Pricing Without Mispricing

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Introduction

We can only test whether information is properly reflected in prices in the context of a pricing model that defines the meaning of "properly." (Fama, 1991)

- We ask what asset pricing model best defines "properly."
- Our assumption: decade-old information is correctly priced.

- "Proper" model $\rightarrow \alpha = 0$ for strategies using only such information.
- We test this $\alpha = 0$ implication for prominent asset pricing models.

Overview of main results

- CAPM of Sharpe (1964) and Lintner (1965) passes the test
- Multifactor models we consider fail the test
  - 2 factors: CAPM+BAB, Black (1972), Frazzini and Pedersen (2014)
  - 3 factors: Fama and French (1993)
  - 4 factors: Hou, Xue, and Zhang (2015)
  - 5 factors: Fama and French (2015)
- Failures occur for the largest stocks
  - large stocks provide our test the most power
  - because their betas and characteristics are the most persistent
- Multifactor betas
  - can help capture mispricing of current information
  - distort $E(R)$ after prices eventually reflect that information
- Provide novel evidence of mispricing due to under-reaction among large stocks

Flip side of the joint hypothesis problem

- Two sides of the problem
  - wrong asset pricing model confounds tests of market efficiency
  - market inefficiency confounds test of asset pricing models
- Potential research objectives
  1. use the correct pricing model to test market efficiency
  2. use correctly (efficiently) priced information to test pricing models
- 1 is hard—why some look for no-arbitrage violations (rare/narrow)
- 2 is easier—plausible that decade-old information is correctly priced
- But low power is a drawback
  - decade-old information may relate little to today's factor exposures
  - making it hard to distinguish models (i.e., tell which factors belong)
- We nevertheless find power to distinguish among prominent models
- Encourage other ways to explore pricing in the absence of mispricing

Our test

- Sort assets on a characteristic, x, lagged τ months
- Long-short investment strategy within an asset universe, A
- Strategy's α w.r.t. a given set of factors, f

$$r_t = \alpha + \beta' f_t + \epsilon_t \ ; \quad \alpha = \alpha(x, \tau, f, A)$$

- If f^* would price assets in an efficient market, then for any x,
  - $\alpha(x, 1, f^*, A) = 0$ if the market is efficient
  - $\alpha(x, 120, f^*, A) = 0$ even if the market is inefficient—**we assume**
- Given a pricing model's specification of f, we ask whether $f = f^*$
  - null hypothesis: $\alpha(x, 120, f, A) = 0$
  - if rejected, infer $f \neq f^*$
- Usual test of an asset pricing model:
  - null hypothesis: $\alpha(x, 1, f, A) = 0$
  - does not ask whether $f = f^*$
  - still useful (of course)

Power and beta stability

- Suppose f improperly includes or excludes a factor, f_j (i.e., $f \neq f^*$)
- Strategy's multifactor beta on f_j is $\beta_j(x, \tau, f, A)$
- Necessary condition for our test to have power:

$$\beta_j(x, 120, f, A) \neq 0$$

- Condition probably fails for many choices of x and A
  - decade-old values of x may be unrelated to current betas on f_j
  - as if assets are randomly selected for strategy's long and short legs
- Greater likely power if
  - $\beta_j(x, 1, f, A) \neq 0$
  - assets' betas on f_j are stable over time
- Expect more power when
  - asset universe, A, consists of large-cap stocks
  - characteristic, x, is fairly persistent

Betas are most stable for large stocks

- Size segments of NYSE/AMEX/NASDAQ stocks
  - NYSE percentiles of (decade-old) market-cap
  - Large: above 70th
  - Medium: between 70th and 20th
  - Small: below 20th
- Rank correlations between current and decade-old factor betas (1968–2018)

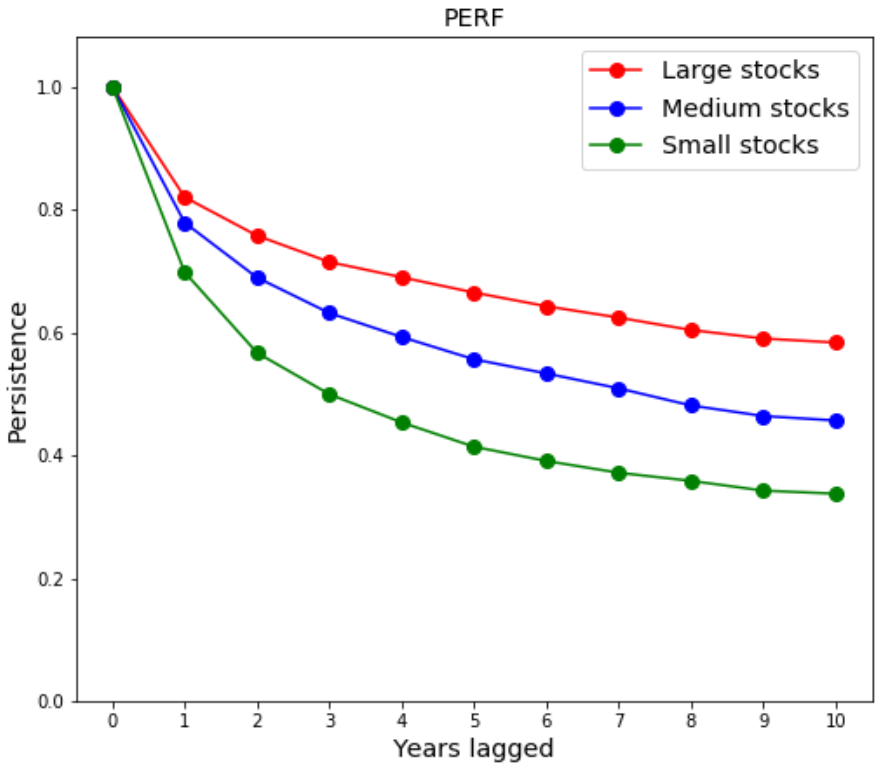
Factor	Large	Medium	Small
MKT	0.27	0.23	0.14
SMB	0.33	0.19	0.15
HML	0.17	0.12	0.04
CMA	0.03	−0.02	−0.01
RMW	0.10	0.06	0.05

