Lecture 5

Equity Returns in Cross Section (Part 2)

Fama-French (FF) Factor Models

Preceding analysis shows certain firm characteristics predict returns

FF argue that this must mean these characteristics are picking up a relevant dimension of risk

Use this insight to create factor portfolios

Three original factors are MKT, SMB, HML

Assumption here is that expected returns depend on factor loadings (beta coefficients), not on the characteristics themselves (subtle difference)

FF 3-factor model

$$E(r_i) = r_f + \beta_{MKTRF}\left(E(r_{mkt}) - r_f\right) + \beta_{SMB}E(r_{SMB}) + \beta_{HML}E(r_{HML})$$

or

$$E(r_i) - r_f = \beta_{MKTRF}\left(E(r_{mkt}) - r_f\right) + \beta_{SMB}E(r_{SMB}) + \beta_{HML}E(r_{HML})$$

Notes:

1. Amount returns differ from this on average is called the FF three-factor alpha
2. The factor loadings must be estimated using linear regression for each asset, (often ignore the alpha estimate at the individual security level)
3. The risk premia on the risk factors can be estimated from past data and potentially adjusted to reflect thoughts on shifts in the risk premia
4. It is possible to be a large firm but to loading positively on SMB, similar statements across the board

Example: Google/Alphabet Stock

Regression statistics for:	Single index with S&P 500 as market proxy
	Single index with broad market index (NYSE+NASDAQ+AMEX)
	Fama French three-factor model (Broad Market+SMB+HML)

5 years recent monthly returns			
	Single Index Specification		FF 3-Factor Specification
Estimate	S&P 500	Broad Market Index	with Broad Market Index
Correlation coefficient	0.59	0.61	0.70
Adjusted R-Square	0.34	0.36	0.47
Residual SD = Regression SE (%)	8.46	8.33	7.61
Alpha = Intercept (%)	0.88 (1.09)	0.64 (1.08)	0.62 (0.99)
Market beta	1.20 (0.21)	1.16 (0.20)	1.51 (0.21)
SMB (size) beta	-	-	-0.20 (0.44)
HML (book to market) beta	-	-	-1.33 (0.37)
Standard errors in parenthesis			

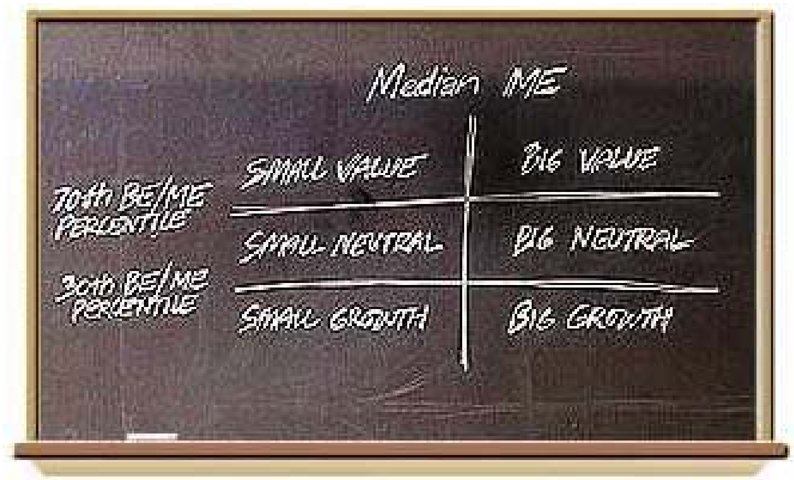
The Fama and French Factors:

- Small Minus Big:

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

- High Minus Low:

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



R^{small}=1/3 (Small Value + Small Neutral + Small Growth)

R^{big} = 1/3 (Big Value + Big Neutral + Big Growth)

R^{value}=1/2 (Small Value + Big Value)

R^{growth}=1/2 (Small Growth + Big Growth)

Along the size dimension, FF sort stocks into two groups: small and big.
Along the value dimension, FF sort stocks into three groups: 30% in value, 40% neutral, and 30% growth.

