Digesting Anomalies: An Investment Approach

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Outline

Main results

- Fama and French (1996) model fails to account for many anomalies: R&D, momentum, accruals, asset growth.
- Construct a new *q*-factor model that summarize cross section stock returns based on q-theory
- A horse race of Fama-French 3-factor model, Carhart 4-factor model, and their 4-factor model to test 80 anomalies:
  - A half of anomanies (from NYSE breakpoints and value-weighted returns) are insignificant: a wide-spread p-hacking in anomaly literature (Hou, Xue, and Zhang, 2017)
  - Among 35 significant anomalies, their model performs better than the other two

	q	Carhart model	FF3 model
Average $\hat{\alpha}$	0.20%	0.33%	0.55%
Number of significant $\hat{\alpha}$	5	19	27
Number of GRS test reject	20	24	28

Economic Model - Production Side

- A two period stochastic general equilibrium model
- Firm i at time 0 has assets A_{i0}, profitability Π_{i0}, cash flow $A_{i0}\Pi_{i0}$.
- Investment for date 0 is $I_{i0} = A_{i1}$ because assets A_{i0} depreciate at rate 100%
- Adjustment cost is in quadratic form: $(a/2)(I_{i0}/A_{i0})^2 A_{i0}$, with $a > 0$
- If $D_{i0} = A_{i0}\Pi_{i0} - I_{i0} - (a/2)(I_{i0}/A_{i0})^2 A_{i0} > 0$ then firms distribute dividends back to household
- At time 1, cash flow $A_{i1}\Pi_{i1}$, pay all as dividends because firm i does not invest at time 1 and ex-dividend price $P_{i1} = 0$

Household side

- A representative household maximizes its expected utilities: $U(C_0) + \rho E_0 [U(C_1)]$
- $P_{i0} = E_0 [M_1 (P_{i1} + D_{i1})]$ or $E_0 \left[M_1 r_{i1}^S \right] = 1$ where
  - $r_{i1}^S = (P_{i1} + D_{i1}) / P_{i0}$ is stock return
  - $M_1 = \rho U'(C_1)/U'(C_0)$

Problem and Equilibrium

- Firm i chooses I_{i0} to maximize cum-dividend equity value at time 0:
- $P_{i0} + D_{i0} = \max_{\{I_{i0}\}} A_{i0}\Pi_{i0} - I_{i0} - (a/2)(I_{i0}/A_{i0})^2 A_{i0} + E_0\left[M_1 A_{i1}\Pi_{i1}\right]$
- FOC: $1 + a\frac{I_{i0}}{A_{i0}} = E_0\left[M_1\Pi_{i1}\right]$
  - Marginal cost includes paying the purchasing price of unity and marginal adjustment cost
  - Marginal benefit is marginal profitability at time 1, discounted to time 0 using M_1
- Stock return:
- $r_{i1}^S = (P_{i1} + D_{i1})/P_{i0} = A_{i1}\Pi_{i1}/E_0\left[M_1 A_{i1}\Pi_{i1}\right] = \Pi_{i1}/E_0\left[M_1\Pi_{i1}\right]$
- Replace the FOC condition: $r_{i1}^S = \Pi_{i1}/\left(1 + a\frac{I_{i0}}{A_{i0}}\right)$

Implications

- Take expectation: $E_0\left[r_{i1}^S\right] = E_0\left[\Pi_{i1}\right] / \left(1 + a\frac{I_{i0}}{A_{i0}}\right)$
- Investment channel:
  - Firms invest more when marginal q is high and low discount rate (i.e., low cost of capital)
  - E.g., for a project $NPV = \sum \frac{CF_t}{(1+r)^t}$ then low r implies higher NPV and firms invest more
- Profitability channel:
  - High expected profitability relative to low investment must mean high discount rates
  - If discount rate is low, firms should invest more rather than less
  - Similarly, low expected profitability relative to high investment must mean low discount rate

