Class 6: Equity Quant Investing, Part 1

Financial Markets, Spring 2020, SAIF

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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 intepretations:
  - The CAPM.
  - Market efficiency.
  - Behavioral finance.

Time-Series of Cross-Sectional Stock Returns

Size Sorted Portfolios

Market Capitalization = Stock Price $\times$ Number of Shares Outstanding

	Size Decile	Size (m$)	# of Stocks
Small	1	116	1362
	2	472	470
	3	912	378
	4	1,509	304
Med	5	2,308	233
	6	3,378	207
	7	5,212	225
	8	8,890	182
	9	17,244	182
Big	10	83,791	173

As of July 2015. Source: Prof. Ken French's Website.

Book-to-Market Sorted Portfolios

$$\textbf{BtM} = \text{book-to-market ratio} = \frac{\text{book value of equity}}{\text{market value of equity}}$$

	BtM Decile	BtM	# of Stocks	Size (m$)
Growth	1	0.095	432	8,440
	2	0.196	338	9,895
	3	0.269	330	10,430
	4	0.348	276	10,210
Neutral	5	0.431	314	4,726
	6	0.547	319	7,310
	7	0.654	333	2,586
	8	0.817	327	5,728
	9	0.972	378	2,878
Value	10	1.339	371	2,359

As of 2015. Source: Prof. Ken French's Website.

Sorting is Done Dynamically

- Stock characteristics fluctuate over time. Need to periodically update this information and re-sort stocks by their new characteristics. The sorting frequency depends on the variability of the signals.
- For example, Fama and French resort their size-sorted portfolios at the end of each June. A stock that was in the top size decile last year might have shrunk in size and gets re-sorted into a lower decile this year.
- So the stock composition of a characteristics-sorted portfolio changes over time. The turnover rate is higher for characteristics that move more frequently.
- For example, the momentum strategy requires you to re-sort stocks every month using past returns. Compared with the size-sorted portfolio, the momentum sorting is more frequent (once a month vs. one a year) and the sorting signal is also more variable (past returns vs. market cap).

The Fama French 25 Portfolios

- Size labels: A (small), B, C, D, and E (big).
- BtM labels: 1 (low), 2, 3, 4, and 5 (high).

	1	2	3	4	5
A	A1				A5
B					
C					
D					
E	E1				E5

A1 $\rightarrow$ small growth A5 $\rightarrow$ small value
E1 $\rightarrow$ big growth E5 $\rightarrow$ big value

Number of Stocks in Each Portfolio

- Each month, we have a cross section of stocks.
- The size of the cross section varies from month to month.
- So the portfolio size also varies from month to month.

July 2015

	1	2	3	4	5
A	269	208	285	347	542
B	159	115	134	141	82
C	107	89	89	78	55
D	120	103	75	51	35
E	115	91	50	43	35

January 1962

	1	2	3	4	5
A	7	12	32	56	92
B	25	28	46	48	50
C	31	47	43	51	29
D	60	57	47	26	18
E	81	62	35	22	11

Average Market Cap and Book-to-Market

Average Size ($M) as of July 2015

	1	2	3	4	5
A	246	235	243	240	149
B	1,220	1,201	1,211	1,135	1,084
C	2,831	2,944	2,720	2,753	2,819
D	6,860	6,863	6,895	6,806	6,737
E	48,736	56,086	56,500	44,859	40,072

Book-to-Market as of July 2015

	1	2	3	4	5
A	0.15	0.31	0.49	0.72	1.36
B	0.14	0.32	0.49	0.71	1.18
C	0.13	0.30	0.48	0.73	1.33
D	0.15	0.31	0.49	0.72	1.11
E	0.14	0.30	0.51	0.78	1.10