A Plethora of Choices in Defining Portfolios

Updating size (market cap.) every month or just once a year (FF choose the latter)

Choosing breakpoints based on all firms or a subset of firms (FF choose the latter)

Equal-weighting or value-weighting within a portfolio (if different, this tells you something)

Updating accounting items, every quarter or every year

Accounting for lag in accounting reporting – many fiscal year-end values are only known with a lag

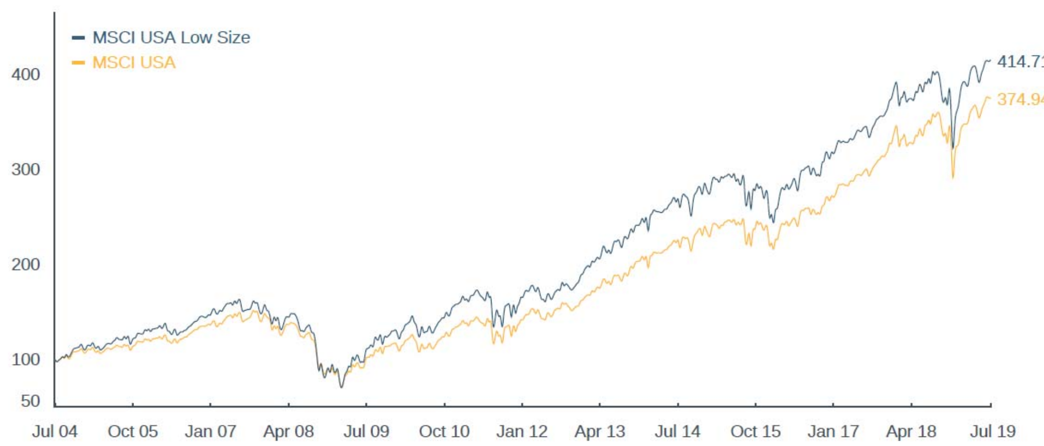
Fiscal years versus calendar years

Key is to sort on information that would be known at the time of portfolio formation. If other choices matter, then this often tells you something that may be useful in improving a model.

Size: alternative implementation in practice

- MSCI Low Size index weighs stocks by $1/\ln(MktCap)$
- Rebalancing twice per year, on the last day of May and November.
- There are many other providers of indices, such as Vanguard, BlackRock, and State Street.

CUMULATIVE INDEX PERFORMANCE - GROSS RETURNS (USD) (JUL 2004 – JUL 2019)



INDEX RISK AND RETURN CHARACTERISTICS (MAY 31, 1994 – JUL 31, 2019)

				ANNUALIZED STD DEV (%) [2]			SHARPE RATIO [2,3]				MAXIMUM DRAWDOWN	
	Beta	Tracking Error (%)	Turnover (%) [1]	3 Yr	5 Yr	10 Yr	3 Yr	5 Yr	10 Yr	Since May 31, 1994	(%)	Period YYYY-MM-DD
MSCI USA Low Size	1.03	5.08	17.35	13.21	12.85	13.79	0.76	0.70	0.99	0.53	58.34	2007-07-13—2009-03-09
MSCI USA	1.00	0.00	2.52	12.13	12.04	12.64	0.97	0.86	1.06	0.54	54.91	2007-10-09—2009-03-09

[1] Last 12 months [2] Based on monthly gross returns data [3] Based on ICE LIBOR 1M

Source: MSCI

Value: alternative implementation in practice

- Academics use book-to-market to proxy for value, but there are many other ways to implement the same idea.