Investment channel

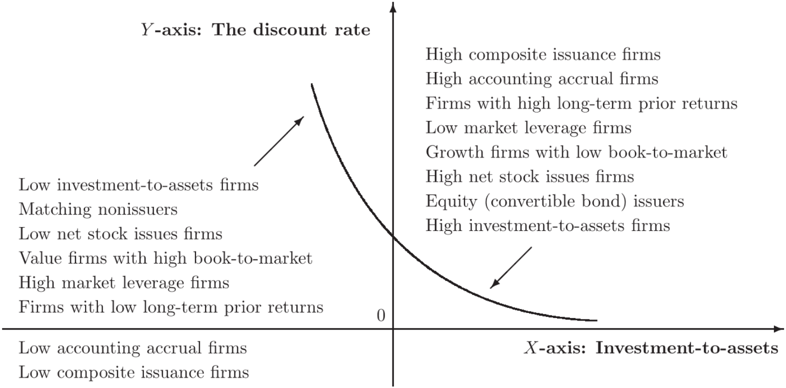

Figure: Investment channel

Explain puzzles

- Through investment channel:
  - New equity issue: issuers have more sources of funds so they invest more and earn lower returns.
  - Value premium: M/B and marginal q are highly correlated so value firms (high B/M or low M/B) have low marginal q and invest less. Thus, value firms have higher returns.
  - Long-term reversal: high valuation ratios (e.g., long-term prior returns) often results from a stream of positive shocks on fundamentals. They should invest more and earn lower returns.
- Through profitability channel:
  - Momentum: momentum winners have higher expected profitability so they earn higher expected returns.
  - Financial distress: less financial distressed firms are more profitable should earn higher expected returns.

Data

- CRSP data on monthly return, dividends, and price
- Accounting data from Compustat
- Sample from Jan 1972 to Dec 2012
- Financial firms and negative book equity firms are excluded

Empirical model: 4 factors

- The model$E[r^i] - R^f =$ $\alpha^i + \beta^i_{MKT} E[MKT] + \beta^i_{ME} E[r_{ME}] + \beta^i_{I/A} E[r_{I/A}] + \beta^i_{ROE} E[r_{ROE}]$
- Investment-to-Asset: annual change in total assets divided by 1-year-lagged total assets
- ROE: income before extraordinary items divided by 1-quarter-lagged book equity
- Construct the q-factors from $2 \times 3 \times 3$ from independently sort on size, I/A, ROE
  - Size: use median
  - I/A and ROE: use 30%-40%-30%
  - Use NYSE breakpoints and value-weighted returns
- Totally, we have 18 portfolios and their monthly stock returns
- Size factor $r_{ME} = \overline{9\ small} - \overline{9\ big}$
- Investment factor: $r_{I/A} = \overline{6\ low\ I/A} - \overline{6\ high\ I/A}$
- Profitability factor: $r_{ROE} = \overline{6\ high\ ROE} - \overline{6\ low\ ROE}$

Descriptive statistics

- FF3 and Carhart models fail to capture average returns of q-factors
- In contrast, q-factor model could explain the HML and UMD
- Harvey, Liu, Zhu (2013) suggest a newly discovered factor should have $t > 3$

Panel A: Descriptive statistics

	Mean	α	β_{MKT}	β_{SMB}	β_{HML}	β_{UMD}	R^2
r_{ME}	0.31	0.23	0.17				0.06
	(2.12)	(1.62)	(4.33)				
		0.04	0.02	0.99	0.17		0.93
		(1.09)	(1.59)	(57.37)	(7.05)		
		0.01	0.02	0.99	0.19	0.03	0.94
		(0.15)	(2.40)	(61.51)	(7.34)	(2.16)	
$r_{I/A}$	0.45	0.52	−0.15				0.13
	(4.95)	(5.93)	(−5.58)				
		0.33	−0.06	−0.02	0.39		0.50
		(4.85)	(−3.66)	(−0.81)	(11.98)		
		0.28	−0.05	−0.02	0.41	0.05	0.52
		(3.85)	(−3.24)	(−0.87)	(11.94)	(1.97)	
r_{ROE}	0.58	0.63	−0.11				0.04
	(4.81)	(5.62)	(−2.38)				
		0.77	−0.09	−0.33	−0.20		0.20
		(6.94)	(−2.08)	(−5.75)	(−2.38)		
		0.50	−0.03	−0.33	−0.10	0.28	0.40
		(4.75)	(−0.98)	(−4.38)	(−1.48)	(6.27)	

Figure: Descriptive statistics

Correlation matrix

- r_{ME} and SMB correlation is 95%: well resemble size effect
- $r_{I/A}$ and HML correlation is 69%, so *investment* plays the role of B/M in this model
- r_{ROE} and UMD correlation is 50%, so *profitability* plays the role of *momentum* in this model

Panel B: Correlation matrix (p-values)