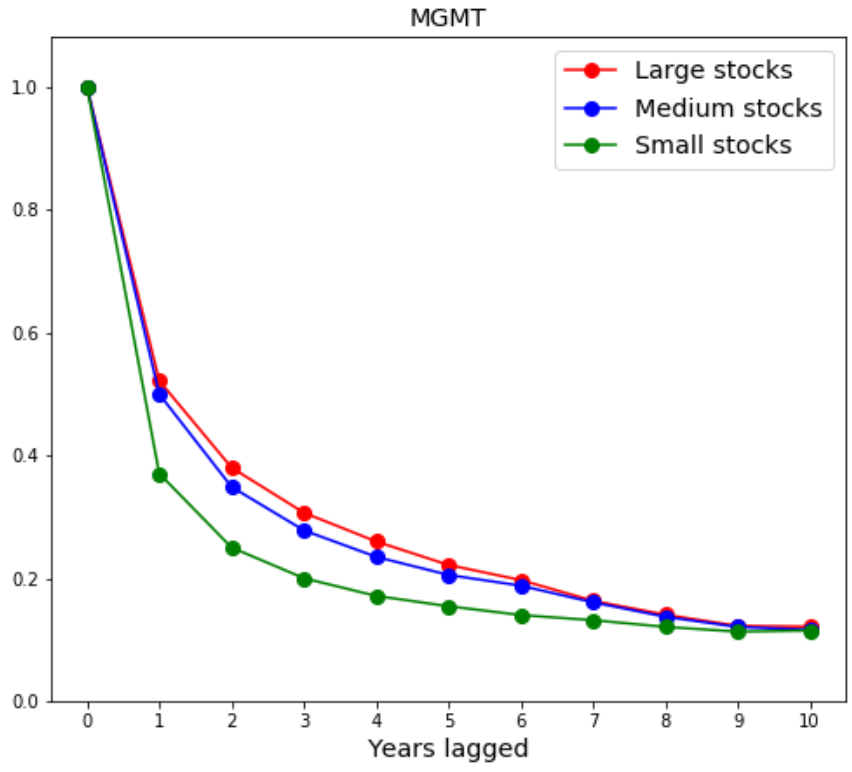
Stock characteristics and long-short spreads

- Focus on two characteristics, for parsimony and transparency
- PERF and MGMT, Stambaugh and Yuan (2017)
  - Constructed by clustering 11 prominent anomalies
  - PERF: gross profitability, return on assets, distress, O-score, momentum
  - MGMT: net stock issues, composite equity issues, accruals, net operating assets, asset growth, investment/assets
- Long-short spreads
  - Separately within each size category
  - Separately for PERF and MGMT scores
  - Top 30% vs. bottom 30% ("underpriced" vs. "overpriced")
  - Market-value weighting within each leg

Persistence in PERF and MGMT scores

$$\text{Plots of } \frac{\text{avg. top}-\text{bottom score difference at year-}k\text{ lag}}{\text{avg. top}-\text{bottom score difference at year-0 lag}}$$





Pricing tests using decade-old PERF scores

	Mega-cap	Large	Medium	Small	All stocks
CAPM	0.19	0.21	−0.09	−0.14	0.12
	(1.16)	(1.55)	(−0.54)	(−0.87)	(0.99)
FF3	0.48	0.46	0.10	−0.16	0.31
	(3.32)	(4.16)	(0.73)	(−0.96)	(2.86)
FF5	0.29	0.29	0.26	−0.20	0.17
	(2.16)	(2.62)	(2.10)	(−1.10)	(1.62)
Q4	0.37	0.33	0.25	−0.21	0.18
	(2.21)	(2.35)	(1.64)	(−0.99)	(1.54)
CAPM+BAB	0.31	0.38	0.28	−0.10	0.29
	(1.81)	(2.71)	(2.02)	(−0.49)	(2.19)

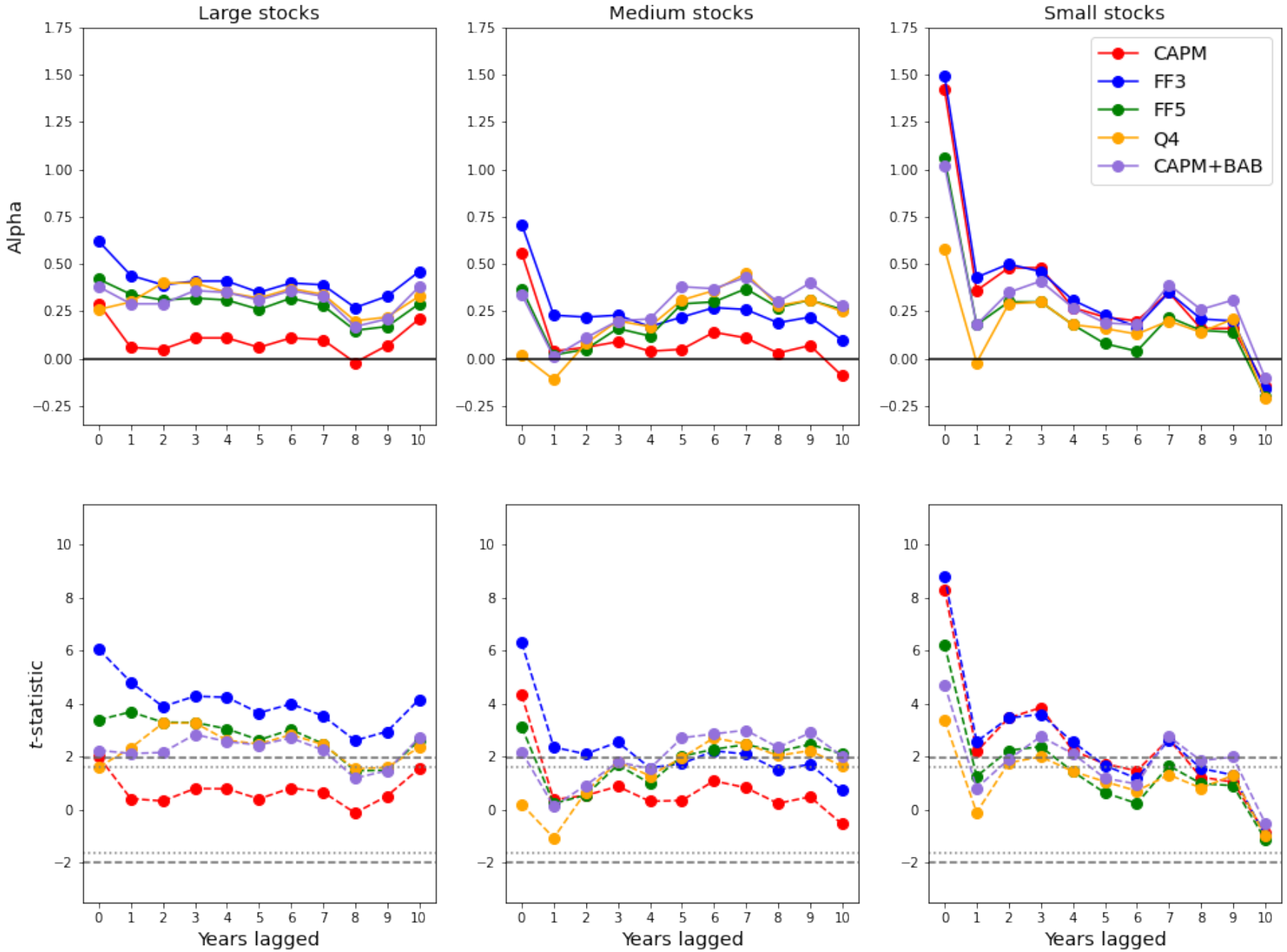
Pricing tests using decade-old MGMT scores

