hat{b}_y^-$	0.72	0.62	116
Up-Beta	$\hat{b}_y^+$	0.61	0.64	132
Abs( Down – Up )	$ \hat{b}_y^- - \hat{b}_y^+ $	0.40	0.43	

Calendar Year Betas. 240k firm-years. LV 1927-2016.

# 1. Down-betas can forecast future down-betas

- ▶ Of course, we all agree that investors care not about past but about future down-beta.
- ▶ ACXT7: down-beta can predict future down-beta:

$$\hat{b}_y^- \approx 0.56 \cdot \hat{b}_{y-1}^- + c + e, \quad R^2 \approx 30\%$$

ACXT7 is basically right!

$N \approx 240k$ .  $i$  subscripts on  $\hat{b}_y^-$  and  $e$ . Panel or FM.  $se$  is tiny. estimates.

- ▶ But if you care about  $\hat{b}_y^-$ , can you do better?
- ▶ All-days beta  $\hat{b}_{y-1}$  always has about twice as many days for estimation as down-beta  $\hat{b}_{y-1}^-$ ,
- ▶ ...and it has more X-axis support,
- ▶ ...but if  $\hat{b}_y^-$  (process) is truly different, down-beta could predict itself better,
- ▶ ...or not.
- ▶ **Empirically easy to investigate.**
  - ▶ Not shown: our conclusions are **very** robust.

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- ▶ ACX: Predict  $\hat{b}_y^-$  with lagged down-beta:

$$\hat{b}_y^- \approx 0.56 \cdot \hat{b}_{y-1}^- + c + e, \quad R^2 \approx 30\%$$

- ▶ LW: Predict  $\hat{b}_y^-$  with lagged all-days betas:

$$\hat{b}_y^- \approx 0.72 \cdot \hat{b}_{y-1}^- + c + e \quad R^2 \approx 40\%$$

$$\hat{b}_y^- \approx 0.74 \cdot \hat{b}_{y-1}^-$$

$$-0.07 \cdot \hat{b}_{y-1}^+ + 0.05 \cdot \hat{b}_{y-1}^- + c + e \quad R^2 \approx 40\%$$

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▶ **If you care about the future down-beta, then forecast it with all-days beta, not with itself.**

▶ Or shrink  $\hat{b}_{y-1}^-$  away to almost nada.

▶ ...because

$$(\Delta_y \equiv) \hat{b}_y^- - \hat{b}_y^+ \approx c + 0.087 \cdot (\hat{b}_{y-1}^- - \hat{b}_{y-1}^+)$$

Most  $\Delta_y$  is just estimation noise.

(PS: It is this noisy realized betas that is also the one used in ACX part 1. It must have huge EIV. (Not shown:) some is even harder-to-estimate time-variation in  $\Delta$ .)

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Above was down-beta prediction.

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Below is stock-return explanation/prediction.

## 2. Simultan Down-Beta vs Return

### Philosophical Points, Ex-Post $\Omega$

- ▶ First half of ACX uses ex-post simultaneous down-betas to explain rates of return.
- ▶ It is defensible that representative investors know stocks' **true** down-betas better than us.
  - ▶ But must be very smart aggregators for pricing!
- ▶ But it seems implausible that they know the **realized** down-betas (from the very same returns being predicted!), and/or any other single year.
  - ▶ At least, use many years [-4 to +4 = no results].

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# ACX T2: Fama-Macbeth, Simul Realized

$$r_{yi} = \gamma_0 + \gamma_1 \cdot \hat{b}_{yi}^- + \gamma_2 \cdot \hat{b}_{yi}^+ + \dots$$

Beta	ACX RFS Simultans	Replic $\hat{b}_y$
$\hat{b}^-$ (T)	0.062 (+6.0)	0.088 (+6.1)
$\hat{b}^+$ (T)	0.020 +2.3	0.002 +0.2
Sample	ACX 1963-2001	ACX

(Strong positive for  $\hat{b}^-$  only if betas are estimated simultaneous (or one future year).  $\hat{b}^-$  is not positive in longer windows around returns. Not shown, 90% of power is from all-days beta, too. Controls were included, but are not reported. About 500k obs/2.2m obs.)