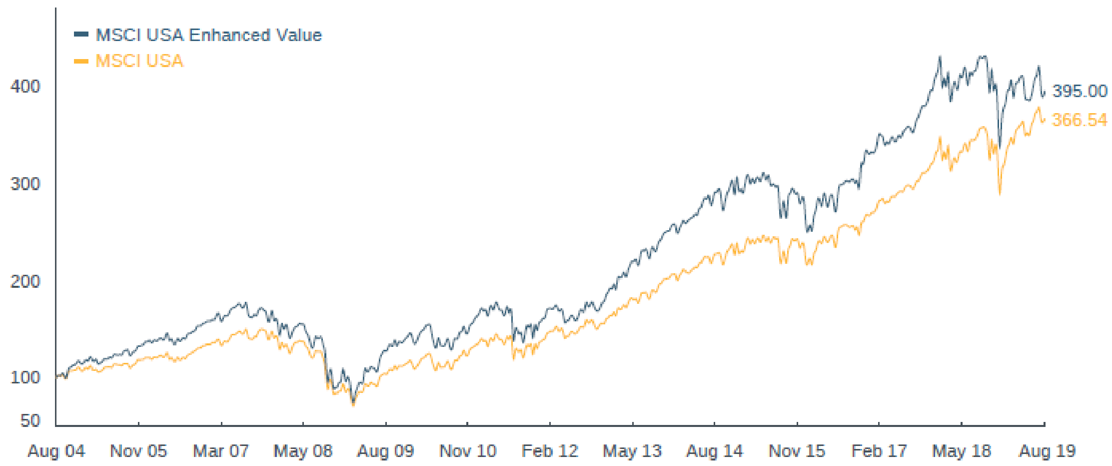
- For example, MSCI's implementation uses three metrics: Forward Price to Earnings (Fwd P/E), Enterprise Value/Operating Cash Flows (EV/CFO) and Price to Book Value (P/B). The last one is the inverse of book/market.

  These numbers are inverted and then converted into z-scores (demean and divided by the cross-section standard deviation). High z-score means high "value to price" ratio.

  The MSCI index are rebalanced twice per year, in May and November. The weight of a stock is proportional to its market cap × Final Value Score.

Value: alternative implementation in practice

CUMULATIVE INDEX PERFORMANCE - GROSS RETURNS (USD) (AUG 2004 – AUG 2019)



Source: MSCI

INDEX RISK AND RETURN CHARACTERISTICS (NOV 28, 1997 – AUG 30, 2019)

				ANNUALIZED STD DEV (%) 2			SHARPE RATIO 2, 3				MAXIMUM DRAWDOWN	
	Beta	Tracking Error (%)	Turnover (%) 1	3 Yr	5 Yr	10 Yr	3 Yr	5 Yr	10 Yr	Since Nov 28, 1997	(%)	Period YYYY-MM-DD
MSCI USA Enhanced Value	1.05	6.06	38.04	14.90	14.25	14.99	0.56	0.42	0.79	0.45	59.48	2007-06-04—2009-03-09
MSCI USA	1.00	0.00	2.56	12.23	12.02	12.65	0.91	0.76	1.01	0.39	54.91	2007-10-09—2009-03-09

[1] Last 12 months [2] Based on monthly gross returns data [3] Based on ICE LIBOR 1M

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

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

- 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

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

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:

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

- Using annual returns from 1962 through 2014:

$E(R^M - r_f)$	$E(R^{\text{SMB}})$	$E(R^{\text{HML}})$
6.46%	3.20%	5.15%
[2.64]	[1.68]	[2.78]

- Using annual returns from 1927 through 2014:

$E(R^M - r_f)$	$E(R^{\text{SMB}})$	$E(R^{\text{HML}})$
8.40%	3.40%	5.00%
[3.81]	[2.28]	[3.33]

Using the FF3 Model to Estimate a Firm’s Cost of Capital

Return to earlier example for Google/Alphabet
Market beta = 1.51, SMB beta = -.20, HML beta = -1.33
Assume interest rate at time of calculation is 2.0%
Assume risk premia equal to post-1962 period average from prior slide (big assumption)

Estimate of expected return on Google/Alphabet:

2% + (1.51 x 6.46%) + (-.20 x 3.20%) + -1.33 x 5.15% = <u>**4.27%**</u>

<u>Note: This is much lower than what the CAPM would predict!</u>

.

