

Class 3: Financial Models in Quant Investing: CAPM and Beyond

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Jun Pan

**Shanghai Advanced Institute of Finance (SAIF)
Shanghai Jiao Tong University**

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Outline

- Quant investing uses quantitative signals to form portfolios:
 - ▶ Size: small-cap stocks minus big-cap stocks.
 - ▶ Value: high book-to-market stocks minus low book-to-market.
 - ▶ Momentum: past winners minus past losers.
- The key insight of the equity quant strategy:
 - ▶ Quant signals: separate the cross-section into high- and low-alpha stocks.
 - ▶ Factor investing: diversify away the unwanted idiosyncratic risk.
 - ▶ Long/short: take out the unwanted systematic.
- The economic interpretations:
 - ▶ The CAPM.
 - ▶ Market efficiency.
 - ▶ Behavioral finance.

The Fama and French Factors

- Small Minus Big:

$$R_t^{\text{SMB}} = R_t^{\text{small}} - R_t^{\text{big}}$$

- High Minus Low:

$$R_t^{\text{HML}} = R_t^{\text{value}} - R_t^{\text{growth}}$$

	Median ME	
70th BE/ME PERCENTILE	SMALL VALUE	BIG VALUE
30th BE/ME PERCENTILE	SMALL NEUTRAL	BIG NEUTRAL
	SMALL GROWTH	BIG GROWTH

The Fama-French Three-Factor Alpha and Beta's

$$R_t^i - r_f = \alpha_i + \beta_i (R_t^M - r_f) + s_i R_t^{\text{SMB}} + h_i R_t^{\text{HML}} + \epsilon_t^i$$

- β_i : the market beta.
- s_i : the size beta.
- h_i : the value beta.
- α_i : the Fama-French three-factor alpha.

Factor Exposures

$$R_t^i - r_f = \alpha_i + \beta_i (R_t^M - r_f) + s_i R_t^{\text{SMB}} + h_i R_t^{\text{HML}} + \epsilon_t^i$$

SMB beta s

	1	2	3	4	5
A	1.38	1.30	1.10	1.03	1.09
B	0.99	0.87	0.77	0.73	0.87
C	0.73	0.53	0.44	0.40	0.55
D	0.38	0.22	0.18	0.22	0.25
E	-0.24	-0.22	-0.23	-0.20	-0.08

HML beta h

	1	2	3	4	5
A	-0.29	0.04	0.28	0.46	0.70
B	-0.39	0.13	0.39	0.56	0.81
C	-0.44	0.18	0.44	0.62	0.77
D	-0.42	0.21	0.45	0.57	0.81
E	-0.36	0.09	0.30	0.60	0.76

The Explanatory Power of the Factors

- One Factor:

$$R_t^i - r_f = \alpha_i + \beta_i (R_t^M - r_f) + \epsilon_t^i$$

- Three Factors:

$$R_t^i - r_f = \alpha_i + \beta_i (R_t^M - r_f) + s_i R_t^{\text{SMB}} + h_i R_t^{\text{HML}} + \epsilon_t^i$$

R2 (%) in one-factor

	1	2	3	4	5
A	63	64	67	64	62
B	75	76	75	73	68
C	80	83	79	75	70
D	85	87	82	78	71
E	89	88	80	72	63

R2 (%) in three-factor

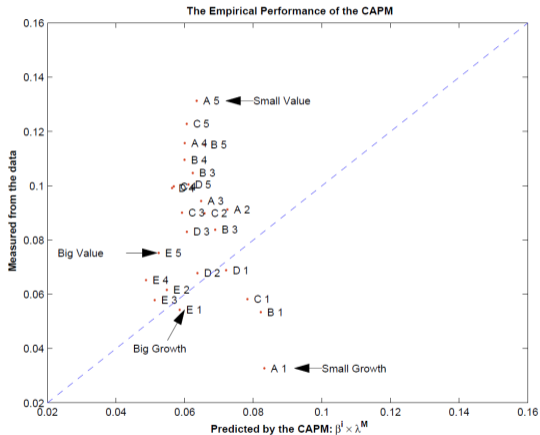
	1	2	3	4	5
A	91	94	95	94	95
B	95	94	94	94	95
C	95	91	90	90	90
D	94	89	88	89	87
E	94	90	86	89	80

The Pricing Relation

$$E(R_t^i) - r_f = \beta_i (E(R_t^M) - r_f) + s_i E(R_t^{\text{SMB}}) + h_i E(R_t^{\text{HML}})$$