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Beta	ACX RFS Simultans	Replic $\hat{b}_y$	Ex-Ante $\hat{b}_{y-1}$
$\hat{b}^-$	0.062	0.088	-0.009
(T)	(+6.0)	(+6.1)	(-1.6)
$\hat{b}^+$	0.020	0.002	-0.005
(T)	+2.3	+0.2	(-0.8)
Sample	ACX 1963-2001	ACX	ACX 1963-01

(Strong positive for  $\hat{b}^-$  only if betas are estimated simultaneous (or one future year).  $\hat{b}^-$  is not positive in longer windows around returns. Not shown, 90% of power is from all-days beta, too. Controls were included, but are not reported. About 500k obs/2.2m obs.)

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Beta	ACX RFS Simultans	Replic $\hat{b}_y$	Ex-Ante $\hat{b}_{y-1}$	
$\hat{b}^-$	0.062	0.088	-0.009	-0.022
(T)	(+6.0)	(+6.1)	(-1.6)	(-3.5)
$\hat{b}^+$	0.020	0.002	-0.005	-0.020
(T)	+2.3	+0.2	(-0.8)	(-3.6)
Sample	ACX 1963-2001	ACX	ACX 1963-01	Extd 1927-16

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# Fama-Macbeth Gammas on

- ▶ 63-01: **Realized** down-betas  $\hat{b}_y^- \xrightarrow{+}$  returns. (0.08)
- ▶ 63-01: “Placebo”  
Ex-post (**plain**) betas  $\hat{b}_y^+ \xrightarrow{+}$  returns. (0.18)
- ▶ 63-01: Ex-post competing effect:  
 $\hat{b}_y = 0.21^{***}$     $\hat{b}_y^- = \mathbf{0.03}^{**}$     $\hat{b}_y^+ \approx -0.04$
- ▶ 63-01: **Ex-ante** any betas:  $\xrightarrow{-}$  returns.
- ▶ 63-01: **Windowed 4yr** betas:  $\xrightarrow{-}$  returns.
- ▶ **1963-2016**:  $\approx$  63-01.

# Defend Ex-Post Realized Beta?

- ▶ Fama: all AP tests are eqbm model and  $\Omega$ .
- ▶ Judgment call: ex-post info seems better in IV regressions, agent-specific consumption, etc.
- ▶ Ex-post info could resolve many pricing mysteries.
- ▶ Most important, FM all-days beta  $\rightarrow$  stock returns:

with	<u>FM Gamma</u>	<u>(T-stat)</u>
... Ex-Ante Betas	-0.3%/year	(-0.22)
... Contemp Betas	+8.4%/year	(+3.84)

and 8.4% is even underestimated due to EIV. See original FM multi-sort, etc.

Above was ACX ex-post  
down-beta evidence ( $\overline{ACX}T2$  to  $\overline{ACX}T5$ ).

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Below is ACX ex-ante  
down-beta evidence ( $\overline{ACX}T8$  to  $\overline{ACX}T10$ ).

... and GMM ( $\overline{ACX}T6$ )

# 3. Down-Beta Future Return Evidence

## ACX Specification:

- ▶ Quintile test portfolios based on down-betas.
  - ▶ Short: Downbeta  $\approx 0.2$ .
  - ▶ Long: Downbeta  $\approx 1.9$ .
- ▶ Zero-Investment Portfolio Tests
  - ▶ Jensen-Black-Scholes (1972), Fama-French (1993).
- ▶ non-LV and LV sets.



# ACX Tables 8-10

Lagged beta predicts future monthly stock returns:

	(not reported) $\hat{b}_{y-1}^-$	0.19	1.89	
	(not reported) $\hat{b}_y^-$	0.60	1.38	
	Quintile: Low $\hat{b}_{y-1}^-$	High $\hat{b}_{y-1}^-$		$\Delta T$ -stat
T8: Net of Risk-free	+0.6%	+0.7%		(0.6)
T9: <b>LV</b> Net of Rf	+0.6%	+0.9%		(2.3)
T10: LV <b>Size/B-M</b> Adj	-0.3%	+0.2%		(3.3)

(LV= Low Vltty. EW Quintiles. Excess= TB. 1963-2001)

# Our Near Replication

$\hat{b}_{y-1}^-$ -Spread Zero Pfiio. Time-Series Regs. %/mo.