Where Does Market Risk Premium Come from?

The market risk premium has its foundation in the CAPM:

- Investors are risk averse.
- Investors in aggregate cannot avoid holding the risk of the overall market.
- Negative beta stocks tend to do well when the market does badly.
- By contrast, positive beta stocks tend to do poorly when the market does badly.
- As a result, risk-averse investors are willing to pay a premium for negative beta stocks and demand a premium for positive beta stocks.
- The market risk premium is a reward for holding the market risk.

Where Do Size and Value Premiums Come from?

- Unlike the market portfolio, the Size and Value portfolios are empirically motivated.
- If we think of them as risk premiums, then we need to understand the *real, macroeconomic, aggregate, nondiversifiable* risk that is proxied by the SMB and HML portfolios.
- In particular, why are investors so concerned about holding stocks that do badly when the SMB and HML portfolios do badly, even though the market does not fall?
  - We know that small stocks are riskier because they have higher betas. The reward demanded for holding small stocks, however, is larger than what can be justified by the CAPM.
  - Similarly, after controlling for the CAPM, why do investors still consider value stocks risky and demand an additional premium?

Why Do We Care?

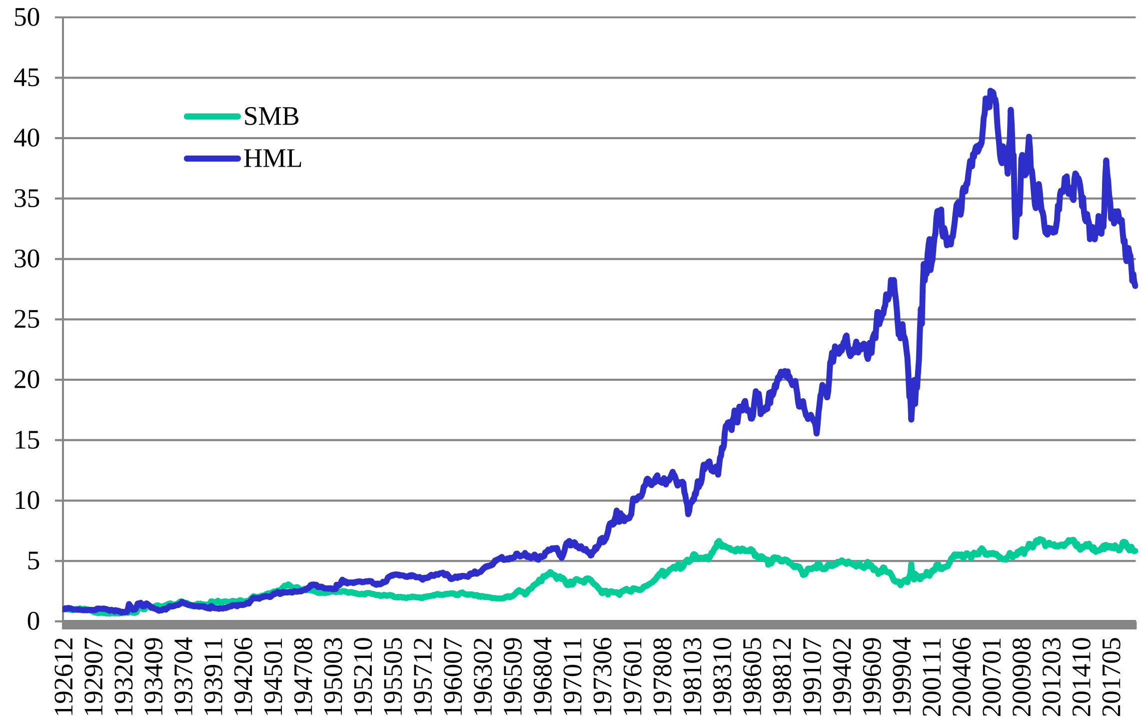
- The prevalent usage of size and value as “risk factors.”
- Morningstar.com classifies stocks and mutual funds based on these factors.
- Index funds and ETFs are being offered based on the three factor model.
- Nevertheless, we know very little about the nature of these factors:
  - Are they risk factors?
  - If so, what risk?
  - If not, then what are they?

