JACOBS LEVY EQUITY MANAGEMENT CENTER
for Quantitative Financial Research

The History of the Cross Section of Returns

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Introduction

- Lots of anomalies
  - 314 “factors” Harvey, Liu, and Zhu (2015)
- What is mechanism behind anomalies
  - Unmodeled risk? Mispricing? Data-snooping?
- Empirical strategy
  - Exploit comprehensive accounting data from 1926 to 2016
    1. Pre-sample period (Jaffe et al ’89, Davis et al ‘00)
    2. In-sample period
    3. Post-sample period (Jagadeesh and Titman ’01, Schwert ’03, McLean and Pontiff ‘16)

Key Findings

- 78% of anomalies “disappear” in pre- and post-periods
  - Sharpe ratios, alphas, and information ratios all decrease; volatility and covariation increase
    - Including investment and profitability
  - Sharpe ratio of 5-factor strategy ≈ Market Sharpe ratio (0.5) in pre-
  - Choice of in-sample period critical to significance
    - Small changes attenuate/eliminate many existing results
- 22% of anomalies survive
  - Pre-sample: real investment, equity financing, distress, ROE/ROA
  - Post-sample: Sales and earnings, total financing, distress, ROE/ROA

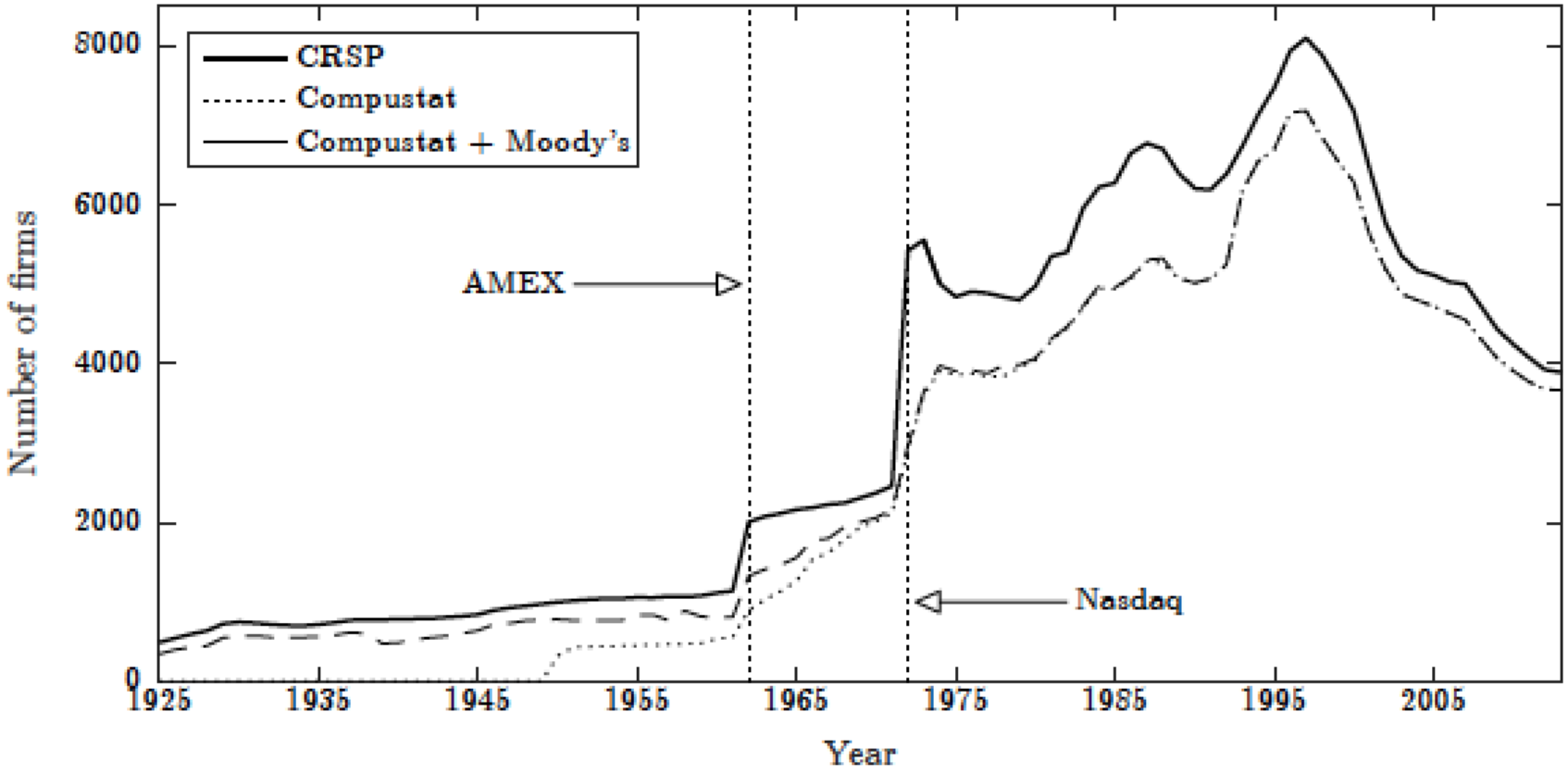
Economic Messages

- Quantify data-snooping concerns
  - Even robust anomalies are not robust out-of-sample
  - True asset pricing model would be rejected using in-sample data
  - In-sample corrections imperfectly correlated with out-of-sample tests
- Anomaly survival tied to underlying macro shifts
  - 1st half of sample → tangible investment and equity financing
  - 2nd half of sample → intangible investment and debt financing