	$\overset{ACX}{T}8$	$\overset{ACX}{T}9$	$\overset{ACX}{T}10$
ACX Alpha	0.11	0.23	0.44
(ACX T-stat)	(0.60)	(2.31)	(3.36)
			SMB
			HML
Sample:	All	LV	LV
<b>Replication</b>	<b>0.11</b>	<b>0.30</b>	<b>0.50</b>
(T-stat)	(0.60)	(1.85)	(3.37)

(Small differences in LV classification and SMB/HML adjustments.)

# Placebo—Plain “All-Days” Beta

$\hat{b}_y^-$ -Spread Zero Pfi. Time-Series Regs. %/mo.

Similar to:	ACX T8	ACX T9	ACX T10
ACX Alpha	.....	n/a	.....
(ACX T-stat)	.....	n/a	.....
			SMB
			HML
Sample		LV	LV
LW Alpha	<b>0.03</b>	<b>0.20</b>	<b>0.45</b>
(T-stat)	(0.15)	(1.08)	(2.63)

**Placebo is a little worse, but really quite similar!**

So, what, if anything, is wrong here?

Average XMKT/mo in ACX sample: 0.54%/mo:

$$\Rightarrow \hat{b}_y \cdot \text{XMKT} \approx 0.77 \cdot 0.54\% \approx 0.42\%/\text{mo}$$

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# Time-Series (FF) Regs, $\hat{b}_{y-1}^-$ -Sort

	$\text{ACX T8}$	$\text{ACX T9}$	$\text{ACX T10}$	N/A
ACX Alpha	0.11	0.23	0.44	n/a
(T-stat)	(0.60)	(2.31)	(3.36)	n/a
				<b>XMKT</b>
			SMB	SMB
			HML	HML
Sample		LV	LV	LV
LW Alpha	0.11	0.30	0.50	<b>0.04</b>
T-stat	(0.60)	(1.85)	(3.37)	<b>(0.31)</b>

# Is Exposure Alpha?

- ▶ Go long stocks with high  $X$  exposure  
Go short stocks with low  $X$  exposure
  - ▶  $X$  can be a zero-investment currency pfio, or commodity pfio, or whatever.
- ▶ Look at a sample period in which  $\bar{X} \gg 0$ .
- ⇒ Portfolio should have pos avg rates of return.
- ▶ Average statement (not tautology).
- ▶ ACX looked at high-(down-)beta portfolios in a time of good stock-market performance.

# Does FM Slope Imply FF Alpha?

- ▶ The 1-Factor CAPM model gives a prescription for how much p<sub>ffio</sub> should have gone up.
  - ▶ FM Slope=Necessary, but not sufficient for FF Alpha.
- ▶ **In ACX, high-(down) beta p<sub>ffios</sub> had higher rates of return only w/o XMKT control.**
- ▶ High-beta stocks ↑ more when/because market ↑.
- ▶ ...as they should have, given that they had positive exposures and the market went up,
- ▶ ...but high (down-)beta stocks did not even go up enough to “break even” in a “positive alpha” way.



# What About Ex-Post Downbeta?

(ACX Fama-Macbeth Focus. Needed for Strong Positive.)

- ▶ We already know:
  - ▶ Down-betas  $\approx$  Plain all-days betas.
  - ▶ From 1963-01,  $\hat{b}_y \xrightarrow{+} r$  was good.
  - ▶ **Marginal** FM  $\hat{b}_y^- \rightarrow r$  was small 0.03.
  - ▶ Downbeta should be a little more positive in FF regs.
- ▶ So, was the marginal **realized simultaneous (ex-post)**  $\hat{b}_y^-$  predicted return even strong enough just to meet the 1-factor benchmark?