Testing the CAPM using 25 Fama-French Portfolios

1. For each portfolio i, we perform regression to obtain an estimate for beta:

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

2. Estimate the market risk premium:

$$\lambda^M = \frac{1}{T} \sum_{t=1}^{T} \left(R_t^M - r_f\right)$$

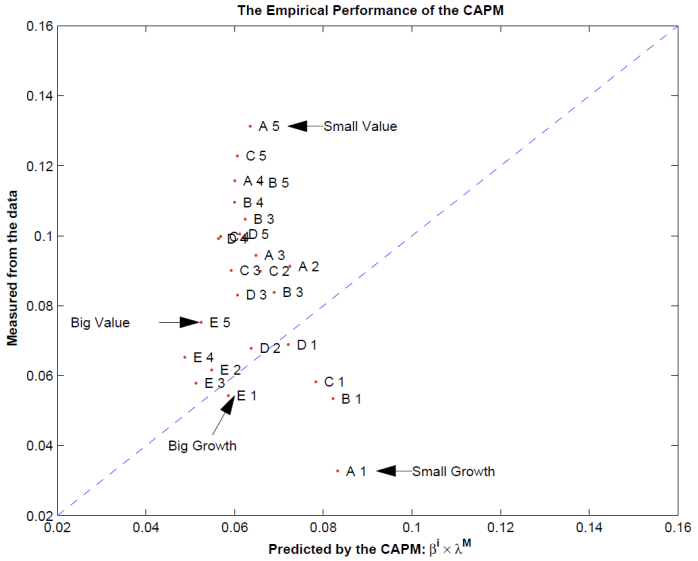
3. The risk premium of portfolio i predicted by the CAPM:

$$\beta_i \, \lambda^M$$

4. Estimate the risk premium of portfolio i using realized returns:

$$\frac{1}{T} \sum_{t=1}^{T} \left(R_t^i - r_f\right)$$

The Empirical Performance of the CAPM



The CAPM Alphas of Fama-French 25 Portfolios

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

	1	2	3	4	5
A	**-5.05** [-2.19]	1.88 [0.95]	2.95 [1.80]	**5.57** [3.46]	**6.78** [3.82]
B	-2.88 [-1.68]	1.49 [1.08]	**4.23** [3.27]	**4.96** [3.78]	**4.94** [3.06]
C	-2.01 [-1.41]	**2.40** [2.23]	**3.08** [2.83]	**4.29** [3.68]	**6.22** [4.31]
D	-0.32 [-0.30]	0.40 [0.45]	**2.24** [2.21]	**4.28** [3.96]	**3.94** [2.81]
E	-0.43 [-0.56]	0.68 [0.91]	0.66 [0.70]	1.65 [1.50]	2.28 [1.57]

Monthly data from January 1962 through July 2015.

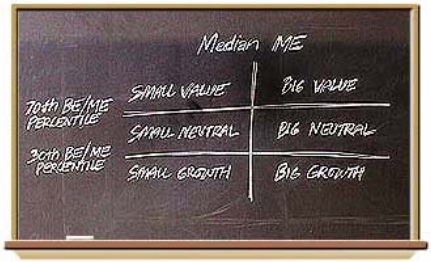
The Fama and French Factors

- Small Minus Big:

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

- High Minus Low:

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



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

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

- 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

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

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
-0.29	0.04	0.28	0.46	0.70
-0.39	0.13	0.39	0.56	0.81
-0.44	0.18	0.44	0.62	0.77
-0.42	0.21	0.45	0.57	0.81
-0.36	0.09	0.30	0.60	0.76

The Explanatory Power of the Factors

- One Factor:

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

- Three Factors:

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

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

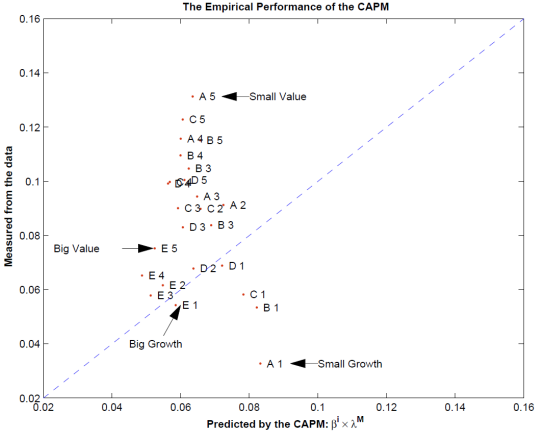
	1	2	3	4	5
A	91	94	95	94	95
B	95	94	94	94	95
C	95	91	90	90	90
D	94	89	88	89	87
E	94	90	86	89	80

