Quantitative Asset Management

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Lecture 2

1. Review: HML and SMB
   Fama and French (1992, 1993) three-factor model
2. Factor Investing ("smart beta")
3. Asset Growth
   Cooper, Gulen and Schill (2008, JF)
4. Profitability
   Novy-Marx (2013, JFE)
5. Fama and French five-factor model
   Fama and French (2015, JFE)

Review: HML and SMB

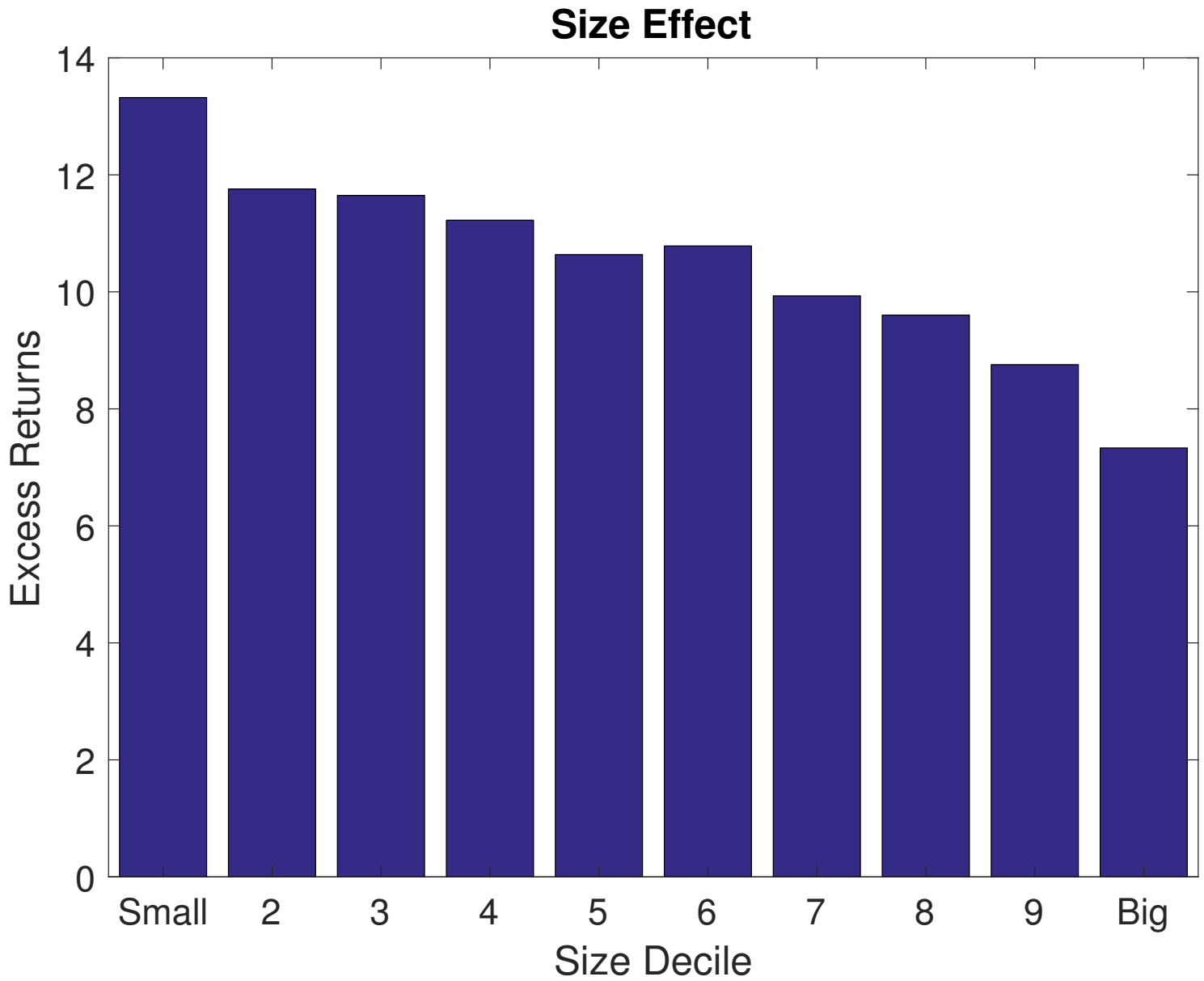
Size Portfolios

- There is a size effect in stock returns (it's not really a size effect: it's about market cap, not the actual size of the company)
- Small cap stocks earn much higher average returns than large cap stocks
- Small cap stocks do have higher betas, but the difference in betas is not large enough to explain the difference in returns

Portfolio Construction

- Let's look at all the stocks in CRSP
- Sort stocks into deciles based on market cap at the end of June each year
- Portfolios are held fixed throughout year
- The portfolios for July of year t to June of t+1 include all NYSE, AMEX, and NASDAQ stocks for which we have market equity data for June of t.
- NYSE Breakpoints
- Source: Kenneth French's data library

- Can also rebalance monthly



Sample: 1926-201902. Monthly data. Annualized Returns.
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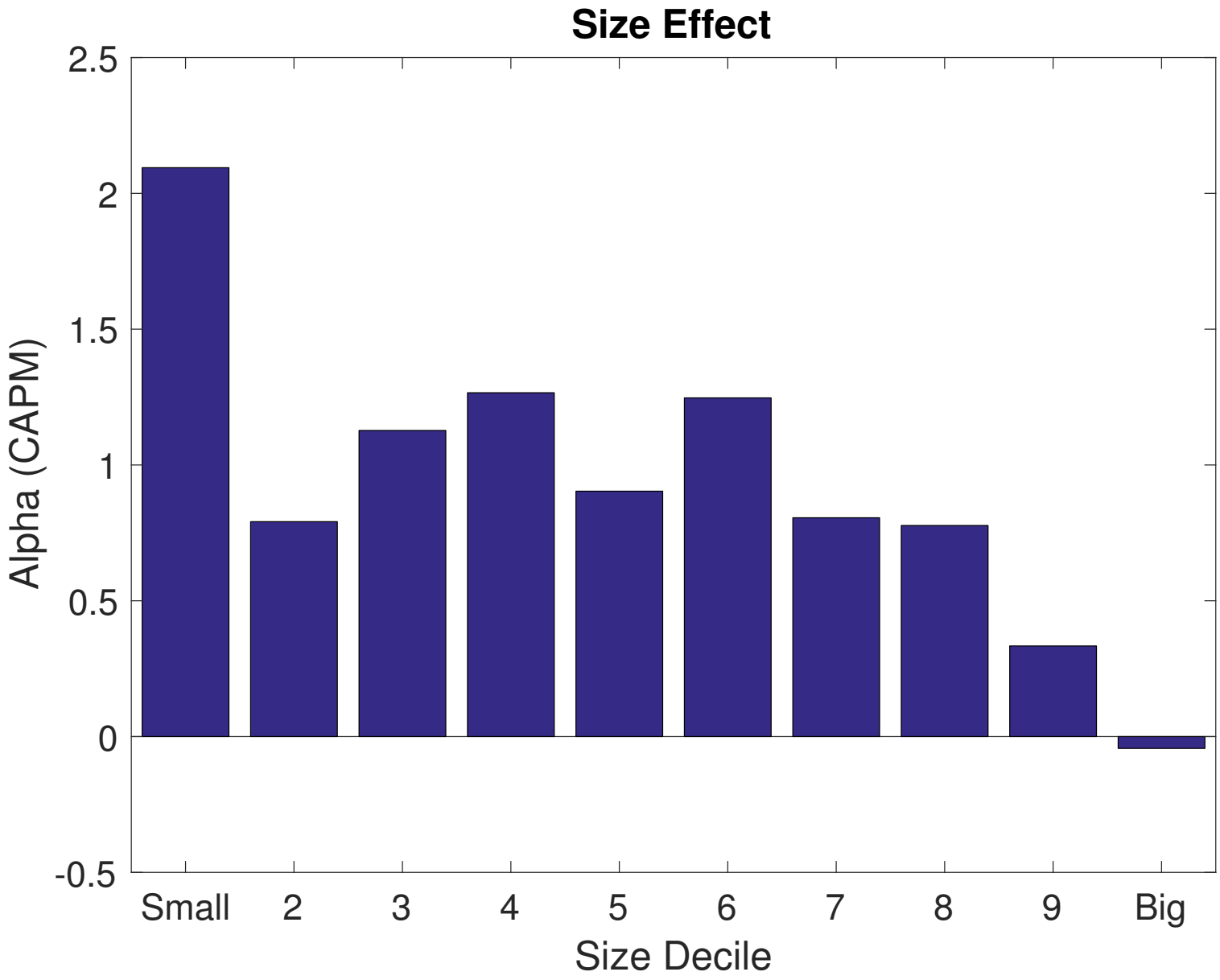

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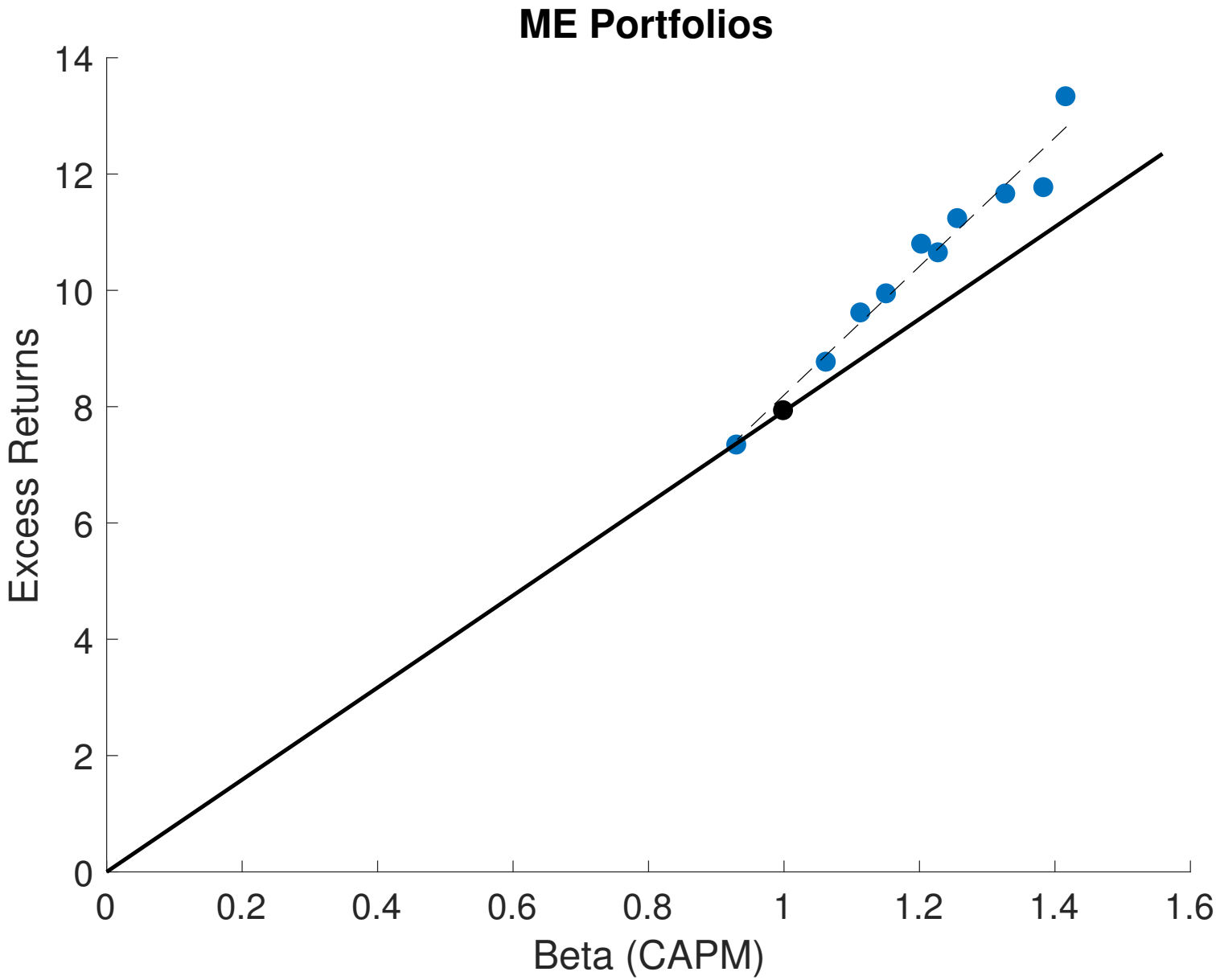

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Beta and Returns in Size Portfolios

- Clearly, the return-beta relation goes the right direction when we look at size portfolios
- Investors do seem to be compensated for taking on beta risk by getting higher returns
- However, the relation between returns and betas is too steep in the data.