# What About **Ex-Post** Downbeta?

	$\overset{ACX}{T}8$	$\overset{ACX}{T}9$	$\overset{ACX}{T}10$	N/A
ACX Alpha		.....n/a	.....	
(T-stat)		.....n/a	.....	
			SMB	<b>XMKT</b> SMB
			HML	HML
Sample		LV	LV	LV
LW Alpha	0.14	0.25	0.45	-0.89
T-stat	(0.63)	(1.33)	(2.67)	(-0.78)

# FM Reassessment

- ▶ Yes, there was a positive FM association between **ex-post** down-betas and rates of return;
- ▶ ...but it was not enough merely to beat the 1-factor target benchmark.

But it's 2016 now. What is the best inference today?

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# And in 2016? (Ex-ante $\hat{b}_y^-$ )

Spec	$\overset{ACX}{T}8$	$\overset{ACX}{T}9$	$\overset{ACX}{T}10$	N/A
ACX Alpha (T-stat)				
			SMB HML	<b>XMKT</b> SMB HML
Sample		LV	LV	LV
LW Alpha T-stat	-0.28 (-1.32)	-0.02 (-0.11)	-0.02 (-0.12)	-0.44 (-4.27)

# Time-Series (FF) Regs, $\hat{b}_{y-1}^-$

From 1963–2016:

- ▶ Higher  $\hat{b}_{y-1}^-$  stocks did not even have higher average rates of return;
- ▶ ...but XMKT continued to be very positive;
- ▶ ...thus 1-F alpha of  $\hat{b}_{y-1}^-$  was not just not positive, it was negative;
- ▶ ...just as it is for  $\hat{b}_{y-1}$  in Frazzini-Pedersen.

# Did Down-Beta $\hat{b}^-$ Give Pos Alpha?

Relative to what?

- ▶ Risk-Neutral Model?  
A: Yes, as of 2001.  
A: No, as of 2016.
- ▶ CAPM? A: Never.
- ▶ Fama-French 3F Model? A: Never.
- ▶ (Fama-French 5F+UMD Model? A: Never.)
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- ▶ To test a beta-risk-reward argument,
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- ▶ ...unless you want to learn whether  $\hat{b}_y^-$  has a less negative relation with future stock returns than  $\hat{b}_y$ !
- ▶ ...which would be sort of silly as an AP test whether investors need comp for (down-)beta risk
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## 4. GMM on 25 FF pfios (ACX T6)

- ▶ GMM is not a great expertise of our's.
- ▶ Down-beta helps explain 25 FF portfolio returns.
  - ▶ remarkable, given motivation about pfio info destruction.
- ▶ ...but with the wrong sign ?!?

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$E(l(x) \cdot r) = 0$	[8.70]	[3.03]	[2.16]

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We need to learn what we have missed.

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Hopefully, we will soon improve paper with Andrew's comments. We want to end up with a better synthesis than his thesis and our antithesis.

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# Part 3: Down-Beta in Asset Classes

- ▶ Lettau-Maggiore-Weber (2014).
- ▶ Uses **full-sample** betas, not realized betas.
- ▶ Like every paper, makes some choices. All ok.
- ▶ Common misconception, already nicely noted in LMW: Currencies are mostly just completely unrelated investments...like cash.

# Ex-Ante vs Full-Window Betas

- ▶ Full-Window betas may be better than ex-ante,
- ▶ ...esp because we have low power on down-market classification.
- ▶ **Ex-Ante** Down-Beta Inference in FM:
  - ▶ some results become weaker (a few become stronger).
  - ▶ LMW's results do not generally reverse, unlike ACX's.(sovereign bonds may become more interesting with more data.)

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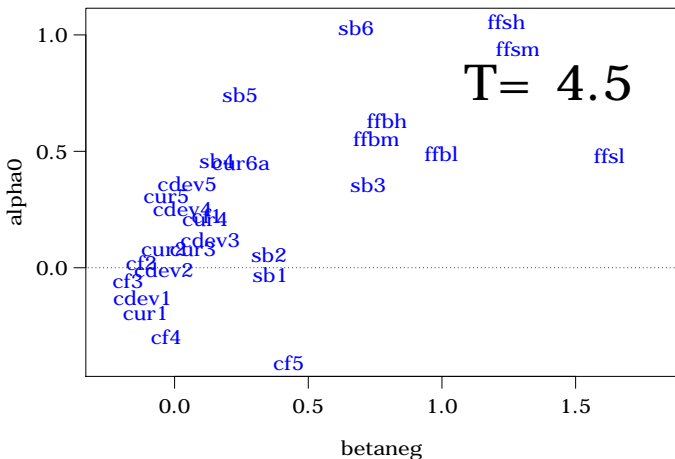
(sovereign bonds may become more interesting with more data.)