- Does academic research lead to death of anomalies?
  - McLean and Pontiff 2016 test has no power against data-snooping alternative

Data

- CRSP monthly returns 1926 to 2015
- Compustat 1962 to 2015 (+ some info back to 1947)
- Davis et al. ‘00 book value of equity 1926 to 1980
- ❖ Moody's Industrial and Railroad Manuals 1918 to 1970
  - Graham, Leary, and Roberts (2014, 2015)
  - Limitations:
    - No financials and utilities
    - More aggregated than Compustat (e.g., no SG&A or R&D)
  - Data quality
    - Multiple checks and verifications (on top of checks in GLR)

Coverage


CRSP
Compustat
Compustat + Moody's
AMEX
Nasdaq
Number of firms
Year
0
2000
4000
6000
8000
1925
1935
1945
1955
1965
1975
1985
1995
2005

Illustrative Vehicle

- Profitability and investment factors
  - Novy-Marx 2013, Fama and French 2015, Hou et al (2015)
  - Profitability = OP/BE (FF 2015)
  - Investment = Asset growth (FF, Hou et al.)
- Create HML-like factors for *all* anomalies
  - E.g., Investment

	Investment		
Size	**Low** (30%)	**Neutral** (40%)	**High** (30%)
Small (50%)	Small-Conservative	Small-Neutral	Small-Aggressive
Big (50%)	Big-Conservative	Big-Neutral	Big-Aggressive

  - Portfolios held constant from July *t* to June *t+1*
  - Avg return on two low portfolios and two high portfolios then difference
  - Mitigate impact of small/micro firms

Monthly Factor Premiums by Era

	Pre-1963 sample			
Portfolio	July 1926 – June 1938	July 1938 – June 1963	July 1926 – June 1963	July 1963 – December 2016
Profitability factor	−0.13	0.09	0.02	0.28
	(−0.31)	(0.64)	(0.14)	(3.09)
Investment factor	0.19	0.03	0.09	0.26
	(0.79)	(0.32)	(0.80)	(3.28)