	Mega-cap	Large	Medium	Small	All stocks
CAPM	0.03	0.09	0.12	0.07	0.08
	(0.32)	(1.01)	(0.74)	(0.41)	(0.86)
FF3	−0.04	0.02	−0.04	−0.01	−0.01
	(−0.34)	(0.18)	(−0.28)	(−0.09)	(−0.09)
FF5	−0.17	−0.12	−0.02	−0.08	−0.14
	(−1.54)	(−1.29)	(−0.14)	(−0.45)	(−1.43)
Q4	−0.14	−0.12	−0.08	−0.11	−0.14
	(−1.17)	(−1.15)	(−0.49)	(−0.58)	(−1.34)
CAPM+BAB	−0.12	−0.11	−0.03	−0.03	−0.13
	(−1.11)	(−1.08)	(−0.19)	(−0.17)	(−1.33)

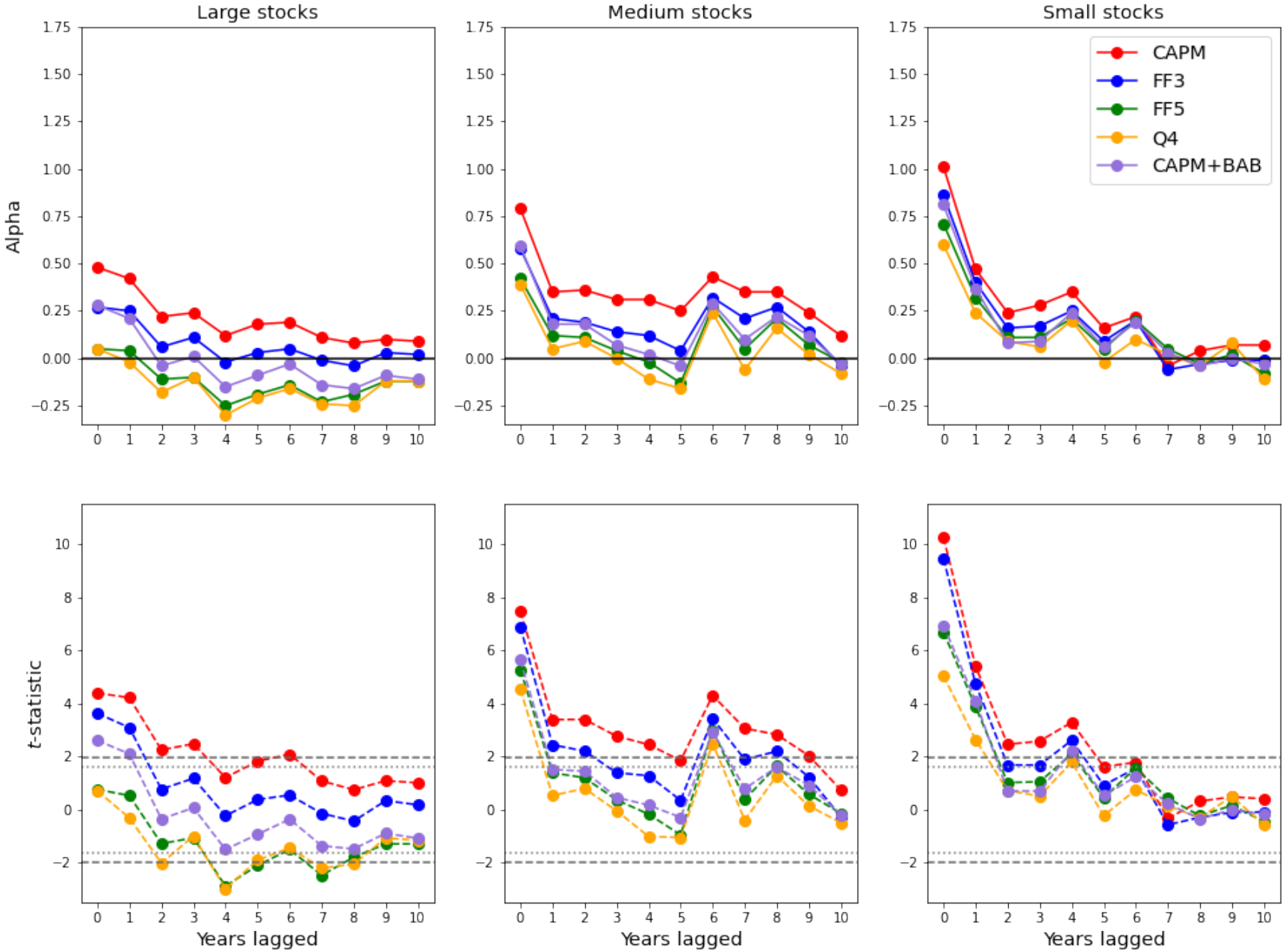
Multiple comparison tests

	Mega-cap	Large	Medium	Small	All stocks	Large/ Medium/ Small
CAPM	0.3581	0.0753	0.6050	0.6727	0.2999	0.1892
FF3	0.0006	0.0000	0.7237	0.6363	0.0125	0.0012
FF5	0.0285	0.0126	0.1434	0.3957	0.1102	0.0570
Q4	0.0233	0.0197	0.2124	0.3404	0.1309	0.1005
CAPM+BAB	0.0777	0.0070	0.1270	0.8145	0.0239	0.0701