Explaining the Size and Value "Anomalies"

- The Rational Camp
  - Value: proxies for the "distress risk."
  - Size: proxies for the illiquidity of the stock.
  - HML and SMB contain information above and beyond that in the market return for forecasting GDP growth.
  - Proxies for variables that forecast time-varying investment opportunities or time-varying risk aversion.
- The Behavioral Camp
  - Expectational errors made by investors
- The Critics
  - Survival bias
  - Data snooping

Performance of SMB and HML

- Under the Fama-French definition of size and value, SMB stopped working since mid-1980s, but HML continues to deliver good excess returns until about 10 years ago.
- Academics like to use long time series of data, so it's still standard to put in SMB. We don't know when/if HML recovers.
- Again, this is just one of many implementations of size and value.



Monthly data from Ken French's website, 1927 Jan-2019 Jun.

Momentum

- Jegadeesh-Titman (1993) showed that the FF3 model doesn't work well for a strategy of buying past winners and selling past losers.

A common implementation, measure momentum the 11-month return of the stock during the period from end of month $t-11$ to the end of month $t-1$ And predict returns in month t+1. Buy winners and sell losers. This strategy works well for the next 12 months. Medium-term momentum effect.

$$Mom_{i,t} = 100 \left[\prod_{m \in \{t-11:t-1\}} (R_{i,m} + 1) - 1 \right]$$

The return over most recent month is left out as performance over short periods tends to revert. Also we tend to see reversion over long horizons.

Does Momentum Look Related to the FF3 Factors?

	Pearson Correlations						
	Mom	$R^{t-12:t-1}$	$R^{t-6:t-1}$	R^{12M}	R^{9M}	R^{6M}	R^{3M}
β	0.07	0.08	0.01	0.06	0.03	−0.00	−0.02
Size	0.18	0.19	0.14	0.19	0.17	0.15	0.11
BM	0.02	0.01	0.06	0.03	0.06	0.06	0.04

Momentum returns are high and not explained by Fama-French 3 factors

Big excess returns!

Panel B: Value-Weighted Portfolio Returns

Sort Variable	1	2	3	4	5	6	7	8	9	10	10-1	CAPM α	FF α
Mom	−0.76	−0.12	0.04	0.35	0.39	0.37	0.53	0.67	0.75	1.18	1.95	2.13	2.37
											(5.39)	(6.48)	(7.54)
R^{12M}	−0.36	0.01	0.26	0.39	0.37	0.43	0.54	0.62	0.73	1.05	1.42	1.66	1.93
											(3.64)	(4.81)	(5.82)
R^{9M}	0.02	0.40	0.40	0.40	0.43	0.44	0.44	0.58	0.65	0.97	0.95	1.24	1.45
											(2.51)	(3.67)	(4.48)
R^{6M}	0.21	0.48	0.48	0.50	0.53	0.47	0.51	0.47	0.53	0.78	0.58	0.85	0.98
											(1.71)	(2.76)	(3.30)
R^{3M}	0.33	0.54	0.60	0.60	0.61	0.51	0.46	0.48	0.47	0.63	0.31	0.57	0.69
											(1.07)	(2.08)	(2.40)
$R^{t-12:t-1}$	−0.71	−0.12	0.19	0.31	0.42	0.40	0.48	0.66	0.74	1.08	1.79	1.96	2.23
											(5.12)	(6.21)	(7.33)
$R^{t-6:t-1}$	−0.52	0.22	0.38	0.40	0.51	0.48	0.52	0.51	0.54	0.97	1.50	1.71	1.86
											(4.11)	(5.14)	(5.91)

11-month cumulative return stopping at month $t-1$

12-month cumulative return stopping at month t

Momentum returns can't be explained by FF3!