- Facts about size anomaly
  - January effect
  - Other measures of size, e.g. sales
  - Before/after 1980

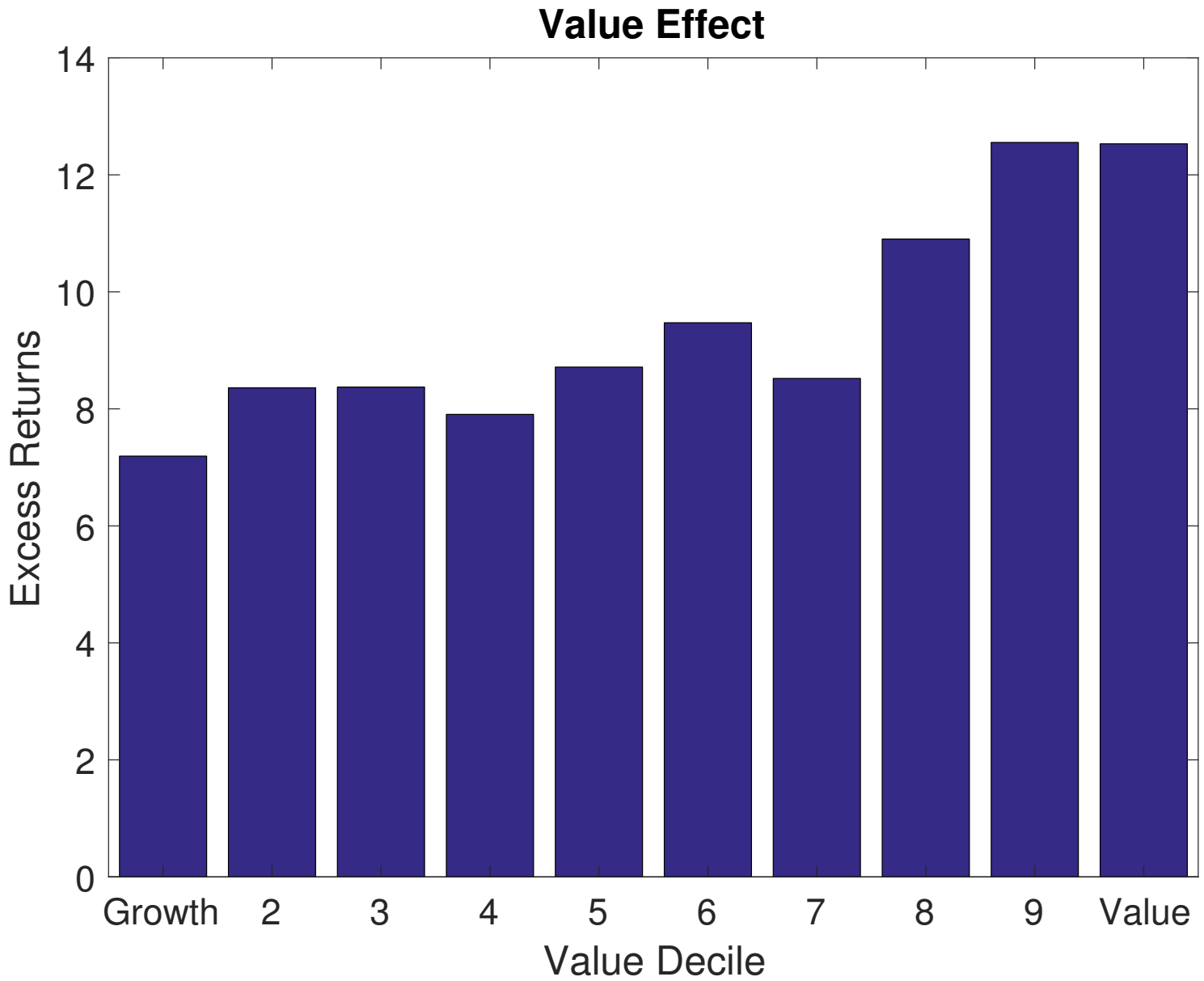
Value Effect

Value Effect

- There is a value effect in stock returns
- Stocks with high Book-to-Market ratios subsequently earn much higher returns than stocks with low Book-to-market ratios
- How are book values constructed?

Portfolio Construction

- Let's look at all the stocks in CRSP
- Sort stocks into deciles based on book-to-market ratios at the end of June each year; high book-to-market stocks are 'value' stocks
- Portfolios are held fixed throughout year
- The portfolios for July of year t to June of t+1 include all NYSE, AMEX, and NASDAQ stocks for which we have market equity data for June of t.
- NYSE Breakpoints
- Source: Kenneth French's data library



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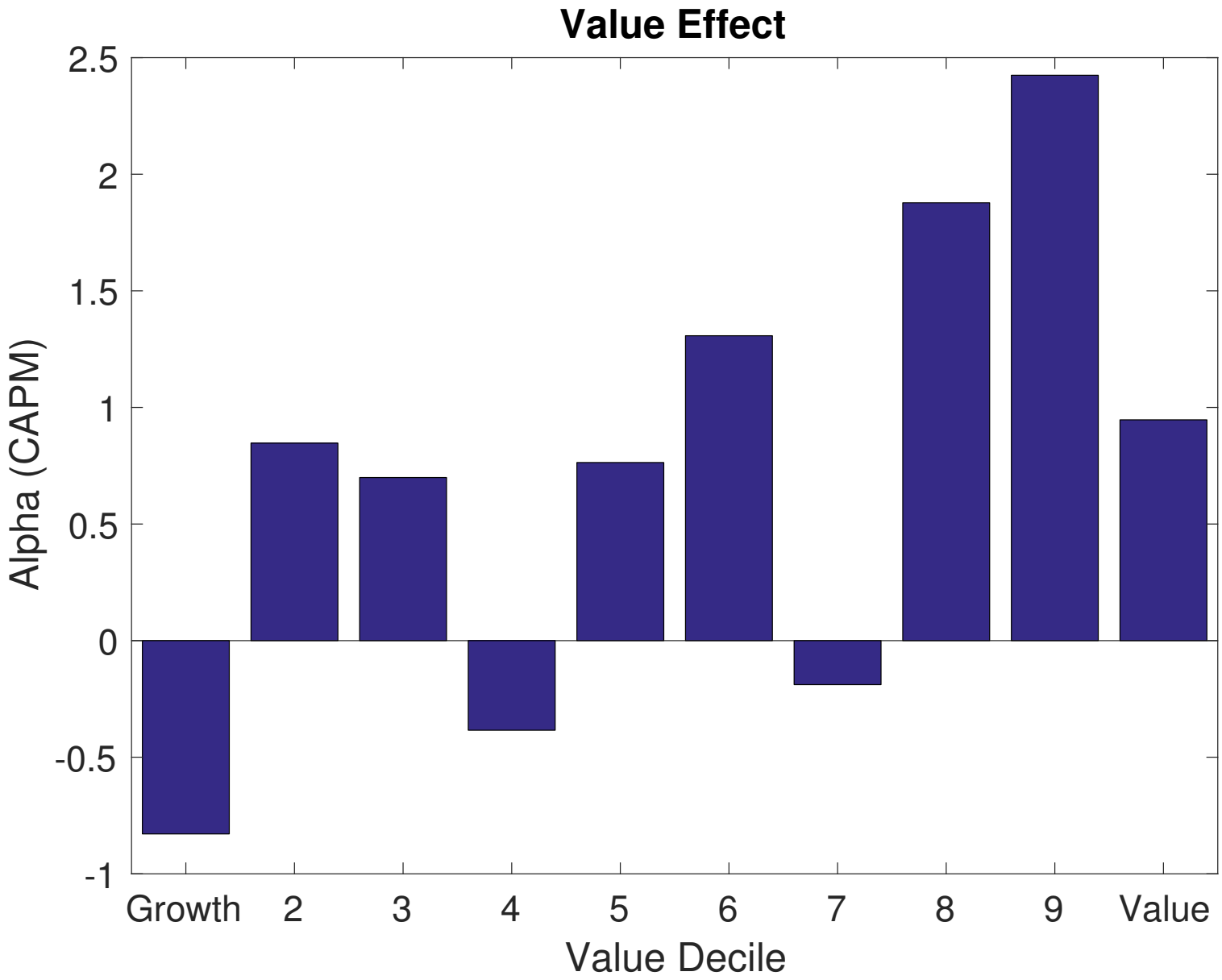
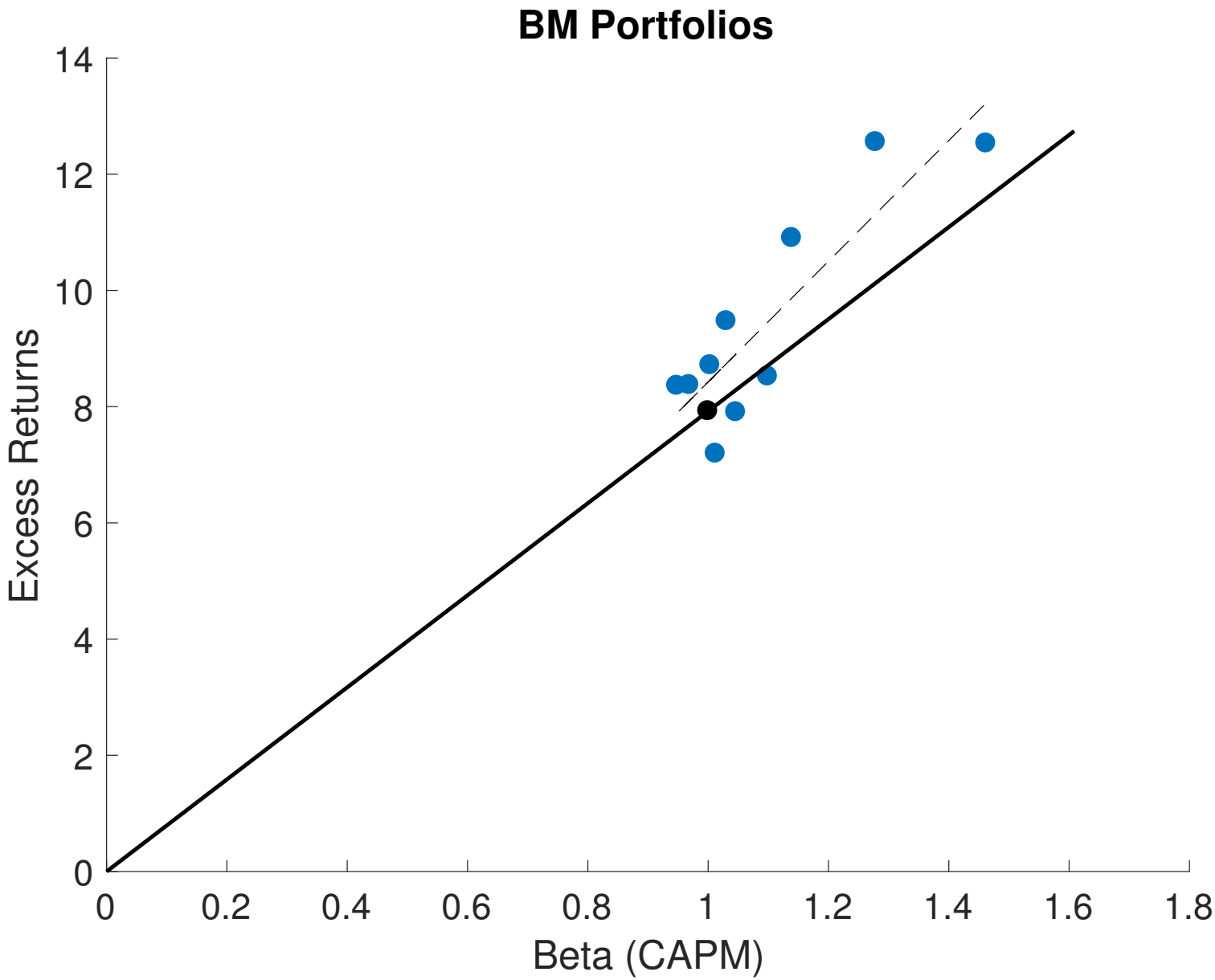
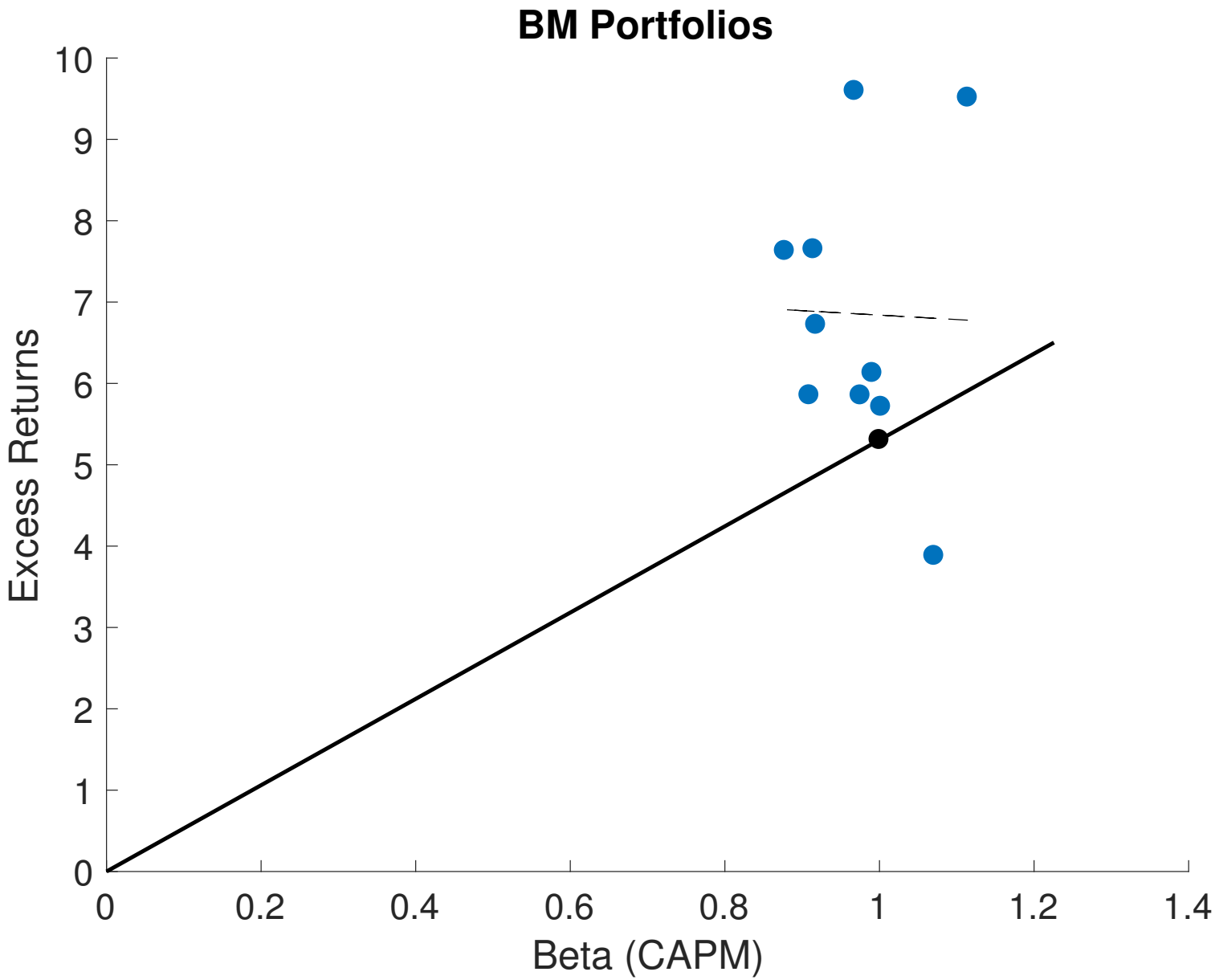