	$r_{I/A}$	r_{ROE}	MKT	SMB	HML	UMD
r_{ME}	−0.11	−0.31	0.25	0.95	−0.07	0.01
	(0.02)	(0.00)	(0.00)	(0.00)	(0.13)	(0.90)
$r_{I/A}$		0.06	−0.36	−0.22	0.69	0.05
		(0.20)	(0.00)	(0.00)	(0.00)	(0.31)
r_{ROE}			−0.19	−0.38	−0.09	0.50
			(0.00)	(0.00)	(0.06)	(0.00)
MKT				0.28	−0.32	−0.15
				(0.00)	(0.00)	(0.00)
SMB					−0.23	−0.01
					(0.00)	(0.79)
HML						−0.15
						(0.00)

Figure: Correlation matrix

Anomalies

- Table 2 presents 80 anomalies that will be tested
- 6 categories:
    1. Momentum: earning momentum and price momentum
    2. Value-versus-growth: B/M, E/P, D/P, SG, Reversal, ...
    3. Investment: I/A, Investment growth, Accruals, Stock Issues, ...
    4. Profitability: ROE, ROA, profit margin, revenue surprise
    5. Intangibles: G index, Industries, RD/Market, RD/Sale...
    6. Trading frictions: market equity, total volatility, idiosyncratic volatility, systematic volatility, dispersion earning forecast, Dimson's beta, turnover, trading volume...

Insignificant anomalies

- 38 anomalies are insignificant in broad cross section
  - 12 out of 13 anomalies in *trading frictions* are insignificant at 5%
- Harvey, Liu, and Zhu (2013): anomalies literature are likely exaggerated
- In addition, we could refer to explanations in McLean and Pontiff (2016)

	R6-1	A/ME	Rev	EF/P	D/P	O/P	SG	LTG	ACI	NXF
m	0.48	0.43	−0.39	0.45	0.27	0.35	−0.27	0.01	−0.27	−0.30
t_m	1.43	1.82	−1.57	1.73	0.94	1.53	−1.34	0.02	−1.70	−1.55
	TA	RNA	PM	ATO	CTO	F	TES	TI/BI	RS	O
m	−0.19	0.13	0.10	0.22	0.20	0.37	0.32	0.13	0.29	−0.08
t_m	−1.31	0.61	0.40	1.11	1.11	1.28	1.92	0.86	1.82	−0.37
	BC/A	RD/S	RC/A	H/N	G	AccQ	ME	Ivol	Tvol	MDR
m	0.18	0.01	0.32	−0.25	0.03	−0.18	−0.24	−0.54	−0.37	−0.31
t_m	0.73	0.06	1.27	−1.47	0.09	−0.79	−0.90	−1.56	−0.95	−0.94
	β	D-β	S-Rev	Disp	Turn	1/P	Dvol	Illiq		
m	−0.13	0.07	−0.31	−0.33	−0.12	−0.00	−0.26	0.27		
t_m	−0.36	0.30	−1.39	−1.24	−0.43	−0.01	−1.30	1.14		

Figure: Insignificant anomalies

Significant anomalies

- 35 significant anomalies in the broad cross section
- They compare between q-factor and FF3 and Carhart models
  - Average high-minus-low $|\bar{\alpha_q}| = 0.2\%/month$, 0.33% for Carhart, and 0.55% for FF3
  - Only 5/35 q-alphas are significant at 5%; 19 for Carhart and 27 for FF3