Data: June 1963—Nov 2012. Std error is Newey-West with 6 lags
Source: Bali-Engle-Murray book, Table 11.3

What about equal-weighted?

Smaller excess returns – why?

11-month cumulative return stopping at month $t-1$

12-month cumulative return stopping at month t

Momentum returns can't be explained by FF3!

Panel C: Equal-Weighted Portfolio Returns

Sort Variable	1	2	3	4	5	6	7	8	9	10	10-1	CAPM α	FF α
Mom	0.29	0.34	0.48	0.64	0.68	0.78	0.92	1.04	1.19	1.37	1.08	1.14	1.36
											(3.42)	(3.85)	(4.62)
R^{12M}	1.10	0.29	0.45	0.52	0.59	0.72	0.84	0.94	1.09	1.20	0.10	0.21	0.45
											(0.28)	(0.64)	(1.36)
R^{9M}	1.27	0.43	0.45	0.50	0.61	0.67	0.75	0.77	0.93	1.18	−0.10	0.05	0.28
											(−0.27)	(0.16)	(0.84)
R^{6M}	1.49	0.53	0.54	0.54	0.55	0.69	0.68	0.72	0.80	0.91	−0.58	−0.43	−0.23
											(−1.75)	(−1.36)	(−0.74)
R^{3M}	1.89	0.68	0.60	0.58	0.66	0.63	0.61	0.64	0.66	0.50	−1.39	−1.23	−1.11
											(−4.72)	(−4.27)	(−3.58)
$R^{t-12:t-1}$	0.39	0.36	0.52	0.63	0.72	0.80	0.91	1.02	1.13	1.28	0.90	0.95	1.20
											(2.84)	(3.23)	(4.04)
$R^{t-6:t-1}$	0.46	0.39	0.56	0.71	0.72	0.78	0.80	0.86	1.00	1.23	0.77	0.87	1.01
											(2.65)	(3.11)	(3.81)

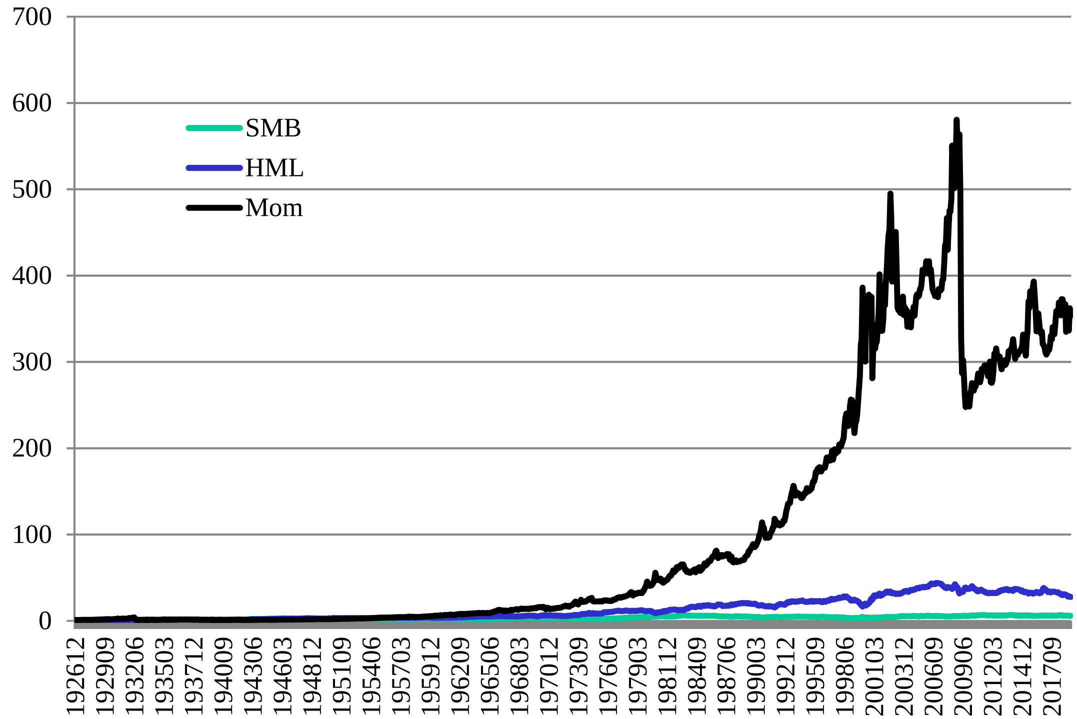
How does MOM compare/fit with other characteristics that predict returns? Most transparent approach is Fama-MacBeth regression

