

Risk Factors in Equity Markets Cont'd

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Outline

- 1 A Five-Factor Asset Pricing Model
 - Fama and French (2015)

Insight

[DCF]

- According to the dividend discount model, the market value of a share of stock is the discounted value of expected dividends per share:

$$m_t = \sum_{\tau=1}^{\infty} \frac{E(d_{t+\tau})}{(1+r)^{\tau}}$$

- m_t is the share price at time t
 - $E(d_{t+\tau})$ is the expected dividend per share for period $t + \tau$
 - r is the IRR on expected dividends (approximately equal to the long-term average expected stock return)
- \Rightarrow if at time t , the stocks of two firms have the same expected dividends but different prices, the stock with a lower price has a higher (long-term average) expected return.

Insight Cont'd

- Modigliani and Miller (1961) show that the time t total market value of the firm's stock implied by the above equation is

$$M_t = \sum_{\tau=1}^{\infty} \frac{E(Y_{t+\tau} - dB_{t+\tau})}{(1+r)^\tau}$$

$$\Rightarrow \frac{M_t}{B_t} = \frac{\sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau}) / (1+r)^\tau}{B_t}$$

$$\frac{B_t}{M_t}$$

book to
market

$$\frac{E(Y_{t+\tau})}{B_t}$$

profitability

$$\frac{dB_{t+\tau}}{B_t}$$

investment
growth rate

- $Y_{t+\tau}$ is total equity earnings for period $t + \tau$.
 - $dB_{t+\tau}$ is the change in total book equity. *additional investment*
- \Rightarrow keeping everything else fixed:

- ① A lower value of M_t , or higher B_t/M_t , implies higher expected return.
 - ② Higher expected earnings imply a higher expected return.
 - ③ Higher expected growth in book equity (investment) implies a lower expected return.
- In other words, B_t/M_t is a noisy proxy for expected return because the market cap M_t also responds to forecasts of earnings and investment.

A Five-Factor Model

primary factors suggested by DCF

- Much of the variation in average returns related to **profitability and investment** is left unexplained by the Fama and French 3-factor model (Novy-Marx (2013); Titman, Wei, and Xie (2004)).
- Motivated by this evidence, Fama and French (2015) add profitability and investment factors to the 3-factor model:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_{i,m}(r_{m,t} - r_{f,t}) + \beta_{i,SMB}r_{SMB,t} + \beta_{i,HML}r_{HML,t} + \beta_{i,RMW}r_{RMW,t} + \beta_{i,CMA}r_{CMA,t} + \varepsilon_{i,t}$$

- $r_{RMW,t}$ is the difference between the returns on diversified portfolios of stocks with **robust and weak profitability**.
- $r_{CMA,t}$ is the difference between the returns on diversified portfolios of **low (conservative) and high (aggressive) investment firms**.
- If the exposures to the 5 factors capture all variation in expected returns, the intercept α_i is zero for all securities and portfolios i .

disentangle the dimensions of average return

poorly diversified

similar

for NYSE 7/13

→ separate breakpoints
for small and big
to divide Bim,
OP, inv.

Table 3: Construction of Factors

Sort	Breakpoints	Factors and their components
① 2 × 3 sorts on Size and B/M, or Size and OP, or Size and Inv	Size: NYSE median	$SMB_{B/M} = (SH + SN + SL)/3 - (BH + BN + BL)/3$ $SMB_{OP} = (SR + SN + SW)/3 - (BR + BN + BW)/3$ $SMB_{Inv} = (SC + SN + SA)/3 - (BC + BN + BA)/3$ $SMB = (SMB_{B/M} + SMB_{OP} + SMB_{Inv})/3$
	B/M: 30th and 70th NYSE percentiles OP: 30th and 70th NYSE percentiles Inv: 30th and 70th NYSE percentiles	$HML = (SH + BH)/2 - (SL + BL)/2 = [(SH - SL) + (BH - BL)]/2$ $RMW = (SR + BR)/2 - (SW + BW)/2 = [(SR - SW) + (BR - BW)]/2$ $CMA = (SC + BC)/2 - (SA + BA)/2 = [(SC - SA) + (BC - BA)]/2$
② 2 × 2 sorts on Size and B/M, or Size and OP, or Size and Inv	Size: NYSE median	$SMB = (SH + SL + SR + SW + SC + SA)/6 - (BH + BL + BR + BW + BC + BA)/6$ $HML = (SH + BH)/2 - (SL + BL)/2 = [(SH - SL) + (BH - BL)]/2$ $RMW = (SR + BR)/2 - (SW + BW)/2 = [(SR - SW) + (BR - BW)]/2$ $CMA = (SC + BC)/2 - (SA + BA)/2 = [(SC - SA) + (BC - BA)]/2$
	B/M: NYSE median OP: NYSE median Inv: NYSE median	
③ 2 × 2 × 2 sorts on Size, B/M, OP, and Inv	Size: NYSE median	$SMB = (SHRC + SHRA + SHWC + SHWA + SLRC + SLRA + SLWC + SLWA)/8$ $- (BHRC + BHRA + BHWC + BHWA + BLRC + BLRA + BLWC + BLWA)/8$ $HML = (SHRC + SHRA + SHWC + SHWA + BHRC + BHRA + BHWC + BHWA)/8$ $- (SLRC + SLRA + SLWC + SLWA + BLRC + BLRA + BLWC + BLWA)/8$ $RMW = (SHRC + SHRA + SLRC + SLRA + BHRC + BHRA + BLRC + BLRA)/8$ $- (SHWC + SHWA + SLWC + SLWA + BHWC + BHWA + BLWC + BLWA)/8$ $CMA = (SHRC + SHWC + SLRC + SLWC + BHRC + BHWC + BLRC + BLWC)/8$ $- (SHRA + SHWA + SLRA + SLWA + BHRA + BHWA + BLRA + BLWA)/8$
	B/M: NYSE median	
	OP: NYSE median	
	Inv: NYSE median	