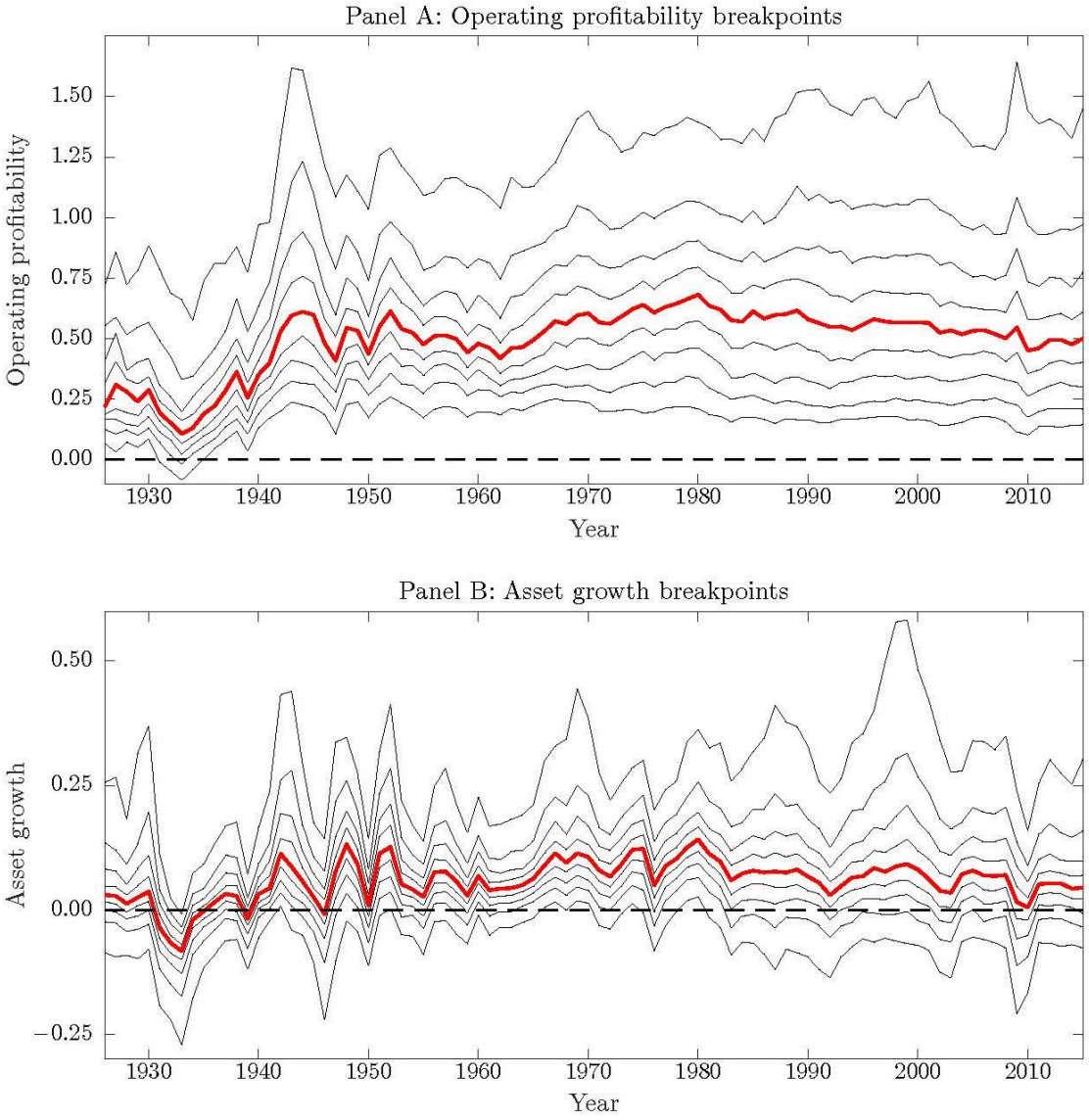
Monthly CAPM Alphas by Era

	Pre-1963 sample			
Factor	July 1926 – June 1938	July 1938 – June 1963	July 1926 – June 1963	July 1963 – December 2016
RMW	0.02	0.19	0.20	0.30
	(0.06)	(1.25)	(1.33)	(3.33)
CMA	0.17	−0.02	0.05	0.33
	(0.71)	(−0.19)	(0.49)	(4.39)

Monthly 3-Factor Alphas

	Pre-1963 sample			
Factor	July 1926 – June 1938	July 1938 – June 1963	July 1926 – June 1963	July 1963 – December 2016
RMW	0.06	0.30	0.25	0.35
	(0.18)	(2.60)	(1.90)	(3.81)
CMA	0.12	−0.07	0.02	0.11
	(0.54)	(−0.82)	(0.16)	(1.96)