Sample: 1926-201902. Monthly data. Annualized Returns.
Source: Kenneth French's data library.

Sample: July 1926 to February 2019



Sample: post 1960



Failure of CAPM

- The CAPM did a reasonable job before 1960, but after that the relation between beta and average returns seems to completely disappear
- Anomalies documented in 1980's: Size and Value

Multi-factor Models: Risk comes in many flavors

- Before we can do performance analysis, we need a good model of risk and risk compensation in financial markets
- We used to think that priced risk comes in only a single flavor: β
- But we know now that risk comes in many flavors
  - Complicates portfolio advice
  - Makes performance analysis more challenging

Why do we expect multiple factors?

- Heterogeneity in investor sophistication:
  - Some less sophisticated investors have portfolios that are biased towards large growth firms (because these are considered to be more glamorous)
  - Then the sophisticated investors (by definition) have to overweight the small value firms in their portfolio of risky assets
  - Now, the sophisticated investors do not and cannot hold the market portfolio
  - This creates new priced factors like value and size

Why do we expect multiple factors?

- Heterogeneity in investor trading technology:
  - Some less sophisticated investors have portfolios that are biased towards high beta stocks because they do not have access to leverage
  - Then the sophisticated investors (by definition) have to overweight the low beta stocks
  - Now, the sophisticated investors do not and cannot hold the market portfolio
  - This creates new priced factors like BAB

Arbitrage Pricing Theory

- **Result: There exist risk prices for each factor such that the expected return on any security can be stated as:**

$$\mathbb{E}[R_i] = \lambda_0 + b_{i,1}\lambda_1 + b_{i,2}\lambda_2 + \ldots + b_{i,L}\lambda_L, \quad \text{for } i = 1, \ldots, N$$

- Very general
- No need to measure the return on the market
- The theory does not tell you which factors to use
- License to go fishing for priced risk factors...

Which Factors?

- One (ad hoc but effective) way to proceed is to use traded factors that we believe to be the main drivers of returns:
  1. Size factor
  2. Value or book-to-market factor
  3. Momentum factor
- This essentially means we are taking a shortcut: we're not trying to actually capture the sources of macroeconomic risk that are priced directly, but we're using traded factors that proxy for these macro-economic risks.

Fama-French

- Fama and French formed three portfolios of stocks sorted by book-to-market ratios and two portfolio of all stocks sorted by size (market cap)
- The intersection of these creates six portfolios:

	Low B/M	medium	High B/M
Small	Small growth	Small neutral	Small value
large	Large growth	Large neutral	Large value

Two-way (double) sorted portfolios

- Two Characteristics
- Independence Sorting: thresholds are computed separately
  - Testing if both anomalies hold separately
  - If characteristics too correlated, may have few stocks in some groups (may lead to insignificant results)
- Sequential Sorting: sort on one characteristic first, then sort on the other characteristic within each group
  - testing if second characteristic anomaly holds within each group formed based on the first characteristic

Fama-French

- The intersection of these creates six portfolios

	Low B/M	medium	High B/M
Small	Small growth	Small neutral	Small value
large	Large growth	Large neutral	Large value

Size Factor

- SMB is the average return on a long position in the three small portfolios and a short position in the three large portfolios

$$SMB = \frac{1}{3}(\text{Small Value} + \text{Small Neutral} + \text{Small Growth})$$

$$- \frac{1}{3}(\text{Large Value} + \text{Large Neutral} + \text{Large Growth})$$

Value Factor

- HML is the average return on a long position in the two value portfolios and a short position in the two growth portfolios:

$$HML = \frac{1}{2}\,(\text{Small Value} \;+\; \text{Large Value})$$

$$-\,\frac{1}{2}\,(\text{Small Growth} \;+\; \text{Large Growth})$$

Fama and French Three-Factor Model

- Fama and French Three-factor Model for stock returns:

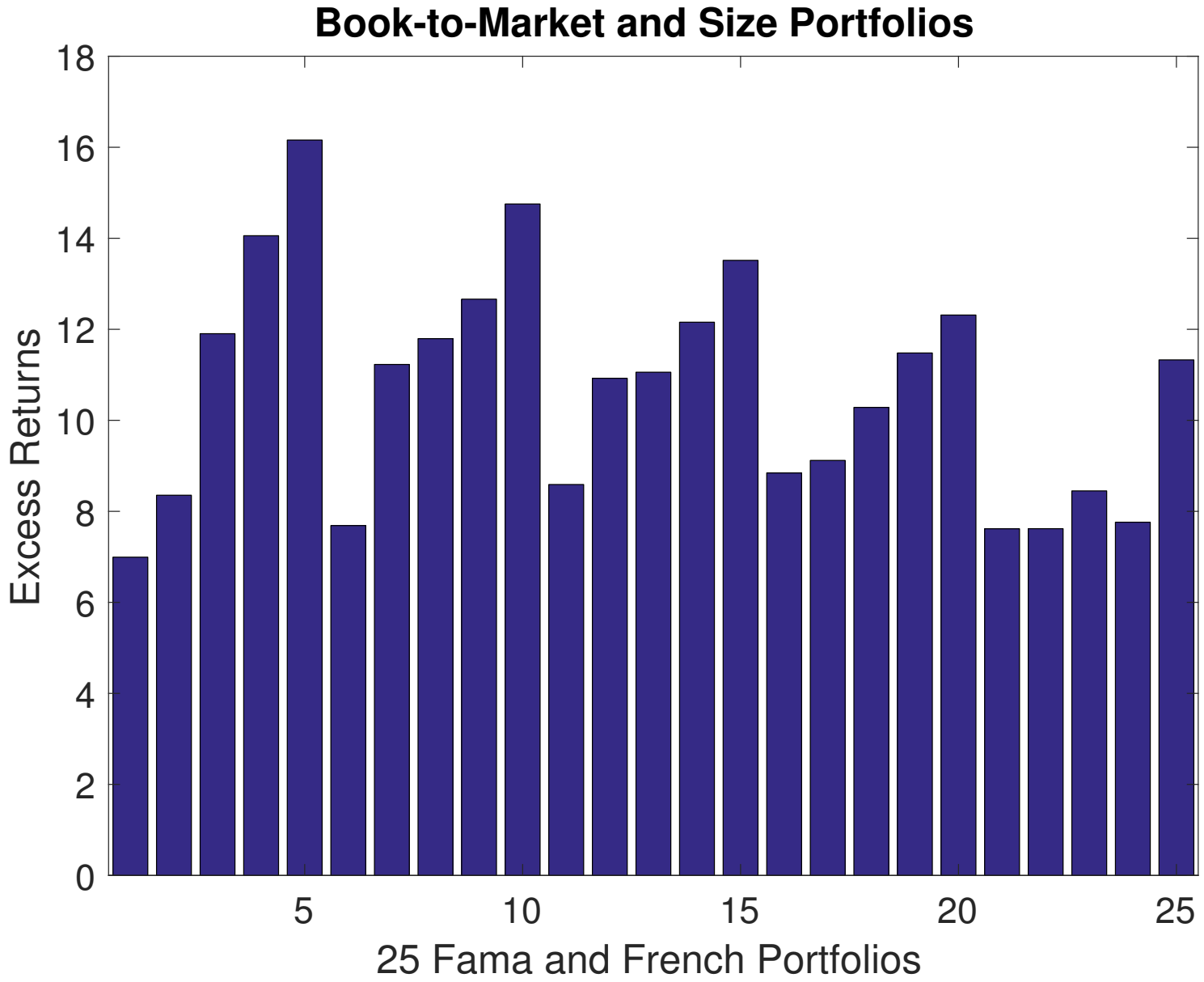
$$(R_i - R_f) = a_i + b_{i,m}\,(R_m - R_f) + b_{i,smb} R_{smb} + b_{i,hml} R_{hml} + e_i$$

- Implication for APT:

$$\mathbb{E}[R_i] = \lambda_0 + b_{i,m}\lambda_m + b_{i,smb}\lambda_{smb} + b_{i,hml}\lambda_{hml}, \quad i = 1, \ldots, N$$

Test Assets

- Let's test this asset pricing model on 25 portfolios (intersection of 5 portfolios sorted by size and 5 portfolios sorted by B/M)
- To test an asset pricing model, we want to check whether it explains the returns on passively managed portfolios
  - That seems like a reasonable way to test this model
  - Once we know we have a decent model, we can use the model to do performance analysis



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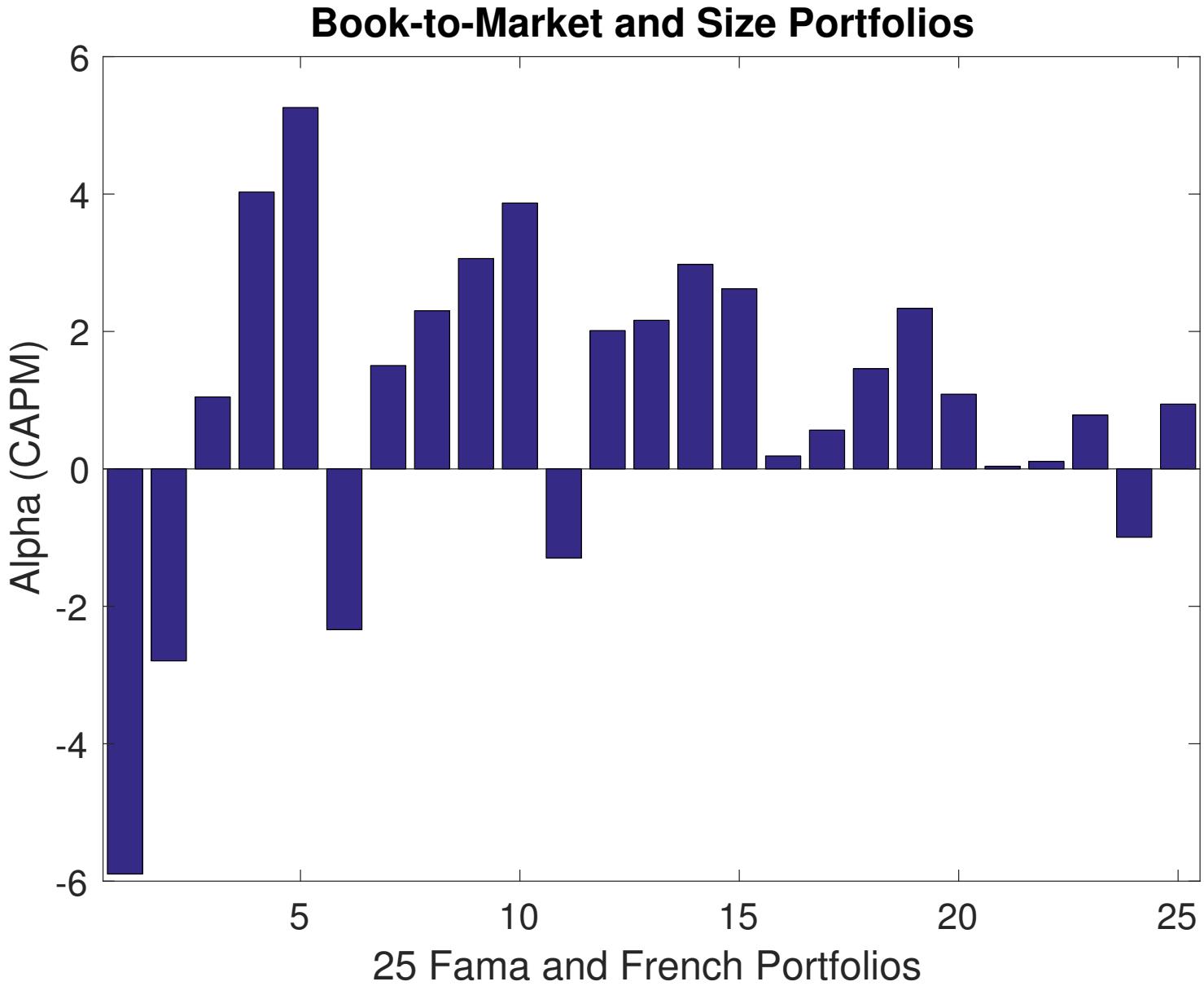