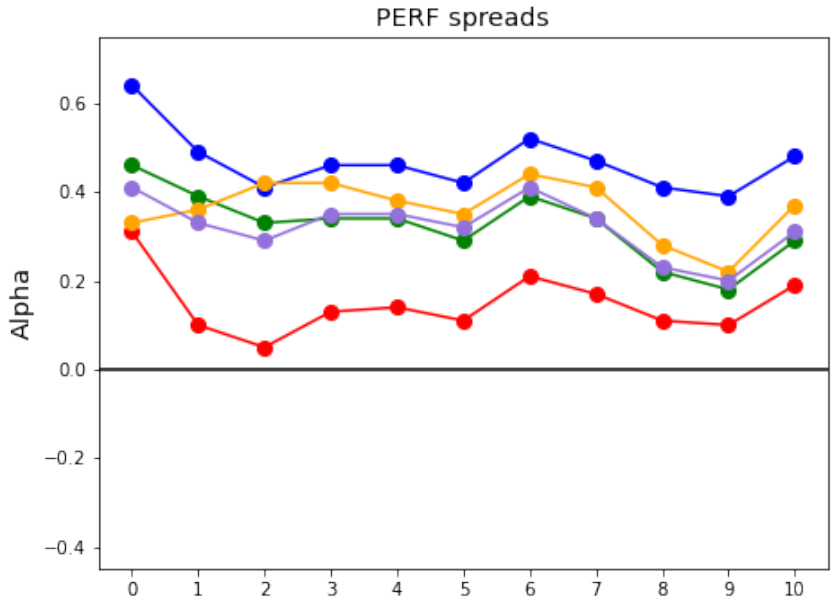
Spreads formed with PERF scores

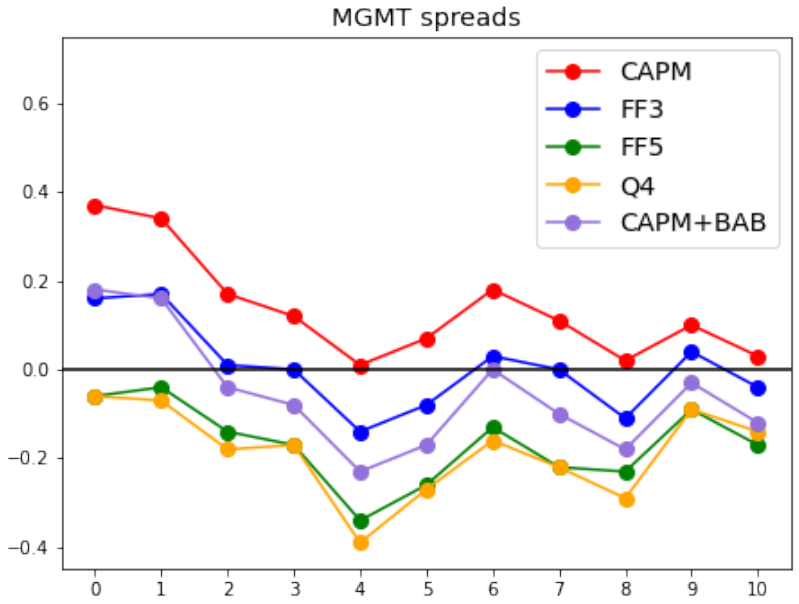


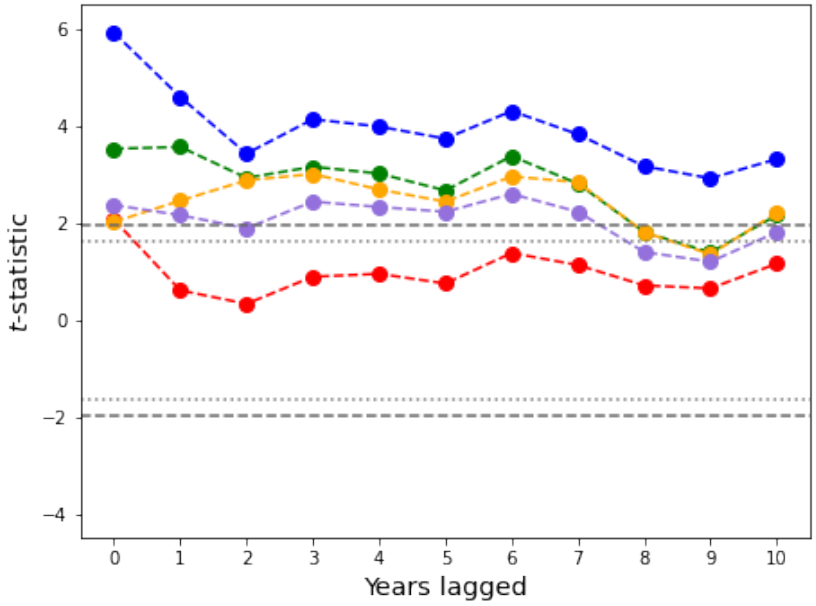
Spreads formed with MGMT scores

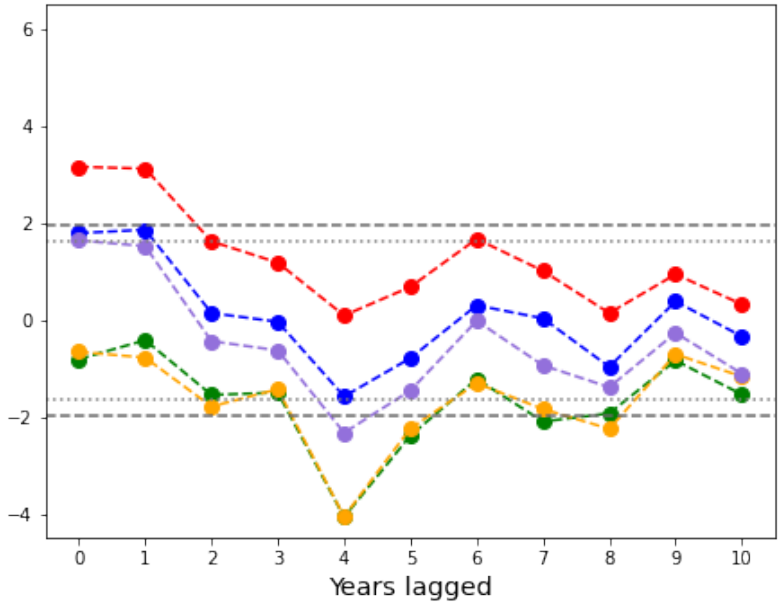


PERF and MGMT spreads among mega-caps









Decomposing the large-stock alphas

- alpha = raw excess return - factor contributions
- E.g.,
  - spread formed using PERF scores lagged one month
  - monthly alpha w.r.t. Fama-French 3-factor model: 0.62%

$$\underbrace{\text{raw excess return}}_{0.21} + \underbrace{(-\beta_{MKT}\overline{MKT})}_{0.14} + \underbrace{(-\beta_{SMB}\overline{SMB})}_{0.01} + \underbrace{(-\beta_{HML}\overline{HML})}_{0.26} = \underbrace{\alpha}_{0.62}$$

Decomposing Fama-French three-factor alphas — PERF spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{HML}\overline{HML}$	α	$t(\alpha)$
0	0.21	0.14	0.01	0.26	0.62	6.05
1	0.02	0.11	0.01	0.29	0.44	4.81
2	0.01	0.10	0.01	0.27	0.39	3.89
3	0.08	0.08	0.01	0.24	0.41	4.28
4	0.08	0.08	0.01	0.24	0.41	4.24
5	0.03	0.09	0.00	0.23	0.35	3.65
6	0.08	0.09	0.00	0.23	0.40	3.99
7	0.07	0.08	0.01	0.23	0.39	3.54
8	−0.05	0.08	0.01	0.23	0.27	2.61
9	0.02	0.09	0.01	0.20	0.33	2.95
10	0.15	0.10	0.01	0.20	0.46	4.16

Decomposing Fama-French three-factor alphas — MGMT spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{HML}\overline{HML}$	α	$t(\alpha)$
0	0.37	0.05	0.02	−0.17	0.27	3.63
1	0.32	0.05	0.02	−0.14	0.25	3.09
2	0.12	0.05	0.03	−0.13	0.06	0.77
3	0.14	0.06	0.02	−0.11	0.11	1.18
4	0.02	0.05	0.02	−0.11	−0.02	−0.23
5	0.09	0.04	0.02	−0.12	0.03	0.38