Characteristic Distributions



The Rest of the Zoo

No.	Anomaly	Original study	Original sample
1	Gross profitability	Novy-Marx (2013)	1963–2010
2	**Operating profitability***	Fama and French (2015)	1963–2013
3	Return on assets*	Haugen and Baker (1996)	1979–1993
4	Return on equity*	Haugen and Baker (1996)	1979–1993
5	Profit margin	Soliman (2008)	1984–2002
6	Change in asset turnover	Soliman (2008)	1984–2002
7	Accruals*	Sloan (1996)	1962–1991
8	Net operating assets	Hirshleifer, Hou, Teoh, and Zhang (2004)	1964–2002
9	Net working capital changes	Soliman (2008)	1984–2002
10	**Book-to-market**	Fama and French (1992)	1963–1990
11	Cash flow / price	Lakonishok, Shleifer, and Vishny (1994)	1968–1990
12	Earnings / price	Basu (1977)	1957–1971
13	Enterprise multiple*	Loughran and Wellman (2011)	1963–2009
14	Sales / price	Barbee, Mukherji, and Raines (1996)	1979–1991
15	**Asset growth**	Cooper, Gulen, and Schill (2008)	1968–2003
16	Growth in inventory	Thomas and Zhang (2002)	1970–1997
17	Sales growth	Lakonishok, Shleifer, and Vishny (1994)	1968–1990
18	Sustainable growth	Lockwood and Prombutr (2010)	1964–2007
19	Adjusted CAPX growth*	Abarbanell and Bushee (1998)	1974–1993
20	Growth in sales − inventory	Abarbanell and Bushee (1998)	1974–1993
21	Investment growth rate*	Xing (2008)	1964–2003
22	Abnormal capital investment*	Titman, Wei, and Xie (2004)	1973–1996
23	Investment to capital*	Xing (2008)	1964–2003
24	Investment-to-assets	Lyandres, Sun, and Zhang (2008)	1970–2005
25	Debt issuance*	Spiess and Affleck-Graves (1999)	1975–1994
26	Leverage	Bhandari (1988)	1948–1979
27	One-year share issuance	Pontiff and Woodgate (2008)	1970–2003
28	Five-year share issuance	Daniel and Titman (2006)	1968–2003
29	Total external financing*	Bradshaw, Richardson, and Sloan (2006)	1971–2000
30	O-Score	Dichev (1998)	1981–1995
31	Z-Score*	Dichev (1998)	1981–1995
32	Distress risk	Campbell, Hilscher, and Szilagyi (2008)	1963–2003
33	Industry concentration	Hou and Robinson (2006)	1951–2001
34	Piotroski's F-score	Piotroski (2000)	1976–1996
35	M/B and accruals*	Bartov and Kim (2004)	1981–2000
36	QMJ: Profitability	Asness, Frazzini, and Pedersen (2013)	1956–2012

Statistically Significant Individual Anomalies

- In-sample
  - Every anomaly CAPM or FF-3 alpha
- Pre-sample
  - 8 average returns, 8 CAPM alphas, 16 FF-3 alphas
- Post-sample
  - 1 average return, 10 CAPM alphas, 9 FF-3 alphas

Average Anomaly across Eras: Returns and Sharpe Ratios

Measure	Pre-sample	In-sample	Post-sample
Average return	0.08	0.29	0.09
	(2.21)	(7.01)	(1.72)
Sharpe ratio	0.15	0.54	0.13
	(3.38)	(7.57)	(1.52)

- Average anomaly…
  - Block bootstrap SEs

Average Anomaly across Eras: Returns and Sharpe Ratios

Measure	Pre-sample	In-sample	Post-sample	Differences: Pre − In	Differences: Post − In	Differences: Post − Pre
Average return	0.08	0.29	0.09	−0.21	−0.20	0.00
	(2.21)	(7.01)	(1.72)	(−3.78)	(−3.69)	(0.03)
Sharpe ratio	0.15	0.54	0.13	−0.39	−0.42	−0.03
	(3.38)	(7.57)	(1.52)	(−4.71)	(−4.14)	(−0.30)