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Two-Stage Approach

- 1st stage: we estimate the loadings by running simple time series regressions of the returns on the factors (one time-series regression for each portfolio). This gets us the b's

$$(R_i - R_f) = a_i + b_{i,m}\,(R_m - R_f) + b_{i,smb} R_{smb} + b_{i,hml} R_{hml} + e_i$$

- 2nd stage: estimate a single cross-sectional of average returns on each portfolio on the loadings to get the risk prices.

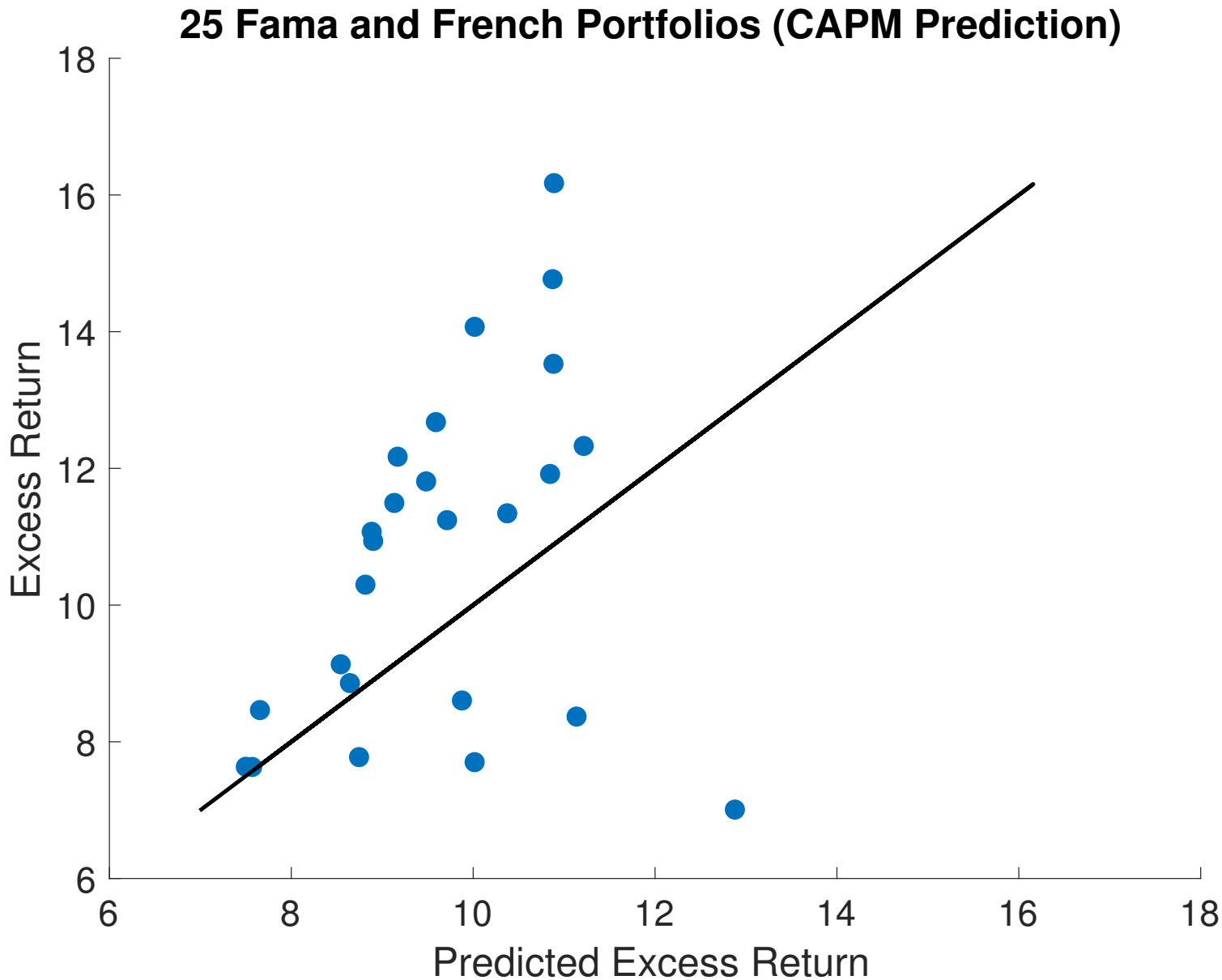
$$\underbrace{\hat{\mathbb{E}}[R_i]}_{\text{Mean}\left(R_i - R_f\right)} = \lambda_0 + b_{i,m}\underset{\Uparrow}{\lambda_m} + b_{i,smb}\underset{\Uparrow}{\lambda_{smb}} + b_{i,hml}\underset{\Uparrow}{\lambda_{hml}}, \quad i = 1, \ldots, N$$

Fama-French

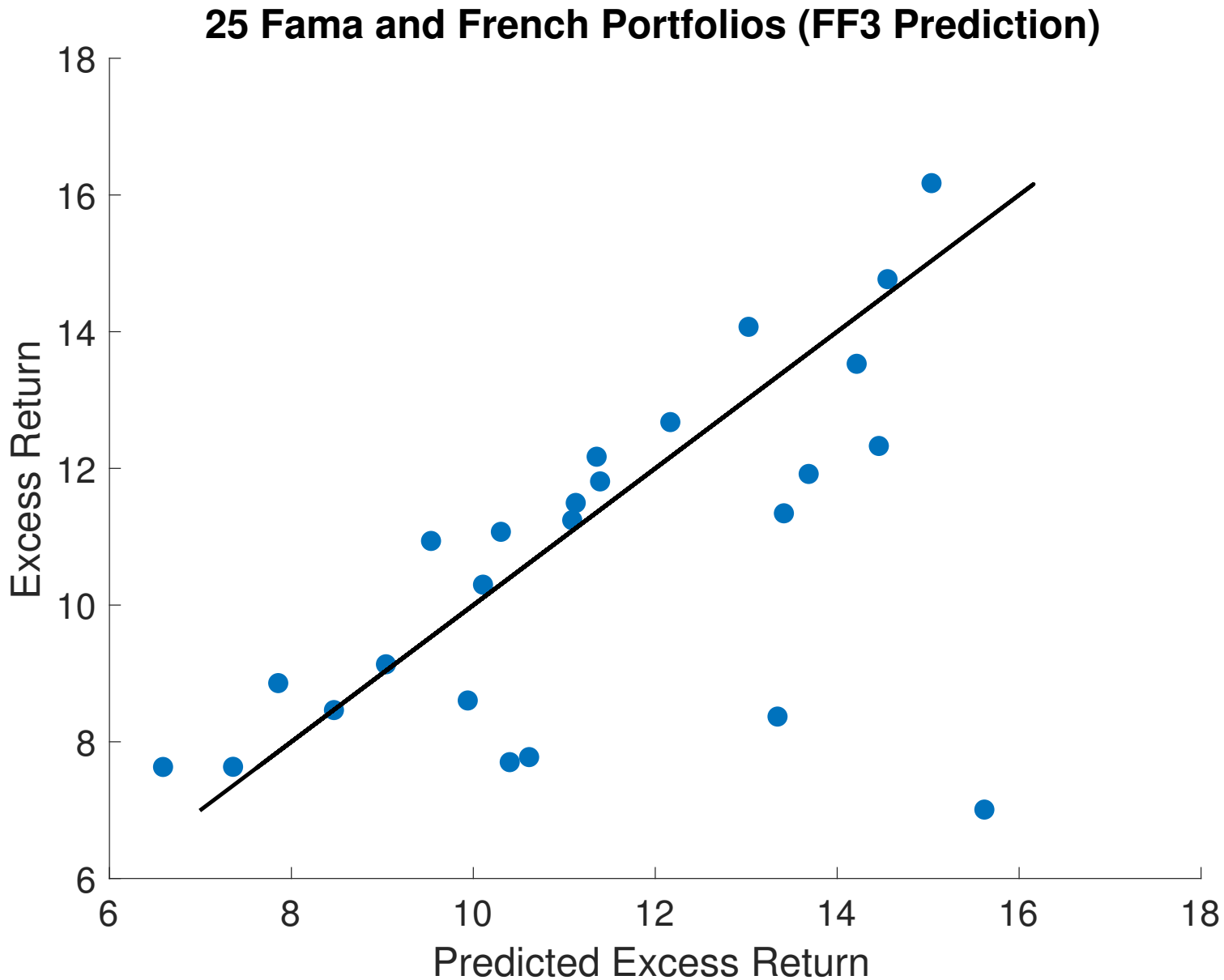
- Three-factor model explains 95% of the variation in average returns on these 25 portfolios sorted by size and book-to-market
- We have an asset-pricing model that works

  In terms of explaining the 25 FF portfolios!
- What does it mean? The Fama-French interpretation:
  - Investors are rewarded for taking on covariance with HML or SMB
  - Investors are not rewarded for investing in small stocks or value stocks
- HML and SMB capture some other sources of macro-economic risk that affect the average investor

Second Stage (CAPM)



Second Stage (Fama and French three-factor model)



Macro-economic Risk

- Do these factors capture macro-economic risk?
- We can check whether these factors price other portfolios (other than the ones sorted by size and book-to-market)
- Other portfolios whose returns are well explained by HML and SMB include
  1. Portfolios of stocks sorted by price/earnings
  2. Portfolios of stocks sorted by sales growth
  3. Portfolios of stocks sorted by reversals
- But these portfolios have high time series R^2

Other Test Assets

- e.g. HML and SMB cannot account for returns on portfolios of stocks sorted by momentum
- Momentum effect is really large!
- Momentum stocks do move together:
  - High momentum stocks move together with other high momentum stocks
  - Low momentum stocks move together with other low momentum stocks
- since momentum stocks co-move, adding a momentum factor eliminates the α on momentum portfolios
- Ad hoc solution: construct a momentum factor, an investment factor, a profitability factor, ...