	SUE-1	SUE-6	Abr-1	Abr-6	RE-1	RE-6	R6-6	R11-1	I-Mom
m	0.45	0.24	0.73	0.30	0.89	0.60	0.85	1.18	0.51
α	0.50	0.27	0.76	0.31	1.02	0.71	0.92	1.29	0.58
α_{FF}	0.55	0.39	0.84	0.38	1.20	0.94	1.12	1.52	0.68
α_C	0.34	0.18	0.62	0.19	0.56	0.37	0.06	0.09	−0.18
α_q	0.16	0.02	0.64	0.26	0.12	0.03	0.24	0.24	0.00
t_m	3.59	2.17	5.50	3.11	3.43	2.58	3.17	3.52	2.33
t	4.26	2.68	5.84	3.33	4.13	3.28	3.63	4.18	2.68
t_{FF}	4.50	3.62	5.93	3.89	4.81	4.52	4.47	4.99	3.25
t_C	2.62	1.69	4.37	2.06	2.56	2.15	0.51	0.67	−1.11
t_q	1.12	0.18	4.07	2.18	0.43	0.14	0.71	0.54	0.01
$\overline{\|\alpha\|}$	0.16	0.11	0.13	0.08	0.19	0.14	0.17	0.21	0.16
$\overline{\|\alpha_{FF}\|}$	0.17	0.13	0.16	0.11	0.27	0.23	0.19	0.26	0.15
$\overline{\|\alpha_C\|}$	0.11	0.09	0.12	0.08	0.11	0.09	0.10	0.13	0.06
$\overline{\|\alpha_q\|}$	0.05	0.07	0.13	0.07	0.10	0.11	0.08	0.13	0.13
p	0.00	0.00	0.00	0.01	0.04	0.21	0.00	0.00	0.09
p_{FF}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
p_C	0.00	0.00	0.00	0.01	0.16	0.12	0.00	0.00	0.45
p_q	0.42	0.04	0.00	0.02	0.46	0.08	0.00	0.01	0.03

Figure: Significant anomalies

Exclude size in q-factor

- An alternative 3-factor q-factor model without size, repeat an old version of Chen, Novy-Marx, Zhang (2011)
  - Chen, Novy-Marx, Zhang (2011) is not published yet
  - In acknowledgment of this paper, *"a timing error in the empirical analysis of the previous work"*

	SUE-1	SUE-6	Abr-1	Abr-6	RE-1	RE-6	R6-6	R11-1	I-Mom
α_3^q	0.21	0.07	0.67	0.30	0.05	−0.05	0.37	0.42	0.15
t_3^q	1.43	0.42	3.95	2.48	0.18	−0.22	0.96	0.85	0.48
$\overline{\lvert\alpha_3^q\rvert}$	0.05	0.07	0.12	0.08	0.14	0.15	0.10	0.16	0.09
p_3^q	0.62	0.13	0.00	0.00	0.20	0.02	0.00	0.00	0.10
	NSI	CEI	IvG	IvC	OA	POA	PTA	ROE	ROA
α_3^q	−0.18	−0.10	0.03	−0.28	−0.44	−0.06	−0.01	−0.14	−0.09
t_3^q	−1.18	−0.65	0.23	−1.86	−2.83	−0.38	−0.05	−0.84	−0.60
$\overline{\lvert\alpha_3^q\rvert}$	0.10	0.12	0.15	0.11	0.13	0.09	0.11	0.10	0.09
p_3^q	0.04	0.01	0.01	0.26	0.02	0.07	0.04	0.03	0.55

Figure: Alternative q-factor without size factor

3-factor vs. 4-factor q-factor

- In 4-factor q-factor model, across 35 anomalies: high-minus-low $|\bar{\alpha_q}| = 0.2\%/month$
- In 3-factor q-factor model, high-minus-low $|\bar{\alpha_q}| = 0.23\%/month$
- Still beats 0.33% in Carhart and 0.55% in FF3
- Across all deciles, the $|\bar{\alpha_q}| = 0.11\%/month$ in 4-factor, 0.12% in 3-factor, compared to 0.12% in Carhart, and 0.16% in FF3
- Conclusion: size factor plays only a limited role in the q-factor model's success

Q-factor loading (1)

- Look at the beta of the q-factor: I/A and ROE and their significance
- Momentum anomalies: come from *high loading on profitability*
- Value premium: come from *high loading on investment*
- ROE, ROA: from profitability
- Others: either profitability or investment

Q-factor loading (2)