Table 4: Summary Statistics of Factors

Statistically and economically significant

Panel A: Averages, standard deviations, and t-statistics for monthly returns

2 × 3 Factors

2 × 2 Factors

2 × 2 × 2 Factors

	R_{M-R_f}	SMB	HML	RMW	CMA	R_{M-R_f}	SMB	HML	RMW	CMA	R_{M-R_f}	SMB	HML	RMW	CMA
Mean	0.50	0.29	0.37	0.25	0.33	0.50	0.30	0.28	0.17	0.22	0.50	0.30	0.30	0.25	0.14
Std dev.	4.49	3.07	2.88	2.14	2.01	4.49	3.13	2.16	1.52	1.48	4.49	2.87	2.13	1.49	1.29
t-Statistic	2.74	2.31	3.20	2.92	4.07	2.74	2.33	3.22	2.79	3.72	2.74	2.60	3.43	4.09	2.71

	HML_{15}	HML_{60}	HML_{120}	RMW_{15}	RMW_{60}	RMW_{120}	CMA_{15}	CMA_{60}	CMA_{120}
2 × 3 factors									
Mean	0.53	0.21	0.32	0.33	0.17	0.16	0.45	0.22	0.23
Std dev.	3.24	3.11	2.69	2.69	2.35	2.68	2.00	2.66	2.47
t-Statistic	4.05	1.69	2.94	3.06	1.81	1.48	5.49	2.00	2.29
2 × 2 Factors									
Mean	0.40	0.16	0.24	0.22	0.13	0.09	0.33	0.11	0.22
Std dev.	2.39	2.36	1.97	1.93	1.69	2.00	1.53	1.87	1.70
t-Statistic	4.16	1.68	3.05	2.76	1.86	1.09	5.37	1.50	3.17
2 × 2 × 2 Factors									
Mean	0.37	0.22	0.16	0.30	0.21	0.09	0.23	0.07	0.17
Std dev.	2.40	2.36	2.01	2.18	1.53	2.22	1.23	1.58	1.59
t-Statistic	3.83	2.28	1.91	3.41	3.38	1.02	4.64	1.03	2.56

Panel B: Correlations between different versions of the same factor

SMB

HML

RMW

CMA

	2 × 3	2 × 2	2 × 2 × 2	2 × 3	2 × 2	2 × 2 × 2	2 × 3	2 × 2	2 × 2 × 2	2 × 3	2 × 2	2 × 2 × 2
2 × 3	1.00	1.00	0.98	1.00	0.97	0.94	1.00	0.96	0.80	1.00	0.95	0.83
2 × 2	1.00	1.00	0.98	0.97	1.00	0.96	0.96	1.00	0.83	0.95	1.00	0.87
2 × 2 × 2	0.98	0.98	1.00	0.94	0.96	1.00	0.80	0.83	1.00	0.83	0.87	1.00

Panel C: Correlations between different factors

2 × 3 Factors

2 × 2 Factors

2 × 2 × 2 Factors

	R_{M-R_f}	SMB	HML	RMW	CMA	R_{M-R_f}	SMB	HML	RMW	CMA	R_{M-R_f}	SMB	HML	RMW	CMA
R_{M-R_f}	1.00	0.28	-0.30	-0.21	-0.39	1.00	0.30	-0.34	-0.13	-0.43	1.00	0.25	-0.33	-0.27	-0.42
SMB	0.28	1.00	-0.11	-0.36	-0.11	0.30	1.00	-0.16	-0.32	-0.13	0.25	1.00	-0.21	-0.33	-0.21
HML	-0.30	-0.11	1.00	0.08	0.70	-0.34	-0.16	1.00	0.04	0.71	-0.33	-0.21	1.00	0.63	0.37
RMW	-0.21	-0.36	0.08	1.00	-0.11	-0.13	-0.32	0.04	1.00	-0.19	-0.27	-0.33	0.63	1.00	0.15
CMA	-0.39	-0.11	0.70	-0.11	1.00	-0.43	-0.13	0.71	-0.19	1.00	-0.42	-0.21	0.37	0.15	1.00

Value firm don't have many growth / investment opportunity and pay a stable stream of dividends.

dispersion on unexplained average returns

5 factor model performs almost as well as 4 factor model without HML.