This table presents the results of Fama and MacBeth (1973) regression analyses of the relation between expected stock returns and momentum. Each column in the table presents results for a different cross-sectional regression specification. The dependent variable in all specifications is the one-month-ahead excess stock return. The independent variables are indicated in the first column. Independent variables are winsorized at the 0.5% level on a monthly basis. The table presents average slope and intercept coefficients along with t-statistics (in parentheses), adjusted following Newey and West (1987) using six lags, testing the null hypothesis that the average coefficient is equal to zero. The rows labeled Adj. R^2 and n present the average adjusted R-squared and the number of data points, respectively, for the cross-sectional regressions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mom	0.007	0.006	0.007	0.006	0.007	0.005	0.007	0.007
	(3.01)	(3.06)	(3.77)	(2.51)	(4.28)	(2.52)	(3.33)	(3.70)
β		−0.373			−0.124	−0.285		−0.059
		(−2.91)			(−0.73)	(−2.32)		(−0.38)
Size			−0.182		−0.178		−0.173	−0.177
			(−3.98)		(−3.27)		(−3.69)	(−3.28)
BM				0.405		0.319	0.246	0.183
				(5.41)		(4.93)	(3.09)	(2.84)
Intercept	0.607	0.877	1.356	0.261	1.448	0.544	1.178	1.310
	(2.22)	(3.62)	(3.15)	(0.95)	(3.62)	(2.36)	(2.51)	(3.13)
Adj. R^2	0.01	0.03	0.02	0.02	0.04	0.03	0.03	0.04
n	4410	4410	4410	3370	4409	3370	3370	3370

Momentum factor and return

- Fama-French define momentum factor as follows. Form 2×3 portfolios by size and prior returns. Then
$$\text{Mom} = \text{Winner} - \text{Loser}$$
$$= \frac{\text{Small High} + \text{Big High}}{2} - \frac{\text{Small Low} + \text{Big Low}}{2}$$
- Academics also label it WML (winner minus loser) or UMD (up minus down).
- Size breakpoint is the median of NYSE stocks; prior-return breakpoints are 30^{th} and 70^{th} percentile of NYSE stocks.
- Momentum delivered high returns historically, dominating size and value.
- But momentum is flat over the last 20 years, largely due to a BIG CRASH about 10 years ago.



Monthly data from Ken French's website, 1927 Jan-2019 Jun.

Behavioral explanations of momentum

- Investors are “overconfident”. If some of their stocks “win”, they attribute it to their own superior skill and buy more, generating momentum
- Investors “underreact” to news

Four factor model

- Adding momentum to the Fama-French three factor model gives us the four-factor model:
$$r_{it} - r_f = \alpha_i + \beta_i\left(r_{Mt} - r_f\right) + s_i SMB_t + h_i HML_t + w_i WML_t + \epsilon_{it}$$

- Taking expectation:
$$E\left(r_{it} - r_f\right) = \alpha_i + \beta_i E\left(r_{Mt} - r_f\right) + s_i E(SMB_t) + h_i E(HML_t) + w_i E(WML_t) + \epsilon_{it}$$

- If the model “works”, what’s α_i?

- This four-factor model is sometimes referred to as the FFC or FFC4 model, after Carhart (1997). (Sometimes just FF4)

- Implementing a trading strategy based on momentum is practically speaking more difficult and more expensive than it is for the other factors