	SUE-1	SUE-6	Abr-1	Abr-6	RE-1	RE-6	R6-6	R11-1	I-Mom
β_{MKT}	−0.08	−0.06	−0.06	−0.03	−0.05	−0.07	−0.09	−0.14	−0.11
β_{ME}	0.10	0.09	0.07	0.09	−0.15	−0.19	0.27	0.40	0.31
$\beta_{I/A}$	0.02	−0.11	−0.13	−0.16	0.04	−0.12	−0.07	0.04	−0.03
β_{ROE}	0.48	0.45	0.28	0.18	1.33	1.12	1.02	1.48	0.82
$t_{\beta_{MKT}}$	−1.82	−1.53	−1.31	−1.20	−0.76	−1.24	−1.17	−1.43	−1.72
$t_{\beta_{ME}}$	1.94	1.27	0.67	1.82	−1.42	−1.98	1.43	1.74	1.86
$t_{\beta_{I/A}}$	0.18	−0.97	−1.25	−2.24	0.25	−0.82	−0.27	0.12	−0.13
$t_{\beta_{ROE}}$	5.75	5.95	3.26	2.94	10.09	9.96	5.31	5.67	4.90
ME	0.69	0.75	−0.01	0.03	0.77	0.87	0.40	0.52	0.62
I/A	−1.46	−0.96	−1.37	−1.13	−0.80	0.72	−4.07	−3.83	−1.18
ROE	5.80	3.38	1.59	1.49	6.58	6.47	4.14	5.34	1.61
t_{ME}	4.91	5.38	−0.29	1.31	8.75	9.65	4.92	4.95	3.67
$t_{I/A}$	−3.30	−2.57	−2.36	−2.58	−1.22	1.13	−5.54	−4.66	−1.79
t_{ROE}	16.46	19.07	13.38	15.47	29.77	27.86	16.00	17.06	10.24

Figure: Q-factor loading

Selected anomalies

- Momentum: earning (SUE-1) and price momentum (R6-6)
- Operating Accruals (OA) and Percent Operating Accruals (POA)
- 25 size-B/M sorted portfolios: as in Fama and French (1993, 1996)
- Sharpe ratios

Earning Momentum

- q-factor captures momentum via ROE factor
- High (low) B/M firms have higher (lower) ROE, so they have higher (lower) expected returns

Panel A: SUE-1

	Low	2	3	4	5	6	7	8	9	High
m	0.36	0.34	0.35	0.28	0.44	0.43	0.64	0.64	0.64	0.80
α	−0.13	−0.15	−0.15	−0.20	−0.01	−0.03	0.20	0.18	0.19	0.38
α_{FF}	−0.12	−0.15	−0.15	−0.18	−0.01	−0.02	0.21	0.24	0.21	0.43
α_C	0.00	−0.06	−0.07	−0.10	0.01	0.02	0.21	0.16	0.13	0.34
t_m	1.47	1.41	1.36	1.17	2.00	1.86	3.01	3.06	2.96	3.89
t	−1.39	−1.92	−1.88	−2.38	−0.18	−0.35	2.58	2.54	2.64	5.14
t_{FF}	−1.29	−1.73	−1.75	−2.30	−0.08	−0.28	2.81	3.43	2.87	5.86
t_C	0.01	−0.69	−0.80	−1.18	0.07	0.29	2.63	2.13	1.69	4.55
The q-factor model regressions										
α_q	0.05	0.00	0.04	0.05	0.00	−0.03	0.09	0.02	0.04	0.21
β_{MKT}	1.03	1.00	1.02	0.94	0.96	0.98	0.98	1.01	0.97	0.95
β_{ME}	−0.16	0.04	0.00	0.02	0.00	−0.04	−0.05	−0.03	0.01	−0.05
$\beta_{I/A}$	0.00	−0.16	−0.12	−0.25	0.06	0.03	0.06	0.07	0.06	0.02
β_{ROE}	−0.22	−0.12	−0.20	−0.19	−0.06	−0.01	0.13	0.21	0.20	0.26
t_q	0.42	−0.04	0.37	0.53	−0.04	−0.32	1.21	0.31	0.44	2.63
$t_{\beta_{MKT}}$	32.75	39.64	39.24	34.70	43.64	41.42	51.90	55.30	42.68	37.45
$t_{\beta_{ME}}$	−3.61	0.97	0.09	0.55	0.09	−0.85	−1.37	−1.22	0.18	−1.50
$t_{\beta_{I/A}}$	−0.01	−2.39	−1.99	−3.30	1.04	0.48	1.12	1.23	0.99	0.36
$t_{\beta_{ROE}}$	−3.19	−2.56	−3.62	−3.48	−1.53	−0.20	2.81	5.77	4.15	7.30
Characteristics in the q-factor model										
ME	1.51	1.53	1.38	1.41	1.39	1.64	1.93	1.85	1.77	2.20
I/A	11.60	11.42	10.26	8.54	6.59	7.33	7.96	8.26	9.00	10.14
ROE	−0.80	1.94	2.05	2.34	2.72	3.24	3.59	3.75	3.95	5.00