	$E(R_t^M - r_f)$	$E(R_t^{\text{SMB}})$	$E(R_t^{\text{HML}})$
1962-2014	6.46% [2.64]	3.20% [1.68]	5.15% [2.78]
1927-2014	8.40% [3.81]	3.40% [2.28]	5.00% [3.33]

Fama-French 25 Portfolios and the Three-Factor Model



Peter Lynch and the Magellan Fund

$$R_t - r_f = \alpha + \beta (R_t^M - r_f) + s R_t^{SMB} + h R_t^{HML} + \epsilon_t$$

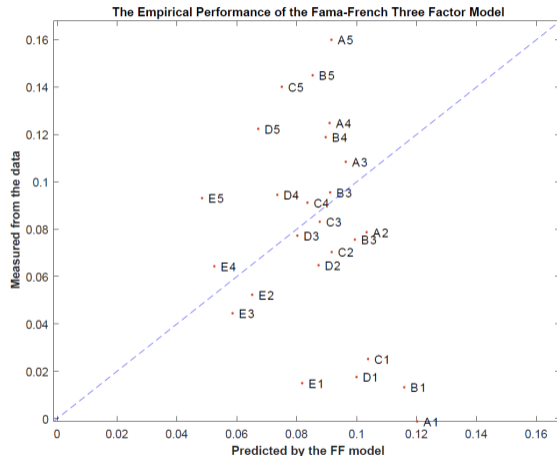
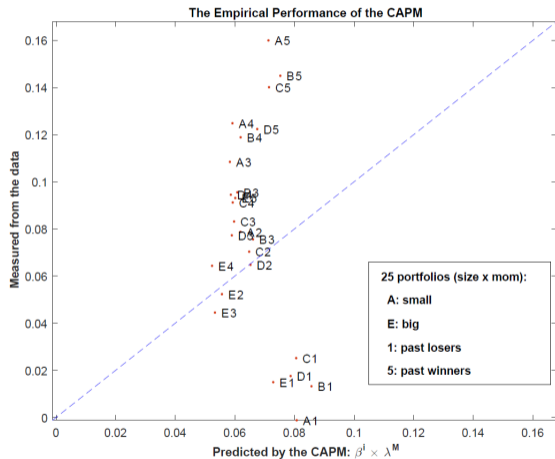
	Overall Period 76/6 – 98/12		Peter Lynch 76/6 – 90/5		Post-Lynch 90/6 – 98/12	
	estimate	s.e.	estimate	s.e.	estimate	s.e.
α	0.51	0.11	0.75	0.13	0.07	0.14
β	1.12	0.03	1.13	0.03	1.04	0.04
s	0.34	0.04	0.55	0.05	0.05	0.05
h	0.02	0.05	-0.01	0.06	0.005	0.06
R^2	0.91		0.94		0.90	

Warren Buffett and Berkshire Hathaway

Monthly returns of BRK.A from November 1976 through December 2008. The sample mean is 1.69% and the standard deviation is 7.29%.

	Full Sample 197611-200812		First Half 197611-199212		Second Half 199301-200812	
alpha	1.36%	1.11%	1.83%	1.49%	0.84%	0.69%
	[4.04]	[3.38]	[3.69]	[2.99]	[1.91]	[1.74]
Market beta	0.71	0.93	0.93	1.04	0.46	0.70
	[9.50]	[11.60]	[8.70]	[8.38]	[4.53]	[7.16]
SMB beta		-0.26		0.31		-0.57
		[-2.42]		[1.54]		[-4.83]
HML beta		0.58		0.58		0.44
		[4.67]		[2.64]		[3.18]
R^2	19.10%	26.33%	28.28%	31.68%	9.72%	29.81%

Momentum Portfolios



The Performance of Momentum Strategy in the CAPM

Annualized CAPM Alpha (in %) with t-stat's

	1	2	3	4	5
A	-8.19 [-3.31]	1.68 [1.00]	5.01 [3.33]	6.57 [4.36]	8.87 [4.64]
B	-7.25 [-3.44]	0.95 [0.65]	3.47 [2.82]	5.69 [4.54]	6.97 [4.16]
C	-5.54 [-2.78]	0.55 [0.46]	2.34 [2.18]	3.19 [3.08]	6.87 [4.58]
D	-6.11 [-3.08]	-0.05 [-0.04]	1.83 [1.98]	3.59 [4.26]	5.49 [4.03]
E	-5.79 [-3.07]	-0.33 [-0.28]	-0.88 [-1.08]	1.20 [1.46]	3.30 [2.70]

Monthly data from January 1962 through July 2015.