# Can CAPM or FFM explain Alphas?

## Is Downbeta helpful?

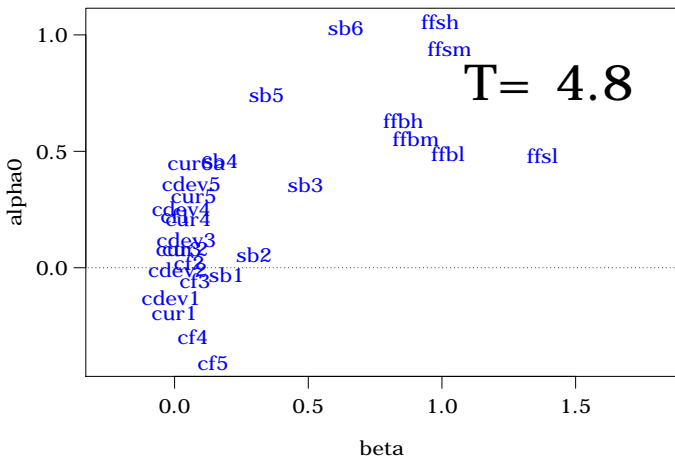
	<b>Down- -Beta</b>	<b>All-Days Beta</b>	<b>Diff- erence</b>
<b>Rf</b>	$\hat{b}^- \rightarrow \alpha_{0F}$	$\hat{b} \rightarrow \alpha_{0F}$	$\hat{b}_y^- - \hat{b} \rightarrow \alpha_{0F}$
<b>CAPM</b>	$\hat{b}^- \rightarrow \alpha_{1F}$	$\hat{b} \rightarrow \alpha_{1F}$	$\hat{b}_y^- - \hat{b} \rightarrow \alpha_{1F}$
<b>FFM</b>	$\hat{b}^- \rightarrow \alpha_{3F}$	$\hat{b} \rightarrow \alpha_{3F}$	$\hat{b}_y^- - \hat{b} \rightarrow \alpha_{3F}$

$$\hat{b}^- \longrightarrow \alpha_{0F}$$



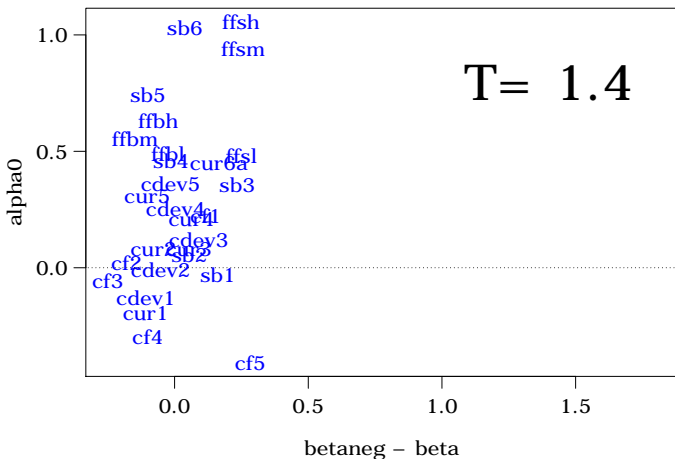
Positive between downbeta and risk-free adj returns.

$$\hat{b} \longrightarrow \alpha_{0F}$$



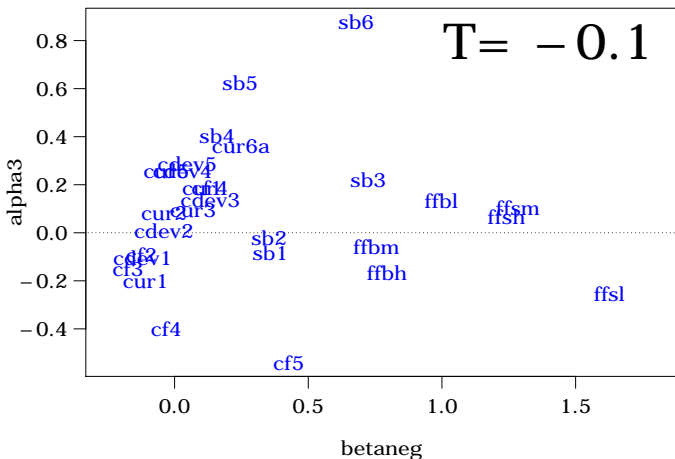
Positive between **plain** beta and risk-free adj returns.