Factor Investing

Factor Investing

- HML Factor:

$$HML = \frac{1}{2}\,(\text{Small Value} \;+\; \text{Large Value})$$

$$-\,\frac{1}{2}\,(\text{Small Growth} \;+\; \text{Large Growth})$$

Factor Investing

- Factor structure
- Explain returns using asset-pricing factors
- E.g. CAPM:

$$R^e_{i,t} = \alpha_i + \beta_i^{MKT} R_t^{e,MKT} + \varepsilon_{i,t}$$

- More generally:

$$R^e_{i,t} = \alpha_i + \sum_{j=1}^{K} \beta_i^j F_t^j + \varepsilon_{i,t}$$

where $\{F_t^j\}_{j=1}^K$ are asset-pricing factors

Factor Investing

- The HML Factor is a long short portfolio

$$HML_t = \frac{1}{2}\left(\text{Small Value}_t + \text{ Large Value}_t\right)$$

$$- \frac{1}{2}\left(\text{Small Growth}_t + \text{ Large Growth}_t\right)$$

$$= \frac{1}{2}\left[\sum_{i=1}^{n} w_{i,t}^{SV} R_{i,t} + \sum_{i=1}^{n} w_{i,t}^{LV} R_{i,t}\right]$$

$$- \frac{1}{2}\left[\sum_{i=1}^{n} w_{i,t}^{SG} R_{i,t} + \sum_{i=1}^{n} w_{i,t}^{LG} R_{i,t}\right]$$

- Portfolios are value weighted (lagged market cap) and

$$\sum_{i=1}^{n} w_{i,t}^{SV} = \sum_{i=1}^{n} w_{i,t}^{LV} = \sum_{i=1}^{n} w_{i,t}^{SG} = \sum_{i=1}^{n} w_{i,t}^{LG} = 1$$

Factor Investing

- The HML Factor is a portfolio:

$$\begin{aligned}\text{HML}_t &= \frac{1}{2}\left(\text{Small Value}_t + \text{ Large Value}_t\right) \\ &\quad - \frac{1}{2}\left(\text{Small Growth}_t + \text{ Large Growth}_t\right) \\ &= \sum_{i=1}^{n} w_{i,t}^{HML} R_{i,t}\end{aligned}$$

where the weight on stock i at period t is

$$w_{i,t}^{HML} = \frac{1}{2}\left[w_{i,t}^{SV} + w_{i,t}^{LV}\right] - \frac{1}{2}\left[w_{i,t}^{SG} + w_{i,t}^{LG}\right]$$

Factor Investing

- The HML Factor is a portfolio:

$$\text{HML}_t = \sum_{i=1}^{n} w_{i,t}^{HML} R_{i,t}$$

- It is a long-short portfolio

$$\sum_{i=1}^{n} w_{i,t}^{HML} = 0$$

- PS 3 and 4: technique to compute weights
  - MOM, SMB and HML

Factor Investing

- Let us consider the following factor model

$$R^e_{i,t} = \alpha_i + \beta_i^{MKT} R_t^{e,MKT} + \beta_i^{HML} HML_t + \beta_i^{SMB} SMB_t + \sum_{j=1}^{K} \beta_i^j F_t^j + \varepsilon_{i,t}$$

  where $\{F_t^j\}_{j=1}^K$ are other asset-pricing factors
  - We won't focus on these other factors today
  - They could include MOM, Investment, Profitability, BAB, ...
- Alphas and betas relative to the factor model above

Factor Investing

- Factor investing: choose factor exposures!
- Construct a portfolio with the exposures you want
- For example:
  - I want beta 0.5 on the market and 1.5 on value
  - I want a market portfolio adjusted towards value:

    beta 1 on the market and 0.2 on HML

- Construct a portfolio (p) with
  - Market exposure: β_p^{MKT}
  - HML exposure: β_p^{HML}
  - No other exposure: $\beta_p^j = 0 \, \forall \, j \neq HML, MKT$

- Extra problem set (optional)
  - Build a function that creates your factor investing strategy

Factor Investing

- Start with the risk-free asset:

$$R_{p,t} = R_t^f$$

- Add the factors you want:

$$R_{p,t} = R_t^f + \beta_p^{MKT} R_t^{e,MKT} + \beta_p^{HML} R_t^{HML}$$
$$R_{p,t} = \left(1 - \beta_p^{MKT}\right) R_t^f + \beta_p^{MKT} R_t^{MKT} + \beta_p^{HML} R_t^{HML}$$

- Let $w_{i,t}^{MKT}$ be the market weight on asset i at period t
  i.e. lagged market cap-based weight
- Factor investing (FI) strategy
  - Long $\left(1 - \beta_p^{MKT}\right)$ the risk-free asset
  - Factor investing weight on asset i at period t:

$$w_{i,t}^{FI} = \beta_p^{MKT} w_{i,t}^{MKT} + \beta_p^{HML} w_{i,t}^{HML}$$

Factor Investing

- Factor investing (FI) strategy
  - Long $\left(1 - \beta_p^{MKT}\right)$ the risk-free asset
  - Factor investing weight on asset i at period t:

$$w_{i,t}^{FI} = \beta_p^{MKT} w_{i,t}^{MKT} + \beta_p^{HML} w_{i,t}^{HML}$$

  - If β_p^{HML} is low, you may not even have to short
- Weights sum to one:

$$\left(1 - \beta_p^{MKT}\right) + \sum_{i=1}^{n} w_{i,t}^{FI} = 1$$

Factor Investing

- Why is this a factor investing strategy?
- Portfolio excess returns:

$$R_{p,t} = R_t^f + \beta_p^{MKT} R_t^{e,MKT} + \beta_p^{HML} R_t^{HML}$$
$$R_{p,t}^e = \beta_p^{MKT} R_t^{e,MKT} + \beta_p^{HML} R_t^{HML}$$

- The factor model estimation will give you:
  - Zero alpha
  - Market exposure: β_p^{MKT}
  - HML exposure: β_p^{HML}
  - No other exposure: $\beta_p^j = 0 \, \forall \, j \neq HML, MKT$

Asset Growth

Cooper, Gulen and Schill (2008, JF)

Real Investments and Stocks Returns

Cross-sectional evidence: negative correlation between investment and future returns

- Asset expansion is typically followed by periods of lower abnormal returns
- Asset contraction is typically followed by periods of higher abnormal returns

Real Investments and Stocks Returns

How to measure a proxy for investment?

- Events associated with expansion/contractions
- acquisitions, equity/debt offering, loans
- spinoffs, share repurchase, debt prepayment, dividends

Larger picture: total investment!

- Asset growth

Asset Growth and Cross-Section of Stock Returns

- Cross-sectional relation: asset growth and stock returns
- Asset Growth: predictor of future stock return
  - Works even among large caps
- Not priced/explained by other determinants of the cross-section of returns
- Asset growth sorted portfolios
  - Long-short portfolio: 13% spread with 1.07 Sharpe Ratio

Asset Growth and Cross-Section of Stock Returns

Data

- NYSE, Amex, NASDAQ exchanges
- exclude financial firms (why?)
- Sample: 1963-2003
- Require at least 2 year of compustat data per firm
- Form all accounting variables at end of June of year t from fiscal year $t-1$.
- Rebalance at the end each June
- Main variable: asset growth (ASSETG)

$$ASSETG_{i,t} = \frac{AT_{i,t-1} - AT_{i,t-2}}{AT_{i,t-2}}$$

using nonmissing/nonzero data only

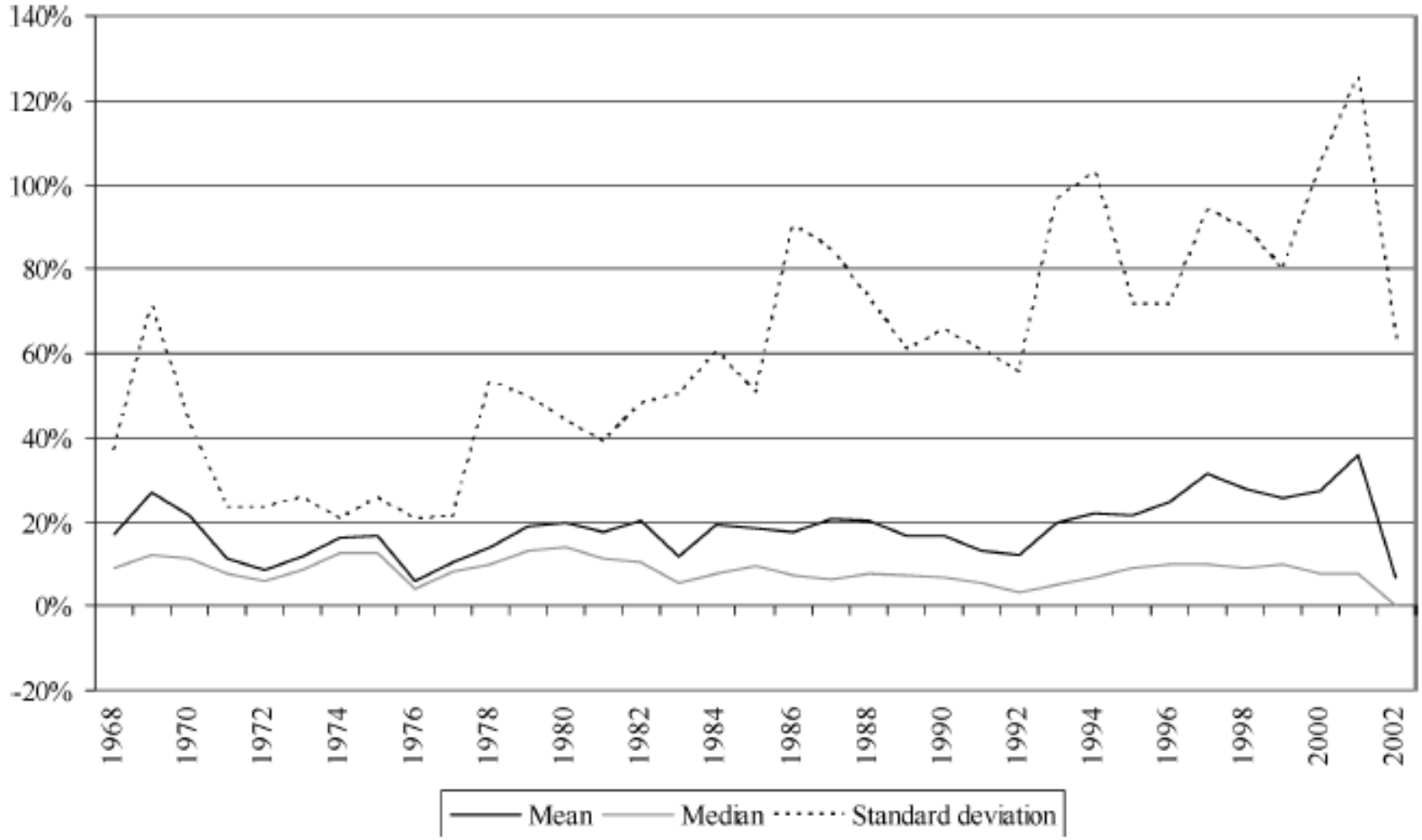


Figure 1. Time series of summary statistics for annual asset growth rates. The figure plots cross-sectional summary statistics for annual asset growth rates for U.S. nonfinancial firms by year from 1968 to 2002.

Characterizing asset growth sorted portfolios

Table I

Asset Growth Deciles: Financial and Return Characteristics

At the end of June of each year t over 1968 to 2002, stocks are allocated into deciles based on asset growth (*ASSETG*) defined as the percentage change in total assets from the fiscal year ending in calendar year $t-2$ to fiscal year ending in calendar year $t-1$. The table reports the financial and return characteristics in the year prior to the portfolio formation date. *L2ASSETG* is the asset growth defined as the percentage change in total assets from the fiscal year ending in calendar year $t-3$ to fiscal year ending in calendar year $t-2$. *ASSETS* is Compustat data item 6, total assets, in millions of \$, from the fiscal year ending in calendar year $t-1$. Market value (*MV*), in millions of \$, is calculated using the price and the number of shares outstanding at the end of June of year t. All accounting variables (book-to-market ratio (*BM*), earnings-to-price ratio (*EP*), leverage, return on assets (*ROA*), and *ACCRUALS*) are calculated using Compustat data in the fiscal year ending in calendar year $t-1$. *BHRET6* is the buy-and-hold return over January(t) to June(t) where t is the portfolio formation year. *BHRET36* is the 36-month buy and hold return over July($t-3$) to June(t). *ISSUANCE* is a 5-year change in the number of equity shares outstanding. The numbers in each cell are time-series averages of yearly cross-sectional medians, with the exception of average market value (*MV-AVG*), in millions of \$, which is the time-series average of yearly cross-sectional mean capitalization. All numbers, with the exception of *ASSETS*, *MV*, and *MV-AVG*, are in decimal form, that is 0.01 is 1%. Details on the construction of these variables are provided in the Appendix.