6	0.11	0.04	0.01	−0.11	0.05	0.55
7	0.04	0.03	0.02	−0.10	−0.01	−0.14
8	0.02	0.01	0.02	−0.10	−0.04	−0.43
9	0.05	0.02	0.02	−0.06	0.03	0.34
10	0.03	0.03	0.02	−0.06	0.02	0.18

Decomposing Fama-French five-factor alphas — PERF spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{HML}\overline{HML}$	$-\beta_{CMA}\overline{CMA}$	$-\beta_{RMW}\overline{RMW}$	α	$t(\alpha)$
0	0.21	0.11	−0.00	0.31	−0.10	−0.10	0.42	3.39
1	0.02	0.10	0.01	0.30	−0.01	−0.07	0.34	3.69
2	0.01	0.09	0.01	0.26	0.01	−0.07	0.31	3.30
3	0.08	0.07	0.01	0.26	−0.05	−0.05	0.32	3.29
4	0.08	0.07	0.01	0.27	−0.07	−0.05	0.31	3.05
5	0.03	0.07	0.00	0.26	−0.06	−0.04	0.26	2.63
6	0.08	0.07	0.01	0.27	−0.08	−0.02	0.32	3.02
7	0.07	0.06	0.01	0.27	−0.09	−0.04	0.28	2.49
8	−0.05	0.06	0.01	0.27	−0.09	−0.05	0.15	1.47
9	0.02	0.06	0.00	0.25	−0.09	−0.08	0.17	1.49
10	0.15	0.08	−0.00	0.25	−0.11	−0.08	0.29	2.62

Decomposing Fama-French five-factor alphas — MGMT spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{HML}\overline{HML}$	$-\beta_{CMA}\overline{CMA}$	$-\beta_{RMW}\overline{RMW}$	α	$t(\alpha)$
0	0.37	0.01	0.02	−0.07	−0.23	−0.05	0.05	0.76
1	0.32	0.01	0.02	−0.04	−0.21	−0.06	0.04	0.53
2	0.12	0.02	0.02	−0.07	−0.15	−0.06	−0.11	−1.28
3	0.14	0.03	0.01	−0.03	−0.17	−0.07	−0.10	−1.06
4	0.02	0.02	0.01	−0.04	−0.16	−0.09	−0.25	−2.88
5	0.09	0.01	0.01	−0.05	−0.16	−0.08	−0.19	−2.10
6	0.11	0.01	−0.00	−0.05	−0.14	−0.07	−0.14	−1.50
7	0.04	−0.00	0.00	−0.02	−0.17	−0.08	−0.23	−2.47
8	0.02	−0.01	0.01	−0.06	−0.10	−0.06	−0.19	−1.79
9	0.05	0.00	0.01	−0.02	−0.10	−0.07	−0.12	−1.29
10	0.03	0.01	0.01	−0.03	−0.09	−0.06	−0.12	−1.29