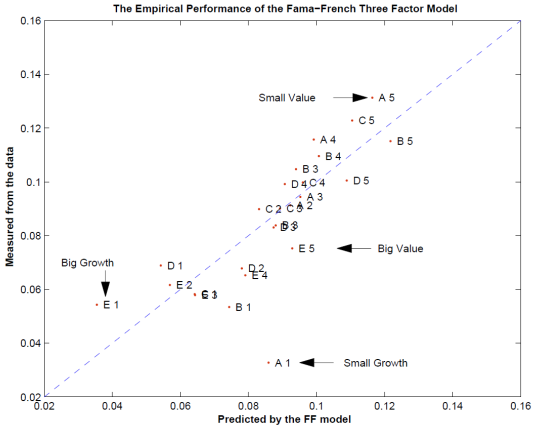
The Pricing Relation

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

	$E(R^M - r_f)$	$E(R^{\text{SMB}})$	$E(R^{\text{HML}})$
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

$$R_t - R_t^f = \alpha + \beta \left(R_t^M - R_t^f \right) + s\, R_t^{SMB} + h\, R_t^{HML} + \epsilon_t$$

	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	

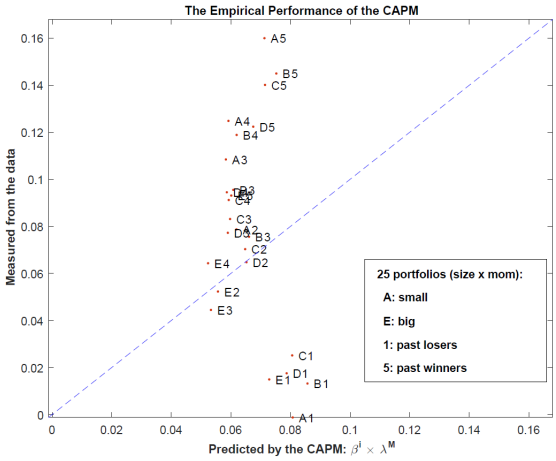
Warren Buffett and Berkshire Hathaway

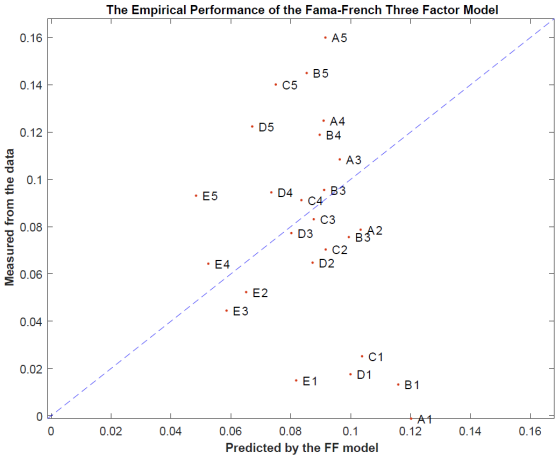
Monthly returns of BRK.A from November 1976 through December 2008. The sample mean is 1.69% and the standard deviation is 7.29%.