The Performance of Momentum Strategy in the FF3 Model

Annualized FF3 Alpha (in %) with t-stat's

	1	2	3	4	5
A	-12.14 [-6.75]	-2.46 [-2.66]	1.21 [1.56]	3.39 [4.32]	6.84 [6.20]
B	-10.27 [-6.18]	-2.38 [-2.47]	0.44 [0.60]	2.92 [4.34]	5.97 [5.82]
C	-7.86 [-4.33]	-2.13 [-2.19]	-0.45 [-0.59]	0.77 [0.97]	6.51 [5.80]
D	-8.24 [-4.24]	-2.25 [-2.06]	-0.29 [-0.36]	2.10 [2.69]	5.52 [4.55]
E	-6.68 [-3.54]	-1.28 [-1.12]	-1.41 [-1.90]	1.19 [1.57]	4.47 [3.69]

Monthly data from January 1962 through July 2015.

Momentum Profits around the World

Portfolio	Mean	Std. Dev.	t(mean)
Panel A: Country-Neutral Momentum Strategies			
All stocks (country-neutral)	0.0093	0.0239	5.36
By country:			
Austria	0.0080	0.0498	2.23
Belgium	0.0110	0.0444	3.42
Denmark	0.0109	0.0478	3.16
France	0.0097	0.0496	2.72
Germany	0.0072	0.0395	2.52
Italy	0.0093	0.0508	2.53
Netherlands	0.0126	0.0497	3.51
Norway	0.0099	0.0658	2.09
Spain	0.0132	0.0801	2.28
Sweden	0.0016	0.0632	0.36
Switzerland	0.0064	0.0428	2.08
United Kingdom	0.0089	0.0408	3.02

“International Momentum Strategies” by Rouwenhorst, *The Journal of Finance*, 1998.

The Four-Factor Model

Add MOM to the Fama-French three-factor model:

$$E(R_t^i) - r_f = \beta_i (E(R_t^M) - r_f) + s_i E(R_t^{\text{SMB}}) + h_i E(R_t^{\text{HML}}) + w_i E(R_t^{\text{MOM}})$$

where the market beta, size beta, value beta, and momentum beta can be estimated by the following regression:

$$R_t^i - r_f = \alpha_i + \beta_i (R_t^M - r_f) + s_i R_t^{\text{SMB}} + h_i R_t^{\text{HML}} + w_i R_t^{\text{MOM}} + \epsilon_t^i$$

The Factor Premiums and Volatility

From 1964 to 2014

	$E(R^M - r_f)$	$E(R^{\text{SMB}})$	$E(R^{\text{HML}})$	$E(R^{\text{MOM}})$
yearly	6.46% [2.64]	3.20% [1.68]	5.15% [2.78]	8.63% [3.47]
monthly	0.49% [2.79]	0.22% [1.79]	0.36% [3.23]	0.71% [4.27]
monthly	σ^M 4.46%	σ^{SMB} 3.08%	σ^{HML} 2.84%	σ^{MOM} 4.21%

US and Chinese Stocks

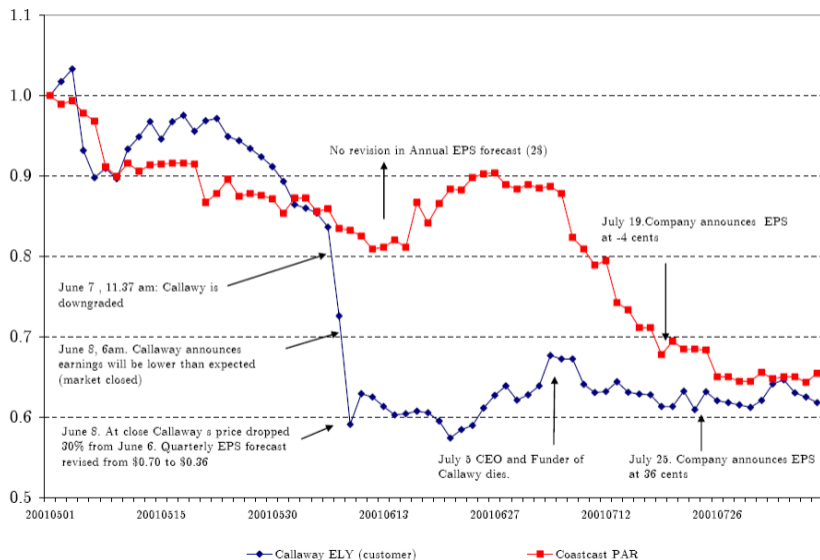
	CRSP VW	CN All	CN LG	CN Med	CN SM
Monthly Returns 1993-2018					
μ	0.83 [3.45]	1.16 [1.85]	0.99 [1.65]	1.41 [2.00]	2.02 [2.60]
σ	4.23	11.05	10.56	12.49	13.74
Monthly Returns 2000-2018					
μ	0.52 [1.79]	0.86 [1.60]	0.80 [1.52]	1.02 [1.61]	1.43 [2.08]
σ	4.33	8.16	7.96	9.60	10.42
Monthly Returns 2010-2018					
μ	1.00 [2.81]	0.28 [0.44]	0.21 [0.34]	0.40 [0.48]	0.99 [1.07]
σ	3.71	6.59	6.38	8.60	9.59