Table 6: HML A Redundant Factor

like 2%

	<i>Int</i> Int %	$R_M - R_F$	SMB	HML	RMW	CMA	R^2
2 × 3 Factors							
$R_M - R_F$ (marker)							
Coef	0.82		0.25	0.03	-0.40	-0.91	0.24
t-Statistic	4.94		4.44	0.38	-4.84	-7.83	
SMB							
Coef	0.39	0.13		0.05	-0.48	-0.17	0.17
t-Statistic	3.23	4.44		0.81	-8.43	-1.92	
HML							
Coef	-0.04	0.01	0.02		0.23	1.04	0.51
t-Statistic	-0.47	0.38	0.81		5.36	23.03	
RMW							
Coef	0.43	-0.09	-0.22	0.20		-0.44	0.21
t-Statistic	5.45	-4.84	-8.43	5.36		-7.84	
CMA							
Coef	0.28	-0.10	-0.04	0.45	-0.21		0.57
t-Statistic	5.03	-7.83	-1.92	23.03	-7.84		
2 × 2 Factors							
$R_M - R_F$							
Coef	0.78		0.28	-0.00	-0.43	-1.30	0.25
t-Statistic	4.80		5.09	-0.02	-3.71	-8.12	
SMB							
Coef	0.38	0.15		-0.03	-0.63	-0.18	0.17
t-Statistic	3.10	5.09		-0.36	-7.60	-1.42	
HML							
Coef	0.00	-0.00	-0.01		0.25	1.08	0.53
t-Statistic	0.01	-0.02	-0.36		5.66	23.13	
RMW							
Coef	0.30	-0.05	-0.14	0.21		-0.51	0.21
t-Statistic	5.22	-3.71	-7.60	5.66		-9.29	
CMA							
Coef	0.19	-0.08	-0.02	0.43	-0.25		0.60
t-Statistic	4.72	-8.12	-1.42	23.13	-9.29		

small and not statistically significant

Table 7: Regression Details for Size-BM Portfolios

$$R(t) - R_f(t) = a + b[R_{M}(t) - R_f(t)] + sSMB(t) + hHML(t) + rRMW(t) + cCMA(t) + e(t).$$

B/M →	Low	2	3	4	High	Low	2	3	4	High
Panel A: Three-factor intercepts: $R_M - R_f$, SMB, and HML										
	a					t(a)				
Small	-0.49	0.00	0.02	0.16	0.14	-5.18	0.07	0.40	2.88	2.37
2	-0.17	-0.04	0.12	0.07	-0.02	-2.75	-0.80	2.24	1.40	-0.38
3	-0.06	0.06	0.02	0.06	0.12	-0.98	0.92	0.33	0.96	1.66
4	0.14	-0.10	-0.04	0.07	-0.08	2.24	-1.46	-0.55	1.05	-0.94
Big	0.17	0.02	-0.07	-0.11	-0.18	3.53	0.40	-0.95	-1.86	-1.92
Panel A: Five-factor coefficients: $R_M - R_f$, SMB, HML, RMW, and CMA										
	a					t(a)				
Small	-0.29	0.11	0.01	0.12	0.12	-3.31	1.61	0.17	2.12	1.99
2	-0.11	-0.10	0.05	-0.00	-0.04	-1.73	-1.88	0.95	-0.04	-0.64
3	0.02	-0.01	-0.07	-0.02	0.05	0.40	-0.10	-1.06	-0.25	0.60
4	0.18	-0.23	-0.13	0.05	-0.09	2.73	-3.29	-1.81	0.73	-1.09
Big	0.12	-0.11	-0.10	-0.15	-0.09	2.50	-1.82	-1.39	-2.33	-0.93
	h					t(h)				
Small	-0.43	-0.14	0.10	0.27	0.52	-10.11	-4.38	3.90	10.12	17.55
2	-0.46	-0.01	0.29	0.43	0.69	-15.22	-0.45	11.77	16.78	24.44
3	-0.43	0.12	0.37	0.52	0.67	-14.70	3.71	12.28	17.07	18.75
4	-0.46	0.09	0.38	0.52	0.80	-15.18	2.76	11.03	15.88	20.26
Big	-0.31	0.03	0.26	0.62	0.85	-14.12	1.09	7.54	21.05	18.74
	r					t(r)				
Small	-0.58	-0.34	0.01	0.11	0.12	-13.26	-10.56	0.31	3.89	3.95
2	-0.21	0.13	0.27	0.26	0.21	-6.75	4.89	10.35	9.86	7.04
3	-0.21	0.22	0.33	0.28	0.33	-6.99	6.77	10.36	8.98	8.88
4	-0.19	0.27	0.28	0.14	0.25	-6.06	7.75	7.99	4.16	6.14
Big	0.13	0.25	0.07	0.23	0.02	5.64	8.79	2.07	7.62	0.49
	c					t(c)				
Small	-0.57	-0.12	0.19	0.39	0.62	-12.27	-3.46	6.59	13.15	19.10
2	-0.59	0.06	0.31	0.55	0.72	-17.76	1.94	11.27	19.39	22.92
3	-0.67	0.13	0.42	0.64	0.78	-20.59	3.64	12.52	18.97	19.62
4	-0.51	0.31	0.51	0.60	0.79	-15.11	8.33	13.35	16.41	18.03
Big	-0.39	0.26	0.41	0.66	0.73	-16.08	8.38	10.80	19.88	14.54