Decile	ASSETG	L2ASSETG	ASSETS	MV	MV-AVG	BM	EP	Leverage	ROA	BHRET6	BHRET36	ACCRUALS	ISSUANCE
1 (Low)	−0.2115	0.0041	20.86	15.70	130.27	0.8156	−0.1931	0.2446	−0.0186	0.086	−0.3286	−0.1253	0.0803
2	−0.0679	0.0294	48.35	26.64	276.70	1.0266	−0.005	0.2437	0.0704	0.0917	−0.1121	−0.0700	−0.0353
3	−0.0079	0.0447	96.46	53.98	602.21	0.9974	0.0536	0.2485	0.1110	0.0921	0.0647	−0.0487	−0.0841
4	0.0319	0.0601	134.48	84.92	930.28	0.9261	0.0732	0.2429	0.1329	0.0784	0.1964	−0.0356	−0.1139
5	0.0661	0.0748	154.60	106.88	1154.12	0.8515	0.0797	0.2400	0.1473	0.0792	0.2757	−0.0283	−0.104
6	0.1025	0.0950	145.20	112.72	1123.79	0.7710	0.0808	0.2263	0.1608	0.0703	0.3360	−0.0206	−0.0752
7	0.1480	0.1165	130.18	116.69	1051.26	0.6918	0.0794	0.2139	0.1743	0.0662	0.3804	−0.0113	−0.0295
8	0.2168	0.1465	100.71	103.96	889.45	0.6076	0.0759	0.2181	0.1886	0.0622	0.4713	0.0014	0.0144
9	0.3529	0.1839	76.74	95.65	903.01	0.5158	0.0685	0.2356	0.2025	0.0427	0.5657	0.0119	0.1167
10 (High)	0.8357	0.2168	66.69	85.61	585.35	0.4256	0.0528	0.2612	0.2173	0.0074	0.7154	0.0341	0.3012
Spread (10-1)	1.0471	0.2127	45.83	69.91	455.08	−0.39	0.246	0.0165	0.2359	−0.0786	1.044	0.1594	0.2209
t(spread)	15.60	26.26	4.83	5.24	3.32	−6.48	5.61	1.17	20.64	−0.33	15.65	28.10	8.36

Asset growth before and after sorting

Table II

Asset Growth Decile Portfolio Returns and Characteristics in Event Time

At the end of June of each year t over 1968 to 2002, stocks are allocated into deciles based on asset growth rates defined as the percentage change in total assets from the fiscal year ending in calendar year $t-2$ to fiscal year ending in calendar year $t-1$. Equal- and value-weighted portfolios are formed based on June(t) asset growth decile cutoffs. The portfolios are held for 1 year, from July of year t to June of year $t+1$, and then rebalanced. Portfolio return statistics are reported every year for 10 years around the portfolio formation year (t) over the period of July 1968 to June of 2003. Panel A reports average annual asset growth rates. Panel B.1 reports average monthly raw returns to equal-weighted portfolios and Panel B.2 reports average monthly raw returns to value-weighted portfolios. Panel C.1 reports three-factor alphas of the equal-weighted portfolios and Panel C.2 reports three-factor alphas of the value-weighted portfolios for all firms and for three size-sorted groups. The size groups are defined by ranking firms into one of three groups (small, medium, and large) using the 30^{th} and 70^{th} NYSE market equity percentiles in June of year t. Panel D.1 reports subperiod three-factor alphas of the equal-weighted portfolios and Panel D.2 reports subperiod three-factor alphas of the value-weighted portfolios. In Panel A, the year -1 row reports the asset growth rates from fiscal year ending in calendar year $t-2$ to $t-1$, year 1 reports the asset growth rates from fiscal year ending in calendar year $t-1$ to t, etc. In Panel B, the year -1 row reports the portfolio returns over July ($t-1$)–June (t) and year 1 reports the portfolio returns over July (t)–June ($t+1$). In Panel B, [−5,−1] ([1, 5]) is the cumulative portfolio return over the 5 years prior (after) the portfolio formation period. All numbers, with the exception of the t-statistics, are in decimal form, that is 0.01 is 1%.

Panel A: Average Annual Asset Growth Rates

	Asset Growth Deciles											
YEAR	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	t(spread)
−5	0.0762	0.0771	0.0800	0.0783	0.0845	0.0924	0.102	0.1148	0.1191	0.1023	0.0260	5.04
−4	0.0686	0.0704	0.0723	0.0756	0.0841	0.0937	0.1041	0.1177	0.1320	0.1158	0.0472	7.34
−3	0.0595	0.0544	0.0641	0.0700	0.0792	0.0960	0.1097	0.1306	0.1483	0.1401	0.0805	8.61
−2	−0.0009	0.0257	0.0423	0.0579	0.0727	0.0930	0.1141	0.1442	0.1818	0.2143	0.2152	26.05
−1	−0.2115	−0.0679	−0.0079	0.0319	0.0661	0.1025	0.1480	0.2168	0.3529	0.8357	1.0471	15.60
1	−0.0225	0.0078	0.0332	0.0532	0.0719	0.0906	0.1098	0.1328	0.1580	0.1693	0.1918	23.33
2	0.0249	0.0305	0.0445	0.0590	0.0707	0.0832	0.0947	0.1071	0.1137	0.1076	0.0827	9.41
3	0.0444	0.0440	0.0508	0.0590	0.0692	0.0759	0.0875	0.0909	0.0989	0.0870	0.0426	7.49
4	0.0584	0.0503	0.0549	0.0607	0.066	0.0728	0.0786	0.0887	0.0927	0.0782	0.0198	3.86
5	0.0554	0.0561	0.0583	0.0622	0.0667	0.0708	0.0797	0.0832	0.0869	0.0767	0.0213	3.81

Asset growth sorted portfolios: ew returns

Table II—*Continued*

Panel B: Raw Return Portfolios

Panel B.1: Equal-Weighted Portfolio Average Monthly Raw Returns

	Asset Growth Deciles											
YEAR	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	*t*(spread)
−5	0.0096	0.0096	0.0099	0.0114	0.0126	0.0144	0.0161	0.0172	0.0198	0.0188	0.0092	7.57
−4	0.0065	0.0069	0.0085	0.0101	0.0116	0.0138	0.0158	0.0193	0.0215	0.0246	0.0181	14.44
−3	0.0004	0.0033	0.0066	0.0093	0.0124	0.0133	0.0162	0.0203	0.0262	0.0349	0.0345	21.53
−2	−0.0064	0.0016	0.0052	0.0087	0.0106	0.0132	0.0159	0.0195	0.0260	0.0386	0.0450	18.80
−1	0.0131	0.0119	0.0121	0.0125	0.0125	0.0132	0.0125	0.0128	0.0113	0.0104	−0.0026	−1.08
1	0.0199	0.0176	0.0154	0.0141	0.0134	0.0124	0.0118	0.0114	0.0085	0.0026	−0.0173	−8.45
2	0.0159	0.0159	0.0141	0.0138	0.0137	0.0132	0.0138	0.0128	0.0119	0.0076	−0.0083	−4.67
3	0.0176	0.0173	0.016	0.0147	0.0145	0.0144	0.0143	0.0140	0.0137	0.0124	−0.0053	−3.79
4	0.0169	0.016	0.0154	0.0141	0.0138	0.0136	0.0132	0.0125	0.0134	0.0127	−0.0042	−3.14
5	0.0167	0.0167	0.0161	0.0143	0.0138	0.0135	0.0133	0.0132	0.0133	0.0134	−0.0033	−2.41
	Cumulative Return											
[−5,−1]	0.3157	0.5054	0.6963	0.9000	1.0833	1.3169	1.5596	1.9929	2.6093	3.7079	3.3922	10.52
[1, 5]	1.6507	1.6201	1.4535	1.3156	1.2562	1.1745	1.1601	1.1008	1.0079	0.7708	−0.8799	−8.63

Asset growth sorted portfolios: vw returns

Panel B.2: Value-Weighted Portfolio Average Monthly Raw Returns

	Asset Growth Deciles											
YEAR	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	*t*(spread)
−5	0.0121	0.0123	0.0117	0.0129	0.0142	0.0146	0.0165	0.0207	0.0243	0.0271	0.0150	7.55
−4	0.0114	0.0109	0.0119	0.0131	0.0128	0.0146	0.0172	0.0202	0.0288	0.0307	0.0193	9.15
−3	0.0064	0.0085	0.0100	0.0123	0.0143	0.0151	0.0157	0.0212	0.0279	0.0357	0.0292	10.92
−2	0.0062	0.0083	0.0090	0.0116	0.0135	0.0149	0.017	0.0206	0.0266	0.0396	0.0334	12.86
−1	0.0223	0.0175	0.0153	0.0146	0.0147	0.0141	0.0153	0.0177	0.0192	0.0230	0.0007	0.28
1	0.0148	0.0124	0.0122	0.0116	0.0100	0.0100	0.0102	0.0092	0.0077	0.0043	−0.0105	−5.04
2	0.0133	0.0126	0.0125	0.0101	0.0109	0.0102	0.0098	0.0097	0.0097	0.0065	−0.0068	−3.39
3	0.0169	0.0137	0.0141	0.0126	0.0102	0.0112	0.0116	0.0105	0.0116	0.0116	−0.0053	−2.82
4	0.0132	0.0107	0.012	0.0109	0.0114	0.0103	0.0103	0.0123	0.0111	0.0120	−0.0012	−0.61
5	0.0128	0.0133	0.0121	0.0123	0.0103	0.01	0.0107	0.0113	0.013	0.0126	−0.0002	−0.11
	Cumulative Return											
[−5,−1]	1.0449	0.9918	1.0078	1.2375	1.3631	1.4788	1.7985	2.5321	3.9221	6.4272	5.3822	4.78
[1, 5]	1.2879	1.1133	1.1305	1.0038	0.931	0.8934	0.9352	0.9056	0.9458	0.7911	−0.4967	−4.25

Asset growth sorted portfolios: α_{FF} by size

Alphas relative to the Fama and French three-factor model

Panel C. Equal- and Value-Weighted Portfolio Fama–French Alphas in Year 1 by Size Groups

Panel C.1: Equal-Weighted Portfolio Fama–French Monthly Alphas

	Asset Growth Deciles											
	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	*t*(spread)
All Firms	0.0076	0.006	0.0035	0.0026	0.002	0.0013	0.0006	0.0003	−0.0026	−0.0087	−0.0163	−8.33
Small size	0.0081	0.0067	0.0044	0.003	0.0027	0.0012	0.0002	0.0001	−0.0033	−0.0096	−0.0177	−9.12
Medium size	−0.0004	0.0007	0.0010	0.0010	0.0011	0.0010	0.0010	0.0002	−0.0016	−0.0064	−0.0060	−2.85
Large size	0.0044	0.0011	0.0003	0.0014	0.0005	0.0001	0.0005	0.0011	−0.001	−0.0041	−0.0086	−3.12

Panel C.2: Value-Weighted Portfolio Fama–French Monthly Alphas

	Asset Growth Deciles											
	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	*t*(spread)
All Firms	0.0024	0.0013	0.0013	0.0017	0.0003	0.0006	0.0015	0.0013	−0.0001	−0.0046	−0.007	−3.84
Small size	0.0005	0.0020	0.0013	0.0016	0.0015	0.0007	−0.0009	−0.0006	−0.0043	−0.0109	−0.0114	−6.46
Medium size	−0.0002	0.0003	0.001	0.0005	0.0008	0.0008	0.0013	0.0004	−0.0012	−0.0057	−0.0055	−2.45
Large size	0.0052	0.0018	0.0013	0.0019	0.0003	0.0005	0.0018	0.0015	0.0008	−0.0028	−0.0081	−2.91

Asset growth sorted portfolios: α_{FF} by subsample

Alphas relative to the Fama and French three-factor model

Panel D. Equal- and Value-Weighted Asset Growth Decile Portfolio Fama–French Alphas in Year 1 by Subperiods

Panel D.1: Equal-Weighted Portfolio Fama–French Monthly Alphas

	Asset Growth Deciles											
Period	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	*t*(spread)
1968–1980	0.004	0.0038	0.0025	0.0027	0.0023	0.0006	0.0005	0.001	0.0004	−0.0031	−0.0071	−3.87
1981–1990	0.0016	0.0013	0.0011	0.0018	0.0017	0.0026	0.0008	−0.0001	−0.0038	−0.0118	−0.0134	−4.80
1991–2003	0.0146	0.0117	0.0068	0.0043	0.0029	0.0018	0.0016	0.0008	−0.0045	−0.0123	−0.027	−6.62

Panel D.2: Value-Weighted Portfolio Fama–French Monthly Alphas

	Asset Growth Deciles											
Period	1(Low)	2	3	4	5	6	7	8	9	10(High)	Spread (10-1)	*t*(spread)
1968–1980	0.003	0.0029	0.002	0.0016	−0.0002	0.0005	−0.0001	0.0003	0.0004	−0.0005	−0.0035	−1.69
1981–1990	0.0006	−0.0001	0.0022	0.0025	0.0005	0.0018	0.0018	0.0001	−0.0009	−0.0059	−0.0066	−2.51
1991–2003	0.0037	0.001	0.001	0.0017	0.001	0.0005	0.0035	0.0031	0.0002	−0.007	−0.0107	−2.52

Asset growth sorted portfolios

Robustness

- What else could be driving these results?

- Control for more factors? Which ones?
- Equity offering / acquisition

- Time consistency?