Decomposing Hou-Xue-Zhang Q4 alphas — PERF spreads

Year	$ExRet$	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{ROE}\overline{ROE}$	$-\beta_{IA}\overline{IA}$	α	$t(\alpha)$
0	0.21	0.09	−0.01	−0.31	0.26	0.26	1.61
1	0.02	0.08	0.03	−0.19	0.36	0.30	2.33
2	0.01	0.08	0.04	−0.10	0.37	0.40	3.26
3	0.08	0.07	0.03	−0.07	0.29	0.40	3.28
4	0.08	0.06	0.02	−0.09	0.27	0.35	2.62
5	0.03	0.07	0.02	−0.07	0.27	0.32	2.48
6	0.08	0.07	0.02	−0.06	0.26	0.37	2.83
7	0.07	0.06	0.03	−0.07	0.26	0.34	2.46
8	−0.05	0.06	0.04	−0.09	0.25	0.20	1.54
9	0.02	0.07	0.02	−0.11	0.22	0.22	1.60
10	0.15	0.08	0.02	−0.11	0.20	0.33	2.35

Decomposing Hou-Xue-Zhang Q4 alphas — MGMT spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{ROE}\overline{ROE}$	$-\beta_{IA}\overline{IA}$	α	$t(\alpha)$
0	0.37	0.03	0.03	0.00	−0.37	0.05	0.71
1	0.32	0.02	0.02	−0.06	−0.33	−0.02	−0.31
2	0.12	0.02	0.03	−0.07	−0.29	−0.18	−2.01
3	0.14	0.04	0.02	−0.05	−0.25	−0.10	−1.00
4	0.02	0.03	0.01	−0.11	−0.26	−0.30	−2.98
5	0.09	0.02	0.01	−0.08	−0.26	−0.21	−1.90
6	0.11	0.02	−0.00	−0.06	−0.23	−0.16	−1.44
7	0.04	0.01	0.01	−0.07	−0.24	−0.24	−2.20
8	0.02	0.00	0.01	−0.08	−0.20	−0.25	−2.05
9	0.05	0.01	0.02	−0.07	−0.13	−0.12	−1.07
10	0.03	0.02	0.02	−0.06	−0.13	−0.12	−1.15

Decomposing alphas with respect to Q4 plus HML — PERF spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{ROE}\overline{ROE}$	$-\beta_{IA}\overline{IA}$	$-\beta_{HML}\overline{HML}$	α	$t(\alpha)$
0	0.21	0.11	−0.01	−0.24	−0.02	0.24	0.29	2.27
1	0.02	0.09	0.02	−0.11	0.06	0.25	0.34	3.59
2	0.01	0.10	0.04	−0.04	0.11	0.21	0.43	4.50
3	0.08	0.08	0.03	−0.00	0.03	0.22	0.44	4.64
4	0.08	0.07	0.02	−0.02	−0.01	0.24	0.38	3.72
5	0.03	0.08	0.02	0.00	−0.00	0.23	0.35	3.60
6	0.08	0.08	0.02	0.01	−0.01	0.23	0.41	3.87
7	0.07	0.07	0.03	−0.01	−0.01	0.23	0.38	3.29
8	−0.05	0.07	0.03	−0.03	−0.01	0.22	0.23	2.10
9	0.02	0.08	0.02	−0.05	−0.02	0.20	0.25	2.11
10	0.15	0.09	0.01	−0.05	−0.05	0.21	0.36	3.16

Decomposing alphas with respect to Q4 plus HML — MGMT spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{SMB}\overline{SMB}$	$-\beta_{ROE}\overline{ROE}$	$-\beta_{IA}\overline{IA}$	$-\beta_{HML}\overline{HML}$	α	$t(\alpha)$
0	0.37	0.03	0.03	−0.03	−0.26	−0.09	0.04	0.57
1	0.32	0.02	0.02	−0.07	−0.25	−0.06	−0.03	−0.45
2	0.12	0.02	0.03	−0.09	−0.19	−0.08	−0.20	−2.35
3	0.14	0.04	0.02	−0.07	−0.18	−0.06	−0.11	−1.11
4	0.02	0.02	0.02	−0.13	−0.16	−0.08	−0.31	−3.37
5	0.09	0.02	0.01	−0.10	−0.16	−0.08	−0.22	−2.14
6	0.11	0.02	0.00	−0.08	−0.13	−0.08	−0.17	−1.65
7	0.04	0.01	0.01	−0.08	−0.17	−0.06	−0.25	−2.34
8	0.02	−0.00	0.01	−0.11	−0.10	−0.09	−0.26	−2.34
9	0.05	0.01	0.02	−0.09	−0.06	−0.06	−0.13	−1.17
10	0.03	0.02	0.02	−0.08	−0.05	−0.06	−0.13	−1.29