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

Review: CAPM and the Multifactor Model

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:

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

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

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

The Factor Premiums and Volatility

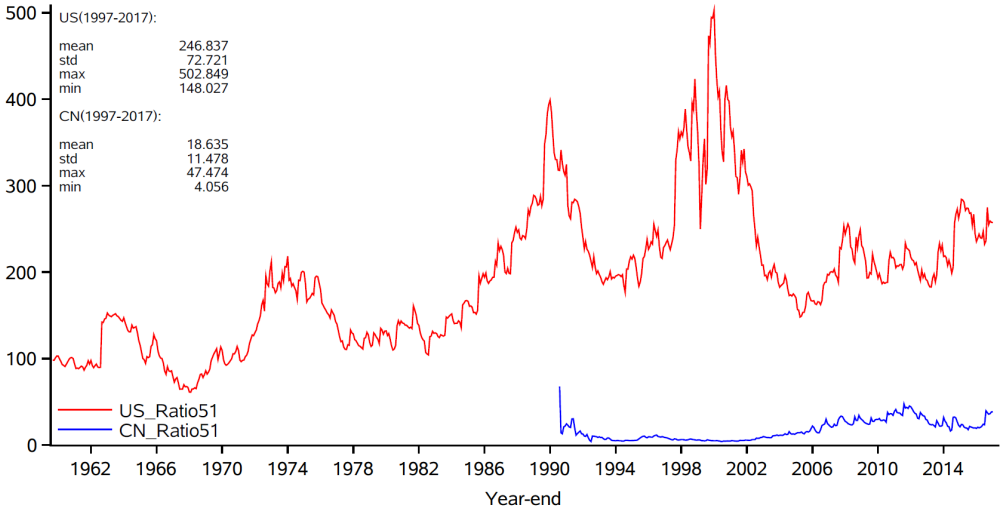
From 1964 to 2014

	$E(R^M - r_f)$	$E(R^{\text{SMB}})$	$E(R^{\text{HML}})$	$E(R^{\text{MOM}})$
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]
	σ^M	σ^{SMB}	σ^{HML}	σ^{MOM}
monthly	4.46%	3.08%	2.84%	4.21%

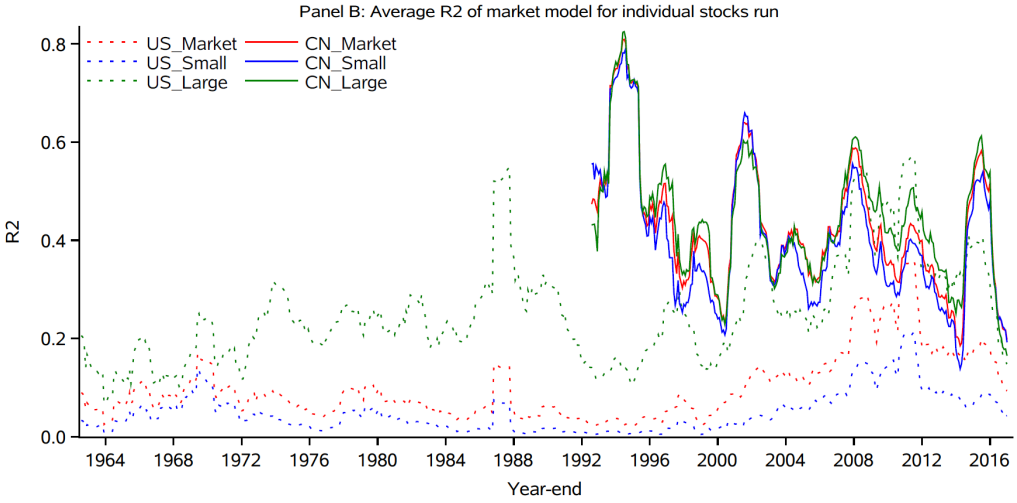
US and Chinese Stocks

	SPX	CN All	CN LG	CN Med	CN SM
		Monthly Returns 1993-2018			
μ	0.81	1.16	0.99	1.41	2.02
	[3.51]	[1.85]	[1.65]	[2.00]	[2.60]
σ	4.10	11.05	10.56	12.49	13.74
		Monthly Returns 2000-2018			
μ	0.49	0.86	0.80	1.02	1.43
	[1.75]	[1.60]	[1.52]	[1.61]	[2.08]
σ	4.20	8.16	7.96	9.60	10.42
		Monthly Returns 2010-2018			
μ	0.99	0.28	0.21	0.40	0.99
	[2.89]	[0.44]	[0.34]	[0.48]	[1.07]
σ	3.57	6.59	6.38	8.60	9.59