Asset growth sorted portfolios: consistency over time

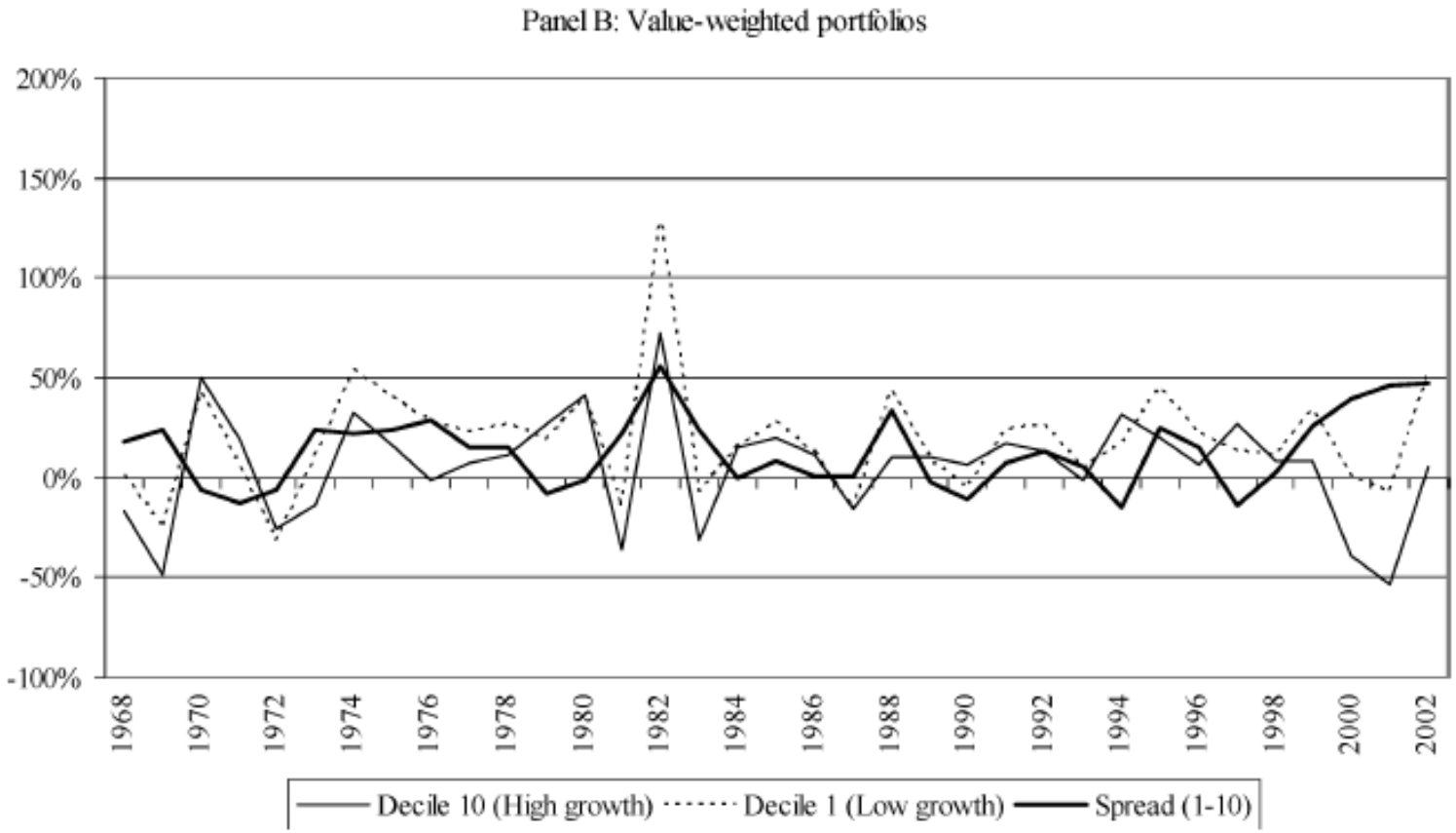


Figure 3. Time series of annual returns for asset growth portfolios. The figure plots the annual buy-and-hold return for equal-weighted (Panel A) and value-weighted (Panel B) portfolios sorted by past asset growth rates. Decile 1 refers to firms in the lowest asset growth decile and decile 10 refers to firms in the highest asset growth decile. The spread is the difference between the returns of the low growth stocks and those of the high growth stocks.

Fama-MacBeth Regressions

Asset growth is associated with returns, after controlling for other predictors

Table III

Fama–MacBeth Regressions of Annual Stock Returns on Asset Growth and Other Variables

Annual stock returns from July 1968 to June 2003 are regressed on lagged accounting and return-based variables. *BM* (book-to-market ratio) is calculated using the Compustat data in the fiscal year ending in calendar year $t-1$ and is defined as in Davis, Fama, and French (2000). *MV* is the June(t) market value, *BHRET6* is the buy-and-hold return over January(t)–June(t), *BHRET36* is the 36-month buy and hold return over July($t-3$) to June(t), *CI* is the measure of abnormal capital investment as defined in Titman, Wei, and Xie (2004), *L2ASSETG* is the asset growth defined as the percentage change in total assets from the fiscal year ending in calendar year $t-3$ to fiscal year ending in calendar year $t-2$, *ASSETG* is the asset growth defined as the percentage change in total assets from the fiscal year ending in calendar year $t-2$ to fiscal year ending in calendar year $t-1$, *5YASSETG* is a 5-year weighted average rank of asset growth, and *5YSALESG* is a 5-year weighted average rank of growth rate in sales. *ACCRUALS* is from Sloan (1996) and *NOA/A* is net operating assets divided by total assets adjusted from Hirshleifer, Hou, Teoh, and Zhang (2004). More details on the construction of these variables are provided in the Appendix. Size groups are defined by ranking firms into one of three groups (small, medium, and large) using the 30th and 70th NYSE market equity percentiles in June of year t. Panel A reports regressions for all firms, and Panels B, C, and D report regressions for small, medium, and large firms, respectively. Beta estimates are time-series averages of cross-sectional regression betas obtained from annual cross-sectional regressions. The t-statistics, in parentheses, are adjusted for autocorrelation in the beta estimates.

Panel A. All Firms

Model		Constant	ASSETG	L2ASSETG	BM	MV	BHRET6	BHRET36	5YSALESG	CI	NOA/A	ACCRUALS	5YASSETG
1	Beta	0.1373	−0.0922	.	0.029	−0.0044	0.0248	0.0056	.		.	.	.
	t-stat	(4.55)	(−6.52)	.	(3.40)	(−1.57)	(1.09)	(0.57)	.		.	.	.
2	Beta	0.1423	−0.0874	−0.0312	0.0276	−0.0044	0.0234	0.0062	.		.	.	.
	t-stat	(4.65)	(−6.76)	(−2.25)	(3.32)	(−1.58)	(1.06)	(0.62)	.		.	.	.
3	Beta	0.1378	−0.0893	.	0.0281	−0.0043	0.0241	0.0055	−0.0041		.	.	.
	t-stat	(3.79)	(−7.41)	.	(3.52)	(−1.57)	(1.11)	(0.55)	(−0.27)		.	.	.
4	Beta	0.1378	−0.0868	.	0.029	−0.0044	0.024	0.0058		−0.0072	.	.	.
	t-stat	(4.55)	(−6.05)	.	(3.38)	(−1.60)	(1.06)	(0.58)		(−3.32)		.	.
5	Beta	0.2058	−0.0918	.	0.0322	−0.0046	0.0249	0.0044	.		−0.1109	.	.
	t-stat	(4.25)	(−6.10)	.	(3.75)	(−1.62)	(1.11)	(0.45)	.		(−2.43)	.	.
6	Beta	0.1223	−0.0704	.	0.0347	−0.0045	0.0122	0.0046	.		.	−0.1785	.
	t-stat	(3.89)	(−5.24)	.	(4.22)	(−1.59)	(0.41)	(0.44)	.	.	.	(−4.00)	.
7	Beta	0.1739	−0.0839	.	0.0245	−0.0041	0.0229	0.0049	.	.	.	.	−0.0275
	t-stat	(5.43)	(−6.98)	.	(3.14)	(−1.50)	(1.03)	(0.48)	.	.	.	.	(−2.22)

Asset growth sorted portfolios: risk or mispricing?

- Returns patterns not explained by
  - Fama and French (1993) three-factor model
  - Carhart(1997 four-factor model
- Risk-based explanations?
- Mispricing?

Profitability

Novy-Marx (2013, JFE)

Gross profitability

Gross profitability and the cross-section of stocks returns

- Same power as book-to-market ratio
- Value: long cheap and short expensive assets
- Profitability: long productive and short unproductive assets

- More profitable firms earn significantly higher average return than unprofitable firms

Data

- Gross profitability: clean measure of economic profits

$$\text{Gross Profitability} = \frac{[\text{Total Revenue}] - [\text{Cost of goods solds}]}{[\text{Total Assets}]} = \frac{REVT - COGS}{AT}$$

Fama-MacBeth Regressions

Profitability versus Value

Table 1
Fama and MacBeth regressions of returns on measures of profitability.

Panel A reports results from Fama and MacBeth regressions of returns on gross profits (revenues minus cost of goods sold, REVT − COGS) scaled by assets (AT), as well as income before extraordinary items (IB) and free cash flow (net income plus amortization and depreciation minus changes in working capital and capital expenditures, NI+DP−WCAPCH−CAPX) each scaled by book equity. Panel B repeats the tests employing profitability measures demeaned by industry (Fama and French 49). Regressions include controls for book-to-market [log(B/M)], size [log(ME)], and past performance measured at horizons of one month ($r_{1,0}$) and 12 to two months ($r_{12,2}$). Independent variables are trimmed at the 1% and 99% levels. The sample excludes financial firms (those with one-digit standard industrial classification codes of six) and covers July 1963 to December 2010.

	Slope coefficients ($\times 10^2$) and [test-statistics] from regressions of the form $r_{tj} = \beta' \mathbf{x}_{tj} + \epsilon_{tj}$						
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Straight profitability variables							
Gross profitability	0.75			0.69	0.62		0.61
	[5.49]			[5.22]	[4.63]		[4.59]
Earnings		0.22		0.08		−0.02	−0.07
		[0.84]		[0.31]		[−0.06]	[−0.27]
Free cash flow			0.27		0.20	0.39	0.33
			[2.28]		[1.64]	[3.17]	[2.67]
log(B/M)	0.35	0.30	0.26	0.34	0.30	0.27	0.31
	[5.98]	[4.97]	[4.59]	[5.54]	[5.17]	[4.48]	[5.05]
log(ME)	−0.09	−0.12	−0.13	−0.11	−0.11	−0.13	−0.11
	[−2.29]	[−3.24]	[−3.20]	[−2.78]	[−2.80]	[−3.34]	[−2.92]
$r_{1,0}$	−5.57	−5.49	−5.52	−5.64	−5.66	−5.56	−5.70
	[−13.8]	[−13.7]	[−13.7]	[−14.1]	[−14.1]	[−13.9]	[−14.3]
$r_{12,2}$	0.76	0.78	0.78	0.74	0.74	0.76	0.73
	[3.87]	[4.02]	[4.02]	[3.80]	[3.80]	[3.93]	[3.74]

Sorted Portfolios

Profitability versus Value

Table 2
Excess returns to portfolios sorted on profitability.

This table shows monthly value-weighted average excess returns to portfolios sorted on gross profits-to-assets [(REVT − COGS)/AT], employing NYSE breakpoints, and results of time series regressions of these portfolios' returns on the Fama and French factors [the market factor (MKT), the size factor small-minus-large (SMB), and the value factor high-minus-low (HML)], with test-statistics (in square brackets). It also shows time series average portfolio characteristics [portfolio gross profits-to-assets (GP/A), book-to-market (B/M), average firm size (ME, in millions of dollars), and number of firms (n)]. Panel B provides similar results for portfolios sorted on book-to-market. The sample excludes financial firms (those with one-digit standard industrial classification codes of six) and covers July 1963 to December 2010.

		Alphas and three-factor loadings				Portfolio characteristics			
Portfolio	r^e	α	MKT	SMB	HML	GP/A	B/M	ME	n
Panel A: Portfolios sorted on gross profits-to-assets									
Low	0.31	−0.18	0.94	0.04	0.15	0.10	1.10	748	771
	[1.65]	[−2.54]	[57.7]	[1.57]	[5.87]				
2	0.41	−0.11	1.03	−0.07	0.20	0.20	0.98	1,100	598
	[2.08]	[−1.65]	[67.5]	[−3.13]	[8.51]				
3	0.52	0.02	1.02	−0.00	0.12	0.30	1.00	1,114	670
	[2.60]	[0.27]	[69.9]	[−0.21]	[5.42]				
4	0.41	0.05	1.01	0.04	−0.24	0.42	0.53	1,114	779
	[1.94]	[0.83]	[70.6]	[1.90]	[−11.2]				
High	0.62	0.34	0.92	−0.04	−0.29	0.68	0.33	1,096	938
	[3.12]	[5.01]	[58.3]	[−2.03]	[−12.3]				
High–low	0.31	0.52	−0.03	−0.08	−0.44				
	[2.49]	[4.49]	[−0.99]	[−2.15]	[−10.8]				

Sorted Portfolios

Profitability versus Value

Panel B: Portfolios sorted on book-to-market									
Low	0.39	0.13	0.98	−0.09	−0.39	0.43	0.25	1,914	965
	[1.88]	[2.90]	[90.1]	[−5.62]	[−23.9]				
2	0.45	−0.02	0.99	0.05	0.04	0.31	0.54	1,145	696
	[2.33]	[−0.29]	[78.1]	[2.61]	[2.23]				
3	0.56	0.03	0.96	0.04	0.22	0.26	0.79	849	640
	[2.99]	[0.53]	[63.5]	[2.09]	[9.71]				
4	0.67	−0.00	0.96	0.10	0.53	0.21	1.12	641	655
	[3.58]	[−0.03]	[74.8]	[5.66]	[27.1]				
High	0.80	0.07	1.01	0.25	0.51	0.21	5.47	367	703
	[3.88]	[1.04]	[60.7]	[10.7]	[20.5]				
High–low	0.41	−0.06	0.03	0.34	0.91				
	[2.95]	[−0.71]	[1.44]	[12.0]	[30.0]				