Decomposing alphas with respect to the CAPM plus BAB — PERF spreads

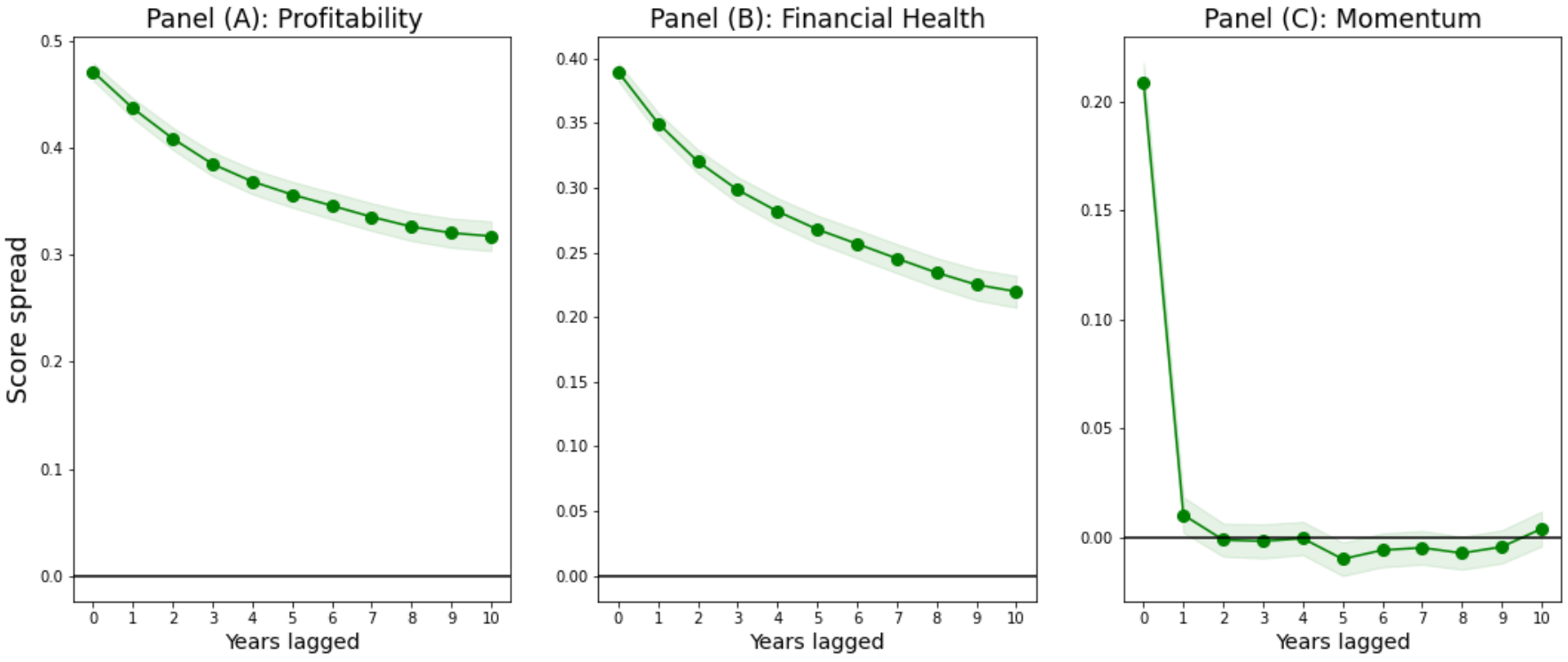
Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{BAB}\overline{BAB}$	α	$t(\alpha)$
0	0.21	0.08	0.08	0.38	2.24
1	0.02	0.05	0.22	0.29	2.12
2	0.01	0.05	0.24	0.29	2.16
3	0.08	0.04	0.24	0.36	2.84
4	0.08	0.04	0.23	0.35	2.57
5	0.03	0.04	0.24	0.31	2.44
6	0.08	0.04	0.24	0.36	2.71
7	0.07	0.04	0.22	0.33	2.25
8	−0.05	0.04	0.18	0.17	1.19
9	0.02	0.05	0.14	0.21	1.48
10	0.15	0.06	0.16	0.38	2.71

Decomposing alphas with respect to the CAPM plus BAB — MGMT spreads

Year	*ExRet*	$-\beta_{MKT}\overline{MKT}$	$-\beta_{BAB}\overline{BAB}$	α	$t(\alpha)$
0	0.37	0.11	−0.20	0.28	2.61
1	0.32	0.09	−0.20	0.21	2.10
2	0.12	0.09	−0.24	−0.04	−0.35
3	0.14	0.09	−0.22	0.01	0.07
4	0.02	0.09	−0.26	−0.15	−1.50
5	0.09	0.08	−0.26	−0.09	−0.93
6	0.11	0.07	−0.21	−0.03	−0.36
7	0.04	0.06	−0.23	−0.14	−1.36
8	0.02	0.05	−0.23	−0.16	−1.48
9	0.05	0.05	−0.19	−0.09	−0.89
10	0.03	0.06	−0.19	−0.11	−1.08

Spreads in PERF characteristics of large stocks

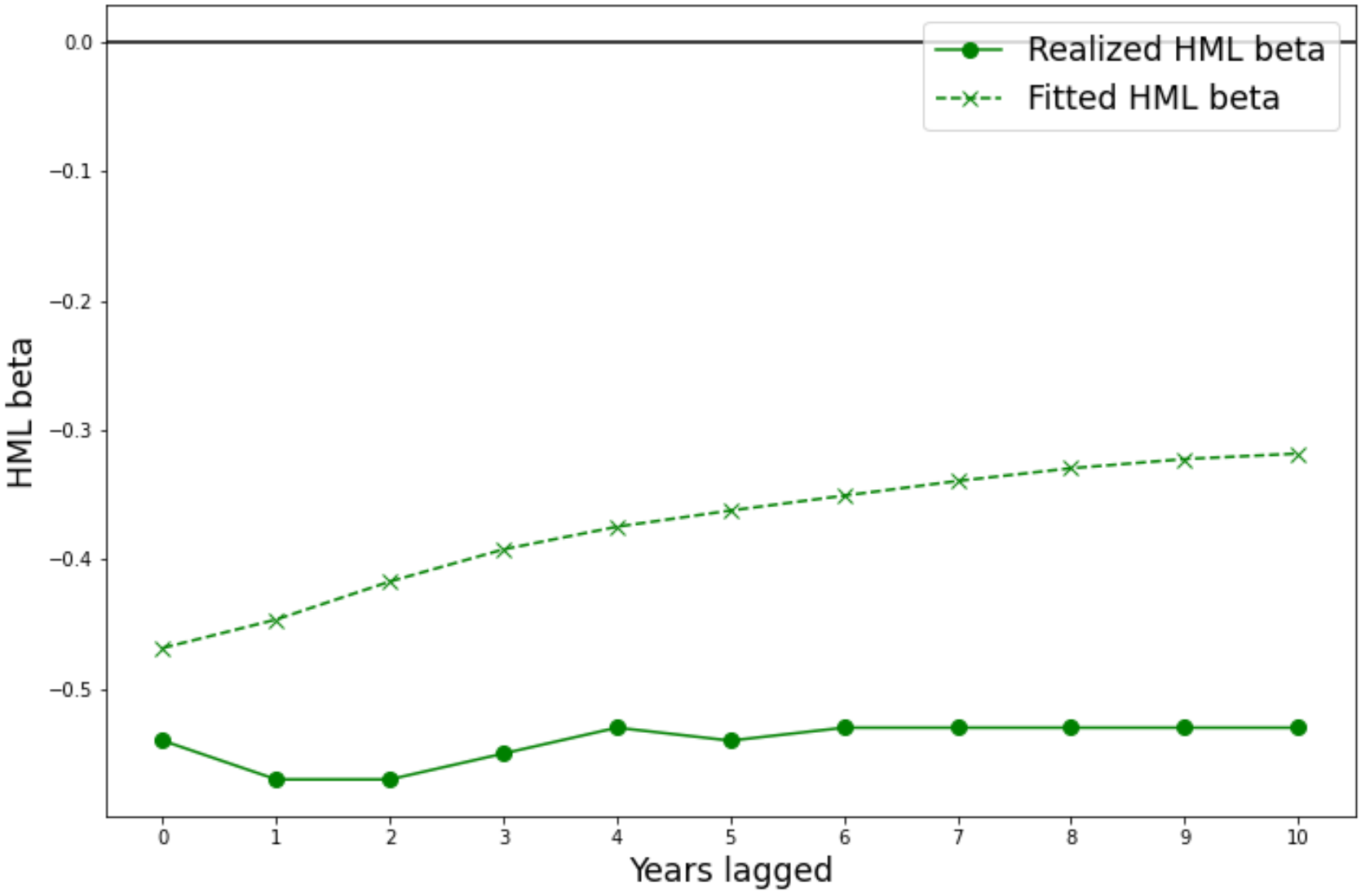
Average long-short difference in a characteristic's score for long-short spreads based on PERF scores lagged k years