Ratio of Average Firm Size, US and China



Average R-Squared of Individual Stocks, US and China



Chinese Mutual Funds

Panel A. Size of Mutual Funds, by Year

	Equity				Mixed				Bond			
Year	#Funds	TNA(B)	Ret(%)	StdRet(%)	#Funds	TNA(B)	Ret(%)	StdRet(%)	#Funds	TNA(B)	Ret(%)	StdRet(%)
2007	55	323.9	12.60	18.01	80	468.1	4.95	25.08	10	23.1	1.83	3.98
2008	72	376.5	-20.86	10.38	97	488.0	-15.88	8.29	16	50.7	0.44	2.45
2009	111	723.3	13.29	6.52	121	692.7	11.72	6.15	20	32.1	-0.06	2.12
2010	143	810.4	-0.23	5.63	134	690.8	0.07	6.37	40	59.0	-0.08	2.55
2011	184	729.1	-7.64	4.39	156	601.4	-6.53	4.51	72	68.4	-1.49	2.42
2012	220	636.3	1.26	3.90	167	529.6	0.78	3.44	85	91.0	1.19	1.82
2013	270	668.6	3.57	5.98	187	531.4	2.77	5.01	125	132.5	-0.59	2.40
2014	326	616.6	5.62	7.05	210	477.0	4.38	6.37	187	135.3	4.37	5.71
2015	186	357.2	12.40	11.32	431	760.2	8.42	11.39	304	320.6	1.29	5.02
2016	42	35.8	-3.06	6.19	712	905.7	-4.78	8.07	397	632.4	-1.20	3.92
2017	123	159.5	3.21	5.94	1,020	1,300.8	2.24	5.50	456	518.2	-0.11	2.54
2018	177	171.9	-7.24	5.09	1,414	1,237.6	-4.93	5.33	639	715.1	0.28	2.70

Chinese Mutual Fund Alpha

	Stock funds		Hybrid funds		Bond funds		Money funds	
Period	200212-201812		200110-201812		200211-201812		200401-201812	
Alpha (%)	0.22	0.24	0.43	0.47	0.23	0.16	0.07	0.07
	(1.28)	(1.36)	(2.84)	(2.97)	(3.69)	(2.87)	(5.73)	(5.25)
Mkt Beta	0.79	0.79	0.61	0.61	0.07	0.08	0.00	0.00
	(39.8)	(37.66)	(33.72)	(31.99)	(9.44)	(11.66)	(-0.37)	(-0.34)
Gov't Bond Beta		-0.01		-0.10		0.08		0.01
		(-0.06)		(-0.68)		(1.53)		(0.70)
Corp Bond Beta		-0.10		-0.04		0.22		-0.01
		(-0.62)		(-0.24)		(4.21)		(-0.50)
R-square (%)	89.26	89.20	84.72	84.76	31.70	46.98	0.08	0.37
# Month	193	185	207	199	194	186	180	172

Chinese Stock Mutual Fund, Alpha (%)

	普通股票型	被动指数型	增强指数型
Period	200305-201812	200304-201812	200212-201812
Alpha	0.33	-0.15	0.16
	(1.62)	(-1.08)	(0.90)
Mkt Beta	0.78	0.90	0.87
	(32.08)	(55.92)	(41.64)
R-square	84.69%	94.36%	90.08%
# Month	188	189	193