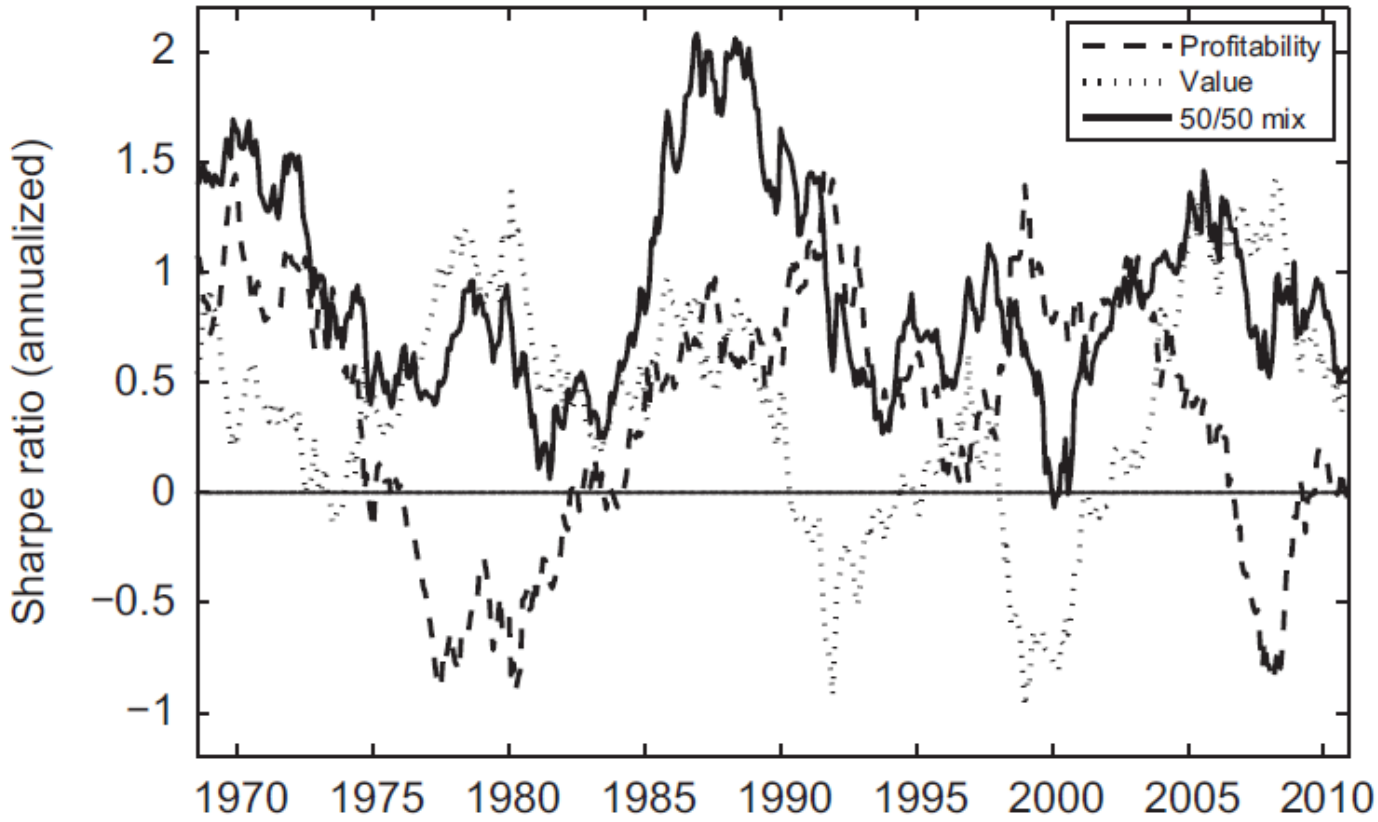


Fig. 1. Performance over time of profitability and value strategies. The figure shows the trailing five-year Sharpe ratios of profitability and value strategies (dashed and dotted lines, respectively) and a 50/50 mix of the two (solid line). The strategies are long–short extreme value-weighted quintiles from sorts on gross profits-to-assets and book-to-market, respectively, and correspond to the strategies considered in Table 2. The sample excludes financial firms and covers June 1963 to December 2010.

Sorted Portfolios

Profitability in Large/Small Caps?

Table 4

Double sorts on gross profits-to-assets and market equity.

This table shows the value-weighted average excess returns to portfolios double sorted, using NYSE breakpoints, on gross profits-to-assets and market equity, and results of time series regressions of both sorts' high minus low portfolios' returns on the Fama and French factors [the market, size and value factors MKT, SMB (small-minus-large), and HML (high-minus-low)]. Test statistics are given in square brackets. The table also shows the average number of firms in each portfolio and each portfolios' average book-to-market (the portfolios exhibit little gross-profits to asset variation within size quintiles and little size variation within profitability quintiles). The sample excludes financial firms (those with one-digit standard industrial classification codes of six) and covers July 1963 to December 2010.

Panel A: Portfolio average excess returns and time series regression results

	Gross profits-to-asset quintiles					Profitability strategies				
	Low	2	3	4	High	r^e	α	β_{mkt}	β_{smb}	β_{hml}
Size quintiles										
Small	0.40	0.64	0.78	0.89	1.07	0.67	0.63	0.05	−0.13	0.13
						[4.59]	[4.27]	[1.48]	[−2.68]	[2.47]
2	0.37	0.71	0.71	0.73	0.90	0.53	0.54	0.01	0.06	−0.08
						[3.97]	[3.96]	[0.35]	[1.34]	[−1.58]
3	0.40	0.73	0.74	0.68	0.81	0.41	0.38	0.10	0.18	−0.15
						[2.88]	[2.71]	[3.02]	[4.01]	[−3.05]
4	0.45	0.62	0.59	0.65	0.84	0.38	0.45	0.03	0.21	−0.35
						[2.82]	[3.62]	[1.00]	[5.14]	[−7.95]
Big	0.30	0.37	0.49	0.36	0.55	0.26	0.50	−0.05	−0.05	−0.51
						[1.88]	[3.90]	[−1.56]	[−1.09]	[−11.3]
Small-minus-big strategies										
r^e	0.10	0.28	0.29	0.53	0.51					
	[0.39]	[1.40]	[1.45]	[2.64]	[2.37]					
α	−0.21	−0.16	−0.13	−0.03	−0.08					
	[−1.30]	[−1.63]	[−1.26]	[−0.31]	[−0.72]					
β_{mkt}	−0.03	−0.00	−0.01	0.01	0.07					
	[−0.69]	[−0.01]	[−0.45]	[0.53]	[2.88]					
β_{smb}	1.54	1.34	1.34	1.32	1.45					
	[28.9]	[41.1]	[38.9]	[39.7]	[41.9]					
β_{hml}	−0.22	0.20	0.17	0.48	0.42					
	[−3.90]	[5.56]	[4.56]	[13.5]	[11.1]					

Sorted Portfolios

Profitability in high/low BM?

Table 6

Double sorts on gross profits-to-assets and book-to-market.

This table shows the value-weighted average excess returns to portfolios double sorted, using NYSE breakpoints, on gross profits-to-assets and book-to-market, as well results of time series regressions of both sorts' high minus low portfolios' returns on the Fama and French factors [the market, size and value factors MKT, SMB (small-minus-large), and HML (high-minus-low)]. Test statistics are given in square brackets. The table also shows the average number of firms, and the average size of firms, in each portfolio (the portfolios exhibit little gross-profits to asset variation within book-to-market quintiles and little book-to-market variation within profitability quintiles). The sample excludes financial firms (those with one-digit standard industrial classification codes of six) and covers July 1963 to December 2010.

Panel A: Portfolio average returns and time series regression results

	Gross profits-to-asset quintiles					Profitability strategies				
	Low	2	3	4	High	r^e	α	β_{mkt}	β_{smb}	β_{hml}
Book-to-market quintiles										
Low	−0.08	0.19	0.27	0.26	0.56	0.64	0.83	−0.24	−0.27	−0.01
						[3.52]	[4.76]	[−6.03]	[−4.81]	[−0.18]
2	0.19	0.30	0.40	0.70	0.90	0.70	0.69	−0.12	0.26	0.01
						[4.13]	[4.00]	[−3.05]	[4.61]	[0.09]
3	0.38	0.39	0.74	0.69	0.87	0.49	0.27	0.09	0.53	0.10
						[2.80]	[1.64]	[2.30]	[9.89]	[1.77]
4	0.50	0.60	0.94	1.04	0.93	0.43	0.28	0.07	0.65	−0.14
						[2.47]	[2.06]	[−0.94]	[9.40]	[−1.27]
High	0.65	0.83	0.96	1.09	1.08	0.44	0.34	−0.04	0.51	−0.08
						[2.38]	[1.79]	[1.83]	[12.6]	[−2.52]
Value strategies										
r^e	0.73	0.64	0.69	0.83	0.52					
	[3.52]	[3.42]	[3.76]	[4.74]	[2.81]					
α	0.45	0.27	0.39	0.38	−0.03					
	[2.76]	[1.65]	[2.26]	[2.80]	[−0.20]					
β_{mkt}	−0.18	−0.06	−0.03	−0.06	0.02					
	[−4.77]	[−1.44]	[−0.86]	[−1.95]	[0.72]					
β_{smb}	−0.04	0.27	0.32	0.74	0.75					
	[−0.75]	[5.00]	[5.57]	[16.6]	[16.2]					
β_{hml}	0.91	0.81	0.58	0.69	0.85					
	[15.7]	[14.1]	[9.52]	[14.2]	[17.0]					

Sorted Portfolios

Profitability in high/low BM?

Panel B: Portfolio average number of firms and average firm size (millions of dollars)

	Gross profits-to-asset quintiles					Gross profits-to-asset quintiles				
	Low	2	3	4	High	Low	2	3	4	High
	Number of firms					Average firm size				
B/M quintiles										
Low	195	101	128	194	343	653	1,461	1,891	2,694	2,493
2	104	95	130	170	192	1,002	1,729	1,590	1,238	669
3	113	104	128	145	142	1,003	1,402	1,266	534	277
4	144	129	128	128	118	955	1,118	630	268	187
High	174	151	135	120	108	568	424	443	213	102

Gross profitability

- International evidence?
- HML, controlling for profitability
- Trade corners of a double sort on value and profitability
  - Using only 500 largest nonfinancial stocks
  - See Table 7

Fama and French five-factor model

Fama and French (2015, JFE)

Fama and French five-factor model

FF five-factor model adds investment and profitability:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it}.$$

- SMB: small minus big (market equity)
- HML: high minus low (book-to-market)
- RMW: robust minus weak (profitability)
- CMA: conservative minus aggressive (investment)

Fama and French five factors

Joint sort on size, BM, inv. (asset growth), and profitability!?

- Easily get many poorly diversified portfolios
- Need fewer portfolios

Fama and French five factors

Table 3
Construction of *Size*, *B/M*, profitability, and investment factors.

We use independent sorts to assign stocks to two *Size* groups, and two or three *B/M*, operating profitability (*OP*), and investment (*Inv*) groups. The VW portfolios defined by the intersections of the groups are the building blocks for the factors. We label these portfolios with two or four letters. The first always describes the *Size* group, small (*S*) or big (*B*). In the 2×3 sorts and 2×2 sorts, the second describes the *B/M* group, high (*H*), neutral (*N*), or low (*L*), the *OP* group, robust (*R*), neutral (*N*), or weak (*W*), or the *Inv* group, conservative (*C*), neutral (*N*), or aggressive (*A*). In the $2 \times 2 \times 2 \times 2$ sorts, the second character is *B/M* group, the third is *OP* group, and the fourth is *Inv* group. The factors are *SMB* (small minus big), *HML* (high minus low *B/M*), *RMW* (robust minus weak *OP*), and *CMA* (conservative minus aggressive *Inv*).

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

Fama and French five-factor model

Test whether intercept is zero for all test assets

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it}.$$

- Test assets used:
  - 25 size-BM (5x5)
  - 25 Size-OP (5x5)
  - 25 Size-Inv (5x5)
  - 32 Size-BM-OP (2x4x4)
  - 32 Size-BM-Inv (2x4x4)
  - 32 Size-OP-Inv (2x4x4)
- Results in Table 5

Fama and French five-factor model

Test for redundant factors

- For each factor:
  - regress each factor on the other four factors
  - Results in Table 6
- Is HML redundant?

Fama and French five-factor model

Remarks

- Five-factor model performs better then 3FF
- 5FF still has a hard time explaining:
  - small-low OP portfolio
  - small-high Inv portfolio
  - small-growth portfolio
- Results are robust to how factors are constructed
- Benchmark: 5FF as in Ken French website (2x3)