- Average anomaly…
  - Block bootstrap SEs

Average Anomaly across Eras: Alphas and Information Ratios

Measure	Pre-sample	In-sample	Post-sample	Differences: Pre − In	Differences: Post − In	Differences: Post − Pre
			CAPM			
Alpha	0.15	0.34	0.17	−0.20	−0.18	0.02
	(4.80)	(9.75)	(3.50)	(−4.27)	(−3.44)	(0.38)
Information ratio	0.22	0.66	0.27	−0.43	−0.40	0.04
	(5.08)	(9.72)	(2.99)	(−5.43)	(−3.83)	(0.43)

Average Anomaly across Eras: Alphas and Information Ratios

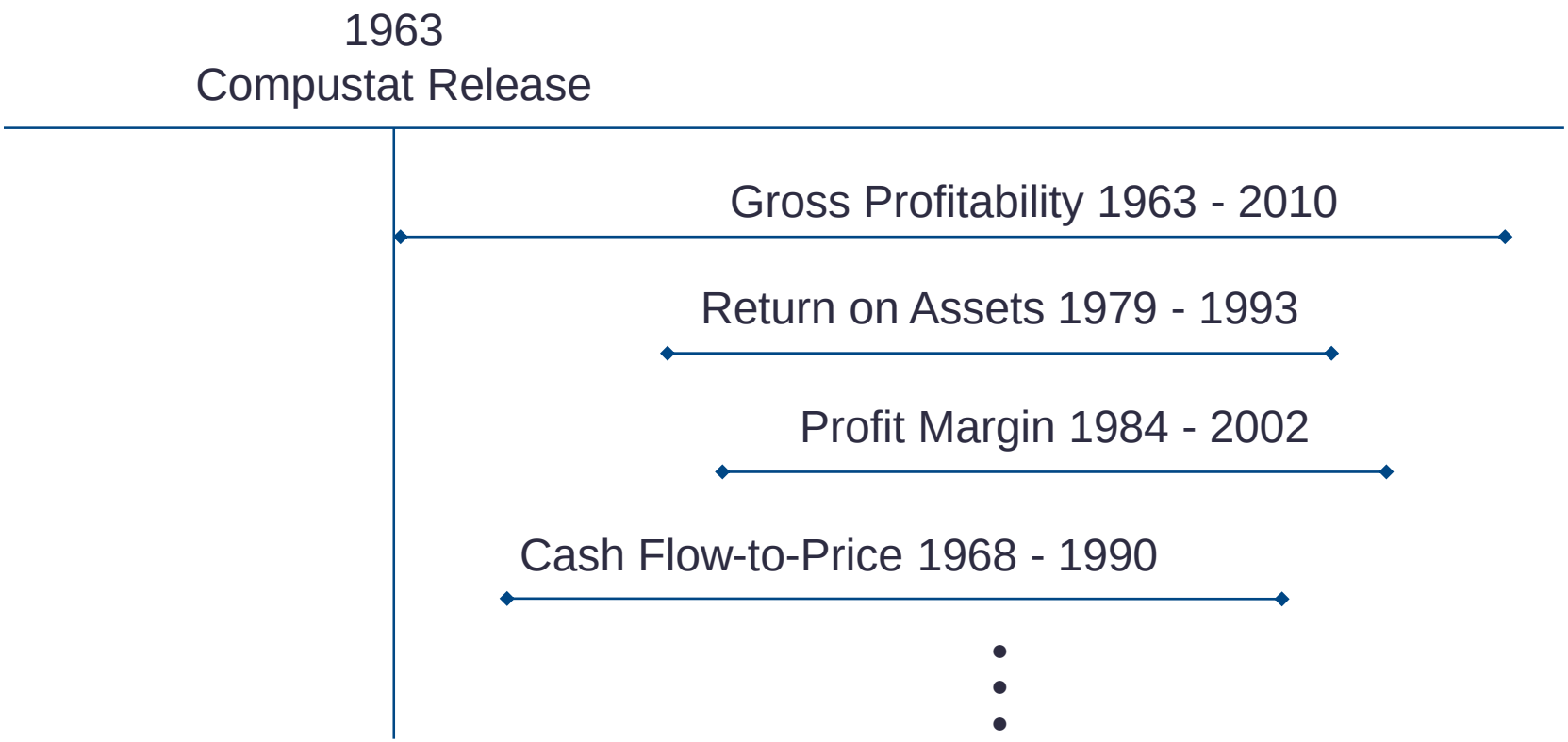
Measure	Pre-sample	In-sample	Post-sample	Differences: Pre − In	Differences: Post − In	Differences: Post − Pre
CAPM						
Alpha	0.15	0.34	0.17	−0.20	−0.18	0.02
	(4.80)	(9.75)	(3.50)	(−4.27)	(−3.44)	(0.38)
Information ratio	0.22	0.66	0.27	−0.43	−0.40	0.04
	(5.08)	(9.72)	(2.99)	(−5.43)	(−3.83)	(0.43)
Three-factor model						
Alpha	0.17	0.27	0.12	−0.10	−0.15	−0.05
	(6.42)	(10.12)	(3.19)	(−2.57)	(−3.44)	(−1.10)
Information ratio	0.28	0.60	0.25	−0.32	−0.35	−0.03
	(6.35)	(9.91)	(2.86)	(−4.26)	(−3.46)	(−0.32)