Large stocks' HML betas regressed on their PERF characteristics

Characteristic	Coefficient
Profitability	−0.0087
	(−8.87)
Financial health	−0.0019
	(−1.81)
Momentum	0.0008
	(0.70)

HML betas of PERF spreads for large stocks



Large stocks' book-to-market ratios regressed on decade-old PERF characteristics and book-to-market ratios

Characteristic	Coefficient
Profitability	-0.0082
	(-3.51)
Financial health	0.0017
	(2.06)
Momentum	0.0003
	(0.35)
Book-to-market	0.1539
	(1.22)

Underreaction and persistent characteristics

- Scenario consistent with our test's rejections of multifactor models:
  - PERF, and thus PERF-spread betas, persist longer than mispricing
  - PERF imperfectly captures the mispricing that it helps identify
- Prior evidence links PERF and its characteristics to underreaction
  - PERF: Chen, Hse, Tao, Yu (2020)
  - profitability: Bouchard, Krüger, Landier, and Thesmar (2019)
  - financial health: Dichev (1998)
  - momentum: Da, Gurun, Warachka (2014)
- Hypothesis consistent with underreaction:
  - PERF is less useful in identifying mispricing, the longer a stock's PERF score has been close to its current value.

    (It's less likely the market is still underreacting to whatever information that PERF score initially captured.)

Effects of persistence in large stocks' mispricing scores

$$\text{Persistence of stock } i \text{ in month } t \;=\; \left[I(Q_{i,t}=5) - I(Q_{i,t}=1)\right] \times \sum_{\tau=13}^{120} \omega_\tau \left[M_{i,t-\tau} - 0.5\right]$$

- Stock i's PERF quintile in month t (1:most underpriced; 5:most overpriced)
- $I(Q_{i,t}=n)$ equals 1 if $Q_{i,t}=n$ and 0 otherwise
- $\omega_\tau = [10 - int((\tau-1)/12)]/9$
- $M_{i,t-\tau}$ is the percentile rank of stock i based on its PERF score in month $t-\tau$
- high (low) percentile rank corresponds to overpricing (underpricing)

Monthly alpha (t-statistic)

	Among stocks whose current scores have persisted					Least minus most	All stocks	Least minus all
Spread	Least	Next 20%	Next 20%	Next 20%	Most			
PERF	0.89	0.65	0.44	0.19	0.24	0.66	0.40	0.50
	(3.57)	(2.81)	(2.03)	(0.94)	(1.02)	(2.29)	(2.22)	(2.69)
MGMT	0.50	0.85	0.86	0.64	0.62	−0.11	0.64	−0.14
	(3.19)	(4.82)	(4.89)	(3.84)	(3.36)	(−0.49)	(5.75)	(−0.91)

BE/ME Sorts

- individual stock BE/ME
- current and decade-old industry BE/ME

	Mega-cap	Large	Medium	Small	All stocks	L/M/S GRS p-value
Panel A: Spreads based on current industry BM						
CAPM	−0.28	−0.17	−0.04	0.00	−0.15	0.4872
	(−1.93)	(−1.17)	(−0.23)	(0.02)	(−1.05)	
FF3	−0.61	−0.52	−0.47	−0.33	−0.52	< 0.0001
	(−5.14)	(−4.74)	(−3.93)	(−2.48)	(−4.74)	
FF5	−0.67	−0.63	−0.72	−0.50	−0.64	< 0.0001
	(−5.63)	(−5.48)	(−6.43)	(−3.93)	(−5.51)	
Q4	−0.59	−0.53	−0.57	−0.39	−0.51	0.0007
	(−4.13)	(−3.65)	(−3.38)	(−2.28)	(−3.35)	
CAPM+BAB	−0.53	−0.46	−0.47	−0.33	−0.46	0.0090
	(−3.63)	(−3.08)	(−2.39)	(−1.73)	(−2.96)	

BE/ME Sorts

	Mega-cap	Large	Medium	Small	All stocks	L/M/S GRS p-value
Panel B: Spreads based on decade-old industry BM						
CAPM	−0.16	−0.14	−0.09	−0.22	−0.08	0.4826
	(−1.22)	(−1.10)	(−0.64)	(−1.39)	(−0.64)	
FF3	−0.31	−0.29	−0.26	−0.44	−0.23	0.0062
	(−2.33)	(−2.42)	(−1.91)	(−2.98)	(−1.97)	
FF5	−0.33	−0.32	−0.48	−0.62	−0.30	< 0.0001
	(−2.45)	(−2.54)	(−3.42)	(−3.83)	(−2.51)	
Q4	−0.28	−0.25	−0.42	−0.57	−0.24	0.0011
	(−1.91)	(−1.82)	(−2.63)	(−3.47)	(−1.83)	
CAPM+BAB	−0.34	−0.33	−0.41	−0.49	−0.27	0.0017
	(−2.45)	(−2.49)	(−2.63)	(−3.02)	(−2.10)	

Reinterpreting related recent studies

- Cho and Polk (2020)
- Chen and Kaniel (2021)
- Keloharju, Linnainmaa, and Nyberg (2020)
- Yara, Boons, Tamoni (2020)

Conclusions

- Test whether a pricing model could hold in an efficient market
- CAPM passes but prominent multifactor models fail
- Failures occur for large stocks, in accord with power considerations
- Multifactor betas distort $E(R)$ once prices correct
- Novel evidence of underreaction in large stocks