The Performance of Fidelity Magellan

Fidelity Magellan, monthly returns

manager	tenure	mean excess	alpha	market beta	SMB beta	HML beta	MOM beta
Stansky	96-05	0.37 [0.74]	0.03 [0.35]	0.99 [50.41]	-0.14 [-7.72]	-0.04 [-1.46]	-0.01 [-0.50]
Vinik	92-96	0.95 [2.26]	-0.31 [-1.19]	1.00 [9.21]	0.12 [0.88]	0.07 [0.55]	0.29 [2.37]
Smith	90-92	0.80 [0.77]	0.26 [2.09]	1.14 [36.69]	0.01 [0.30]	-0.01 [-0.21]	-0.03 [-0.82]
Lynch	76-90	1.59 [3.45]	0.64 [5.01]	1.12 [36.38]	0.49 [9.67]	0.03 [0.59]	0.16 [4.08]
Habermann	72-76	-0.83 [-0.68]	0.42 [0.64]	1.00 [7.85]	0.79 [3.52]	-0.44 [-2.25]	0.07 [0.38]
Johnson	63-72	2.45 [3.32]	0.83 [2.60]	1.10 [11.67]	1.20 [10.07]	0.13 [0.90]	0.75 [7.36]

The Economic Link between Customers and Suppliers



Portfolio Returns of Suppliers, Sorted by Past Returns of Their Customers

Value weights	xret	alpha	MKT	SMB	HML	UMD	R ²
Q1 (low)	-0.596 [-1.42]	-0.821 [-2.93]	0.989 [14.31]	0.384 [4.47]	-0.318 [-3.10]	-0.235 [-3.88]	0.626
Q2	-0.157 [-0.41]	-0.741 [-3.28]	1.057 [17.57]	0.307 [4.10]	-0.115 [-1.28]	-0.022 [-0.42]	0.658
Q3	0.125 [0.32]	-0.488 [-1.89]	1.063 [16.81]	0.309 [3.92]	-0.09 [-0.96]	-0.029 [-0.52]	0.633
Q4	0.313 [0.79]	-0.193 [-0.72]	1.039 [14.43]	0.217 [2.42]	-0.15 [-1.40]	-0.076 [-1.20]	0.564
Q5 (high)	0.982 [2.14]	0.556 [1.99]	0.982 [13.80]	0.681 [7.69]	-0.363 [-3.43]	-0.056 [-0.90]	0.650
L/S	1.578 [3.79]	1.376 [3.13]	-0.007 [-0.07]	0.296 [1.26]	-0.045 [-0.28]	0.179 [1.93]	0.041

“Economic links and predictable returns” by Cohen and Frazzini, *Journal of Finance*, 2008.

Sorting Stocks by their Options Trading Volume (Put/Call)

	day relative to portfolio formation										
	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
Panel A: average daily returns of PC-ranked portfolios (in basis points)											
low PC	31.4	25.0	15.5	12.1	11.4	10.2	9.3	6.9	8.7	7.2	7.8
PC 2	28.6	27.2	12.1	8.3	6.8	6.1	7.3	3.7	4.2	4.6	3.9
PC 3	15.5	12.5	7.1	6.1	5.4	5.6	4.6	4.6	5.2	6.4	3.6
PC 4	13.0	-0.3	3.1	2.1	6.4	4.7	5.2	6.4	6.1	5.1	7.2
high PC	-5.9	-14.6	-6.1	-0.8	-0.7	1.4	3.2	4.3	4.0	4.3	3.7
Panel B: average daily returns of low-PC minus high-PC (in basis points)											
	37.4	39.6	21.6	12.9	12.1	8.8	6.2	2.6	4.7	2.9	4.1
t-stats	19.77	23.79	13.11	8.18	7.77	5.50	3.86	1.67	2.94	1.80	2.62

"The information in option volume for future stock prices" by Pan and Poteshman, *Review of Financial Studies*, 2006.