Figure: Earning momentum

Price Momentum

Panel B: R6-6

	Low	2	3	4	5	6	7	8	9	High
m	0.02	0.28	0.45	0.52	0.46	0.47	0.50	0.55	0.66	0.87
α	−0.61	−0.24	−0.02	0.07	0.03	0.04	0.07	0.11	0.18	0.31
α_{FF}	−0.68	−0.29	−0.07	0.03	−0.01	0.01	0.05	0.10	0.21	0.44
α_C	−0.03	0.16	0.25	0.24	0.11	0.03	−0.02	−0.05	−0.04	0.03
t_m	0.06	1.02	1.89	2.38	2.24	2.37	2.49	2.58	2.85	2.83
t	−3.60	−2.07	−0.28	1.00	0.47	0.84	1.61	1.78	2.40	2.13
t_{FF}	−4.34	−2.49	−0.89	0.40	−0.23	0.18	0.92	1.64	2.76	3.38
t_C	−0.29	2.18	4.24	4.27	1.77	0.55	−0.27	−0.88	−0.63	0.34
The q-factor model regressions										
α_q	0.00	0.04	0.11	0.11	−0.01	−0.07	−0.10	−0.11	−0.04	0.24
β_{MKT}	1.19	1.05	1.00	0.96	0.94	0.94	0.95	0.97	1.03	1.10
β_{ME}	0.16	−0.04	−0.08	−0.08	−0.06	−0.05	−0.02	0.04	0.13	0.43
$\beta_{\mathrm{I/A}}$	−0.34	−0.08	0.02	0.07	0.09	0.14	0.16	0.12	0.02	−0.40
β_{ROE}	−0.74	−0.36	−0.20	−0.09	0.00	0.09	0.15	0.23	0.28	0.28
t_q	−0.02	0.24	0.92	1.21	−0.09	−1.32	−1.73	−1.71	−0.45	1.34
$t_{\beta_{\mathrm{MKT}}}$	24.15	25.44	35.35	40.62	42.64	49.23	55.21	55.07	38.75	27.49
$t_{\beta_{\mathrm{ME}}}$	1.42	−0.48	−1.23	−1.76	−1.22	−1.25	−0.53	1.50	3.25	4.71
$t_{\beta_{\mathrm{I/A}}}$	−2.39	−0.69	0.21	0.95	1.65	3.22	3.93	2.80	0.32	−3.27
$t_{\beta_{\mathrm{ROE}}}$	−5.87	−3.93	−2.86	−1.53	0.05	2.50	4.42	6.62	5.26	3.26
Characteristics in the q-factor model										
ME	0.46	1.15	1.61	1.90	2.07	2.18	2.16	2.07	1.73	0.86
I/A	12.62	10.46	9.48	8.83	8.79	8.62	8.71	8.63	8.44	8.56
ROE	−0.71	1.73	2.45	2.74	2.94	3.11	3.24	3.34	3.43	3.43

Figure: Price momentum

Accruals

- q-factor fails to capture the accruals. Why?
- Intuitively, because *earnings equal operating cash flows plus accruals*, *high OA firms* tend to be *more profitable* and load more heavily on the ROE factor than low OA firms. This pattern in ROE factor loadings goes in the wrong direction in capturing the OA anomaly.