$$\hat{b}^- - \hat{b} \longrightarrow \alpha_{0F}$$



Positive between **delta beta** and risk-free adj returns.

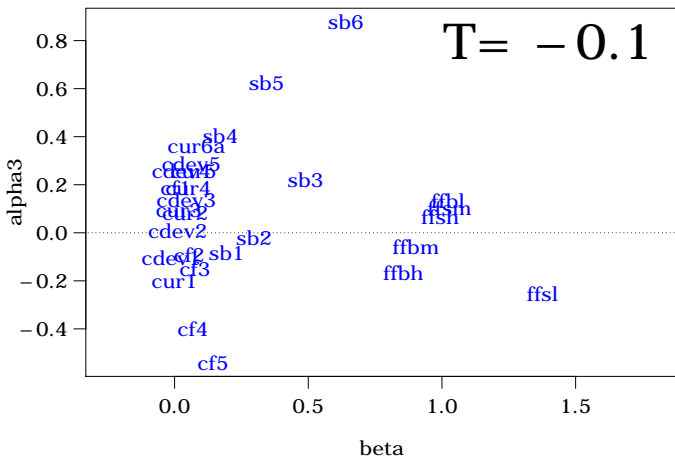
$$\hat{b}^- \longrightarrow \alpha_{3F}$$



No association between down-beta and **FFM**-adj.

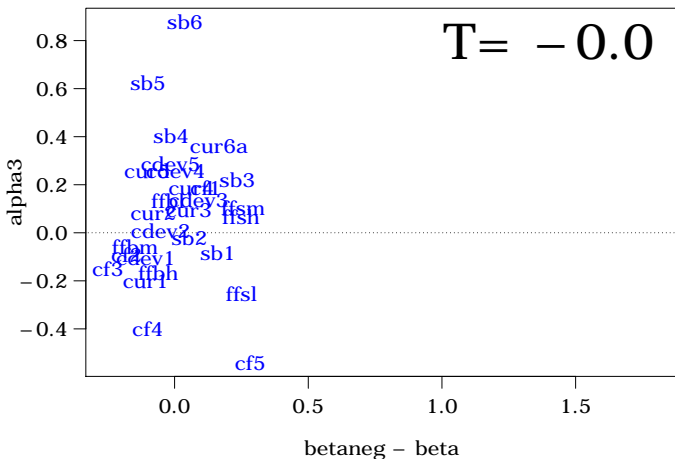


$$\hat{b} \longrightarrow \alpha_{3F}$$



No association between **plain** beta and FFM-adj.

$$\hat{b}^- - \hat{b} \longrightarrow \alpha_{0F}$$



No association between **beta-diff** and FFM-adj.

# Summary on Beta Prediction

- ▶ Plain all-days daily-return betas work great for down-markets, too.
- ▶ Est'd **ex-ante** down-betas are useless:
  - ▶ Even if you care only about down-beta
  - ▶ You are still better off using all-days daily returns.

# Summary on Return Prediction

Despite positive **Fama-Macbeth** coefficients for **ex-post** down-betas associating with stock returns:

- ▶ For many investment strategies, differences between FM and FF tests are modest
  - ▶ but not in near-beta-related strategies,
  - ▶ where strategy has to beat market premium  $ER_m - r_f$ .
- ▶ Down-beta-sorted pfios, ex-ante or ex-post, have zero or negative **CAPM/FFM alphas**.
  - ▶  $\hat{b}_y^-$  are primarily just (noisier) proxies for  $\hat{b}_y$ .
  - ▶  $\hat{b}_y^-$  do not help resolve asset-pricing puzzles.
  - ▶ Returns were not unusual on down-beta dimension.