Problem
help a word

Table 9: Regression Details for Size-OP Portfolios

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + rRMW(t) + cCMA(t) + e(t)$$

OP →	Low	2	3	4	High	Low	2	3	4	High
Panel A: Three-factor intercepts: $R_M - R_f$, SMB, and HML										
	a					$t(a)$				
Small	-0.30	0.10	0.05	0.09	-0.02	-3.25	1.54	0.85	1.30	-0.30
2	-0.24	-0.03	0.05	0.04	0.16	-3.16	-0.55	0.94	0.58	2.08
3	-0.23	0.07	0.01	0.05	0.20	-2.27	1.04	0.14	0.79	2.51
4	-0.11	-0.02	-0.05	0.06	0.18	-1.15	-0.24	-0.73	0.96	2.43
Big	-0.17	-0.20	-0.03	0.05	0.22	-1.90	-2.94	-0.58	1.20	4.03
Panel B: Five-factor coefficients: $R_M - R_f$, SMB, HML, RMW, and CMA										
	a					$t(a)$				
Small	-0.10	0.04	-0.05	-0.05	-0.15	-1.28	0.64	-0.80	-0.80	-2.05
2	-0.05	-0.11	-0.03	-0.11	0.00	-0.83	-1.86	-0.64	-1.92	0.02
3	0.08	0.04	-0.06	-0.07	0.03	1.15	0.67	-1.05	-1.23	0.43
4	0.16	0.02	-0.12	-0.09	0.05	1.91	0.26	-1.97	-1.52	0.76
Big	0.14	-0.11	-0.03	0.02	0.08	2.08	-1.67	-0.57	0.42	1.85
	h					$t(h)$				
Small	-0.14	0.24	0.26	0.28	0.21	-3.82	8.05	9.32	9.31	6.17
2	-0.12	0.17	0.23	0.18	0.15	-3.96	5.84	9.51	6.38	5.08
3	0.00	0.14	0.21	0.19	0.09	0.11	4.36	7.68	6.74	2.93
4	0.03	0.15	0.21	0.10	0.02	0.72	4.80	7.19	3.60	0.69
Big	0.22	0.16	0.04	-0.00	-0.13	6.70	5.33	1.42	-0.19	-6.13
	r					$t(r)$				
Small	-0.67	0.21	0.30	0.47	0.45	-17.70	6.98	10.59	15.08	12.95
2	-0.60	0.21	0.29	0.45	0.55	-19.94	6.90	11.32	15.76	17.91
3	-0.76	0.03	0.24	0.38	0.57	-21.06	0.93	8.33	13.12	17.19
4	-0.75	-0.15	0.23	0.39	0.37	-18.94	-4.54	7.49	12.95	11.09
Big	-0.71	-0.26	-0.08	0.12	0.35	-21.05	-8.41	-2.82	5.66	15.54
	c					$t(c)$				
Small	-0.06	0.25	0.34	0.31	0.14	-1.42	7.58	10.89	9.08	3.76
2	-0.09	0.29	0.26	0.23	0.05	-2.65	8.94	9.52	7.44	1.56
3	-0.17	0.26	0.24	0.23	0.02	-4.41	7.31	7.89	7.49	0.65
4	-0.02	0.30	0.30	0.26	0.02	-0.41	8.56	9.08	8.12	0.48
Big	-0.03	0.23	0.19	-0.04	-0.12	-0.83	6.82	6.16	-1.82	-5.22

perform better