Panel A: OA

	Low	2	3	4	5	6	7	8	9	High
m	0.50	0.56	0.66	0.60	0.57	0.60	0.52	0.40	0.40	0.20
α	−0.06	0.08	0.22	0.18	0.16	0.20	0.07	−0.03	−0.08	−0.39
α_{FF}	0.10	0.14	0.22	0.13	0.11	0.16	0.10	−0.04	−0.05	−0.27
α_C	0.11	0.19	0.20	0.08	0.13	0.13	0.10	0.00	−0.02	−0.22
t_m	1.71	2.38	3.15	2.97	2.77	3.07	2.40	1.76	1.67	0.65
t	−0.50	0.81	2.96	2.38	2.01	2.51	1.10	−0.39	−0.96	−3.65
t_{FF}	0.86	1.47	3.11	1.77	1.40	2.05	1.53	−0.47	−0.65	−3.22
t_C	0.98	1.74	2.58	1.08	1.54	1.56	1.46	0.02	−0.21	−2.49
The q-factor model regressions										
α_q	0.39	0.22	0.24	−0.06	0.06	−0.02	0.00	−0.12	−0.21	−0.17
β_{MKT}	1.08	1.02	0.96	0.95	0.93	0.91	0.98	0.93	1.04	1.11
β_{ME}	0.02	−0.09	−0.12	−0.03	−0.09	−0.04	−0.09	0.05	0.03	0.30
$\beta_{I/A}$	−0.56	−0.09	0.06	0.27	0.22	0.22	0.01	0.01	−0.03	−0.58
β_{ROE}	−0.26	−0.12	−0.05	0.16	0.00	0.17	0.14	0.11	0.22	0.03
t_q	3.13	1.62	3.02	−0.78	0.66	−0.19	0.00	−1.23	−2.23	−1.86
$t_{\beta_{MKT}}$	32.16	35.50	56.68	48.78	38.87	42.85	44.43	41.06	35.50	39.68
$t_{\beta_{ME}}$	0.46	−2.09	−4.28	−1.17	−2.16	−1.19	−2.55	1.19	0.82	6.79
$t_{\beta_{I/A}}$	−6.04	−0.80	1.05	5.83	2.75	3.14	0.12	0.08	−0.42	−9.86
$t_{\beta_{ROE}}$	−3.55	−1.79	−1.08	4.17	0.05	4.06	3.21	2.13	3.83	0.69
Characteristics in the q-factor model										
ME	0.81	1.48	1.93	2.21	2.37	2.14	2.37	1.78	1.46	0.58
I/A	13.87	9.06	7.72	7.37	7.45	7.78	8.63	7.13	11.49	24.02
ROE	1.88	2.61	2.90	2.91	2.86	2.90	3.09	2.94	2.89	2.75

25 size-B/M portfolios

- The q-factor model performs similarly FF3 and Carhart models
- $|\bar{\alpha_q}| = 0.11\%/month$, similar to 0.10% of FF3 and 0.11% of Carhart
- In q-factor, 4 out of 25 have significant alpha, compared to 5 in FF3 and 5 in Carhart

Sharpe ratios

- In the mean-variance framework, a factor model can account for all the anomalies if and only if the efficient portfolio from combining all the anomaly portfolios lies in the span of the factors.
- As such, the efficient combination of the factors should have a Sharpe ratio that is greater than or equal to the maximum Sharpe ratio from combining all the anomaly portfolios.
- In other words, a good model should have higher Sharpe ratio
  - Each factor Sharpe ratio: I/A and ROE are highest
  - Maximum Sharpe ratio of model: q-factor Sharpe ratio = 0.43

Panel A: Sharpe ratios

MKT	SMB	HML	UMD	r_{ME}	$r_{\mathrm{I/A}}$	r_{ROE}
0.10	0.06	0.13	0.16	0.10	0.24	0.22

Panel B: Maximum Sharpe ratios

CAPM	FF	Carhart	q
0.10	0.21	0.30	0.43

Figure: Sharpe ratio of models

Anomalies' maximum Sharpe ratios

- q-factor model is more effective than Carhart and FF3
- But q-factor model is by no means perfect in capturing all anomalies
- A pooled 28 out of 35 high-minus-low anomalies produces a maximum Sharpe ratio of $0.48 > 0.43$

Conclusion

- About one-half of 80 anomalies earn insignificant average returns for high-minus-low deciles formed with NYSE breakpoints and value-weighted returns
- An q-factor model (size, market, investment, and profitability) outperform FF3 and Carhart in capturing many (but not all) of significant anomalies
- Can solve many puzzles: value premium, momentum, new issues.
- But what the model leaves: accruals

A parallel model

- A very similar model: 5-factor Fama-French model
  - Include 5 factor: market, SMB, HML, RMW, and CMA
  - But, they argue that HML may be a redundant factor
  - So what does it leaves:
    - Market
    - SMB or r_{ME}
    - CMA or $r_{I/A}$
    - RMW or r_{ROE}
  - The only difference between them is how they sort the portfolio:
    - q-factor: $2 \times 3 \times 3$
    - FF5: $2{\times}2{\times}2{\times}2$ for four sort and 2×3 or 2×2 for two sort (with size)

Fama and French's critics

- Why not include the B/M factor?
  - May be because $\rho(I/A, HML) = 0.69$
  - But HML is redundant as they discuss, why we need it?
- Restricted because not show different way to form the factors (i.e., different sorts)
- Focus on univariate sort on each anomaly and value-weighted returns. This leads to portfolio return is dominated by big stocks but the anomalies are more pronounced in small stocks.

Thank you

Thank you for your listening and welcome for your comments and questions.

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