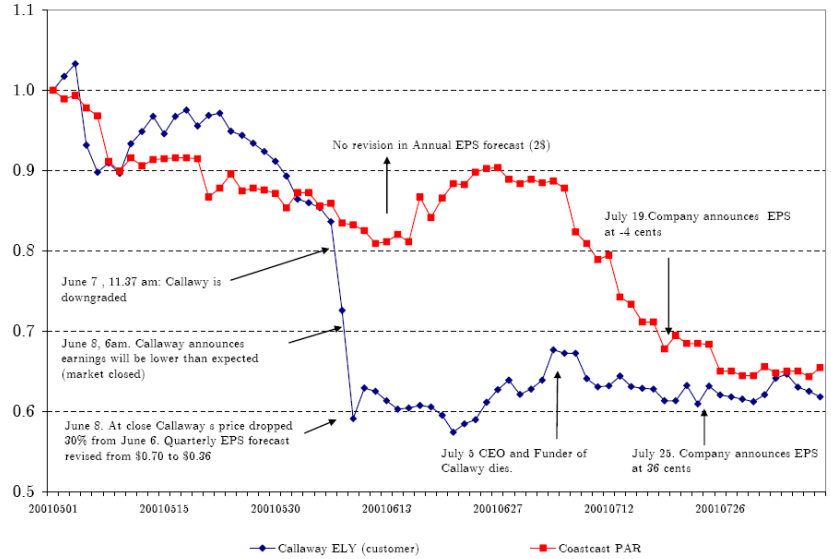
	偏股混合型	平衡混合型	偏债混合型	灵活配置型
Period	200110-201812	200110-201812	200211-201812	200307-201812
Alpha	0.37	0.40	0.42	0.45
	(1.99)	(2.72)	(4.10)	(2.64)
Mkt Beta	0.72	0.58	0.25	0.62
	(32.29)	(32.46)	(20.35)	(30.98)
R-square	83.57%	83.72%	68.21%	83.92%
# Month	207	207	195	186

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	0.03	0.99	-0.14	-0.04	-0.01
		[0.74]	[0.35]	[50.41]	[-7.72]	[-1.46]	[-0.50]
Vinik	92-96	0.95	-0.31	1.00	0.12	0.07	0.29
		[2.26]	[-1.19]	[9.21]	[0.88]	[0.55]	[2.37]
Smith	90-92	0.80	0.26	1.14	0.01	-0.01	-0.03
		[0.77]	[2.09]	[36.69]	[0.30]	[-0.21]	[-0.82]
Lynch	76-90	1.59	0.64	1.12	0.49	0.03	0.16
		[3.45]	[5.01]	[36.38]	[9.67]	[0.59]	[4.08]
Habermann	72-76	-0.83	0.42	1.00	0.79	-0.44	0.07
		[-0.68]	[0.64]	[7.85]	[3.52]	[-2.25]	[0.38]
Johnson	63-72	2.45	0.83	1.10	1.20	0.13	0.75
		[3.32]	[2.60]	[11.67]	[10.07]	[0.90]	[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	-0.821	0.989	0.384	-0.318	-0.235	0.626
	[-1.42]	[-2.93]	[14.31]	[4.47]	[-3.10]	[-3.88]	
Q2	-0.157	-0.741	1.057	0.307	-0.115	-0.022	0.658
	[-0.41]	[-3.28]	[17.57]	[4.10]	[-1.28]	[-0.42]	
Q3	0.125	-0.488	1.063	0.309	-0.09	-0.029	0.633
	[0.32]	[-1.89]	[16.81]	[3.92]	[-0.96]	[-0.52]	
Q4	0.313	-0.193	1.039	0.217	-0.15	-0.076	0.564
	[0.79]	[-0.72]	[14.43]	[2.42]	[-1.40]	[-1.20]	
Q5 (high)	0.982	0.556	0.982	0.681	-0.363	-0.056	0.650
	[2.14]	[1.99]	[13.80]	[7.69]	[-3.43]	[-0.90]	
L/S	1.578	1.376	-0.007	0.296	-0.045	0.179	0.041
	[3.79]	[3.13]	[-0.07]	[1.26]	[-0.28]	[1.93]	

"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.

Main Takeaways