Identification Threats

- Unmodeled risk:
  - Threat: Structural breaks
    - Changes in risks that matter to investors, information costs
- Mispricing:
  - Threat: Transient fads
- Learning:
  - Investors learning and trade away anomalies

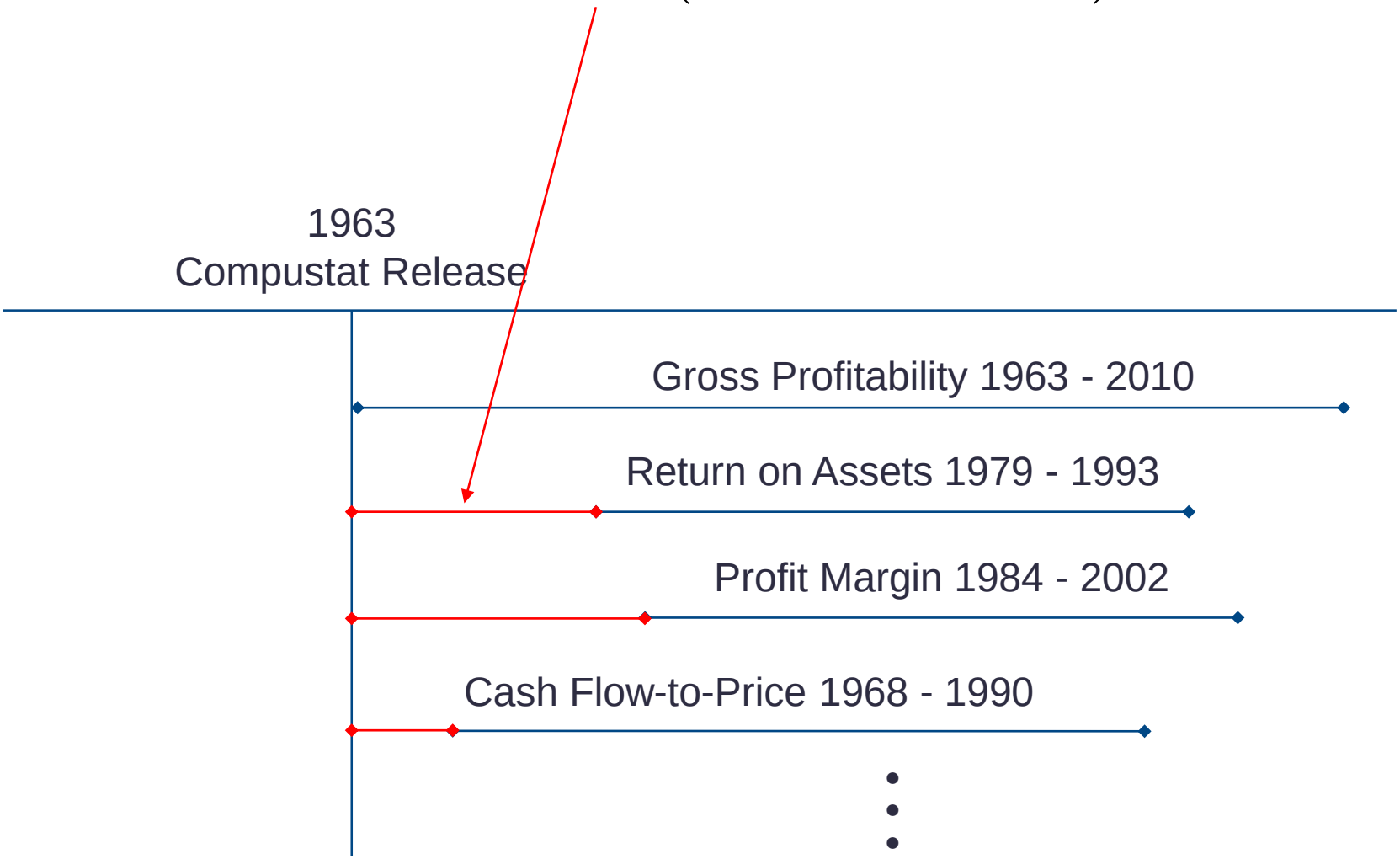
Are Start Dates "Judiciously" Chosen?

- All anomalies could have been measured as of 1963
  - Was there a structural break around this time?



Are Start Dates "Judiciously" Chosen?

$$anomaly_{it} = \beta_0 + \beta_1 I\left(\Pr e - Sample_{it}\right) + \mu_i + \varepsilon_{it}$$



Structural Break Test

$$anomaly_{it} = \beta_0 + \beta_1 I\left(\Pr e - Sample_{it}\right) + \mu_i + \varepsilon_{it}$$

Start year	Average return $\hat{\beta}_0$	$\hat{\beta}_1$
1963	0.30	−0.15
	(6.77)	(−2.16)

Average return drops by 50%

Structural Break Test

$$anomaly_{it} = \beta_0 + \beta_1 I\left(\Pr e - Sample_{it}\right) + \mu_i + \varepsilon_{it}$$

Start year	Average return $\hat{\beta}_0$	$\hat{\beta}_1$
1963	0.30	−0.15
	(6.77)	(−2.16)
1964	0.30	−0.15
	(6.77)	(−1.93)
1965	0.30	−0.13
	(6.78)	(−1.58)
⋮		
1971	0.31	−0.22
	(6.63)	(−2.65)
1972	0.32	−0.21
	(6.64)	(−2.18)
1973	0.31	−0.24
	(6.38)	(−2.20)

Average return decline 40%-80%

Structural Break Test

$$anomaly_{it} = \beta_0 + \beta_1 I\left(\Pr e - Sample_{it}\right) + \mu_i + \varepsilon_{it}$$

Start	Average return		CAPM alpha	
year	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_0$	$\hat{\beta}_1$
1963	0.30	−0.15	0.36	−0.18
	(6.77)	(−2.16)	(10.07)	(−2.97)
1964	0.30	−0.15	0.36	−0.19
	(6.77)	(−1.93)	(10.06)	(−2.86)
1965	0.30	−0.13	0.36	−0.17
	(6.78)	(−1.58)	(10.07)	(−2.42)
		⋮		
1971	0.31	−0.22	0.37	−0.26
	(6.63)	(−2.65)	(9.88)	(−3.78)
1972	0.32	−0.21	0.38	−0.26
	(6.64)	(−2.18)	(9.86)	(−3.24)
1973	0.31	−0.24	0.38	−0.28
	(6.38)	(−2.20)	(9.70)	(−3.31)

CAPM alpha decline 50%-75%

Structural Break Test

$$anomaly_{it} = \beta_0 + \beta_1 I\left(\Pr e - Sample_{it}\right) + \mu_i + \varepsilon_{it}$$

Start	Average return		CAPM alpha		FF3 alpha	
year	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_0$	$\hat{\beta}_1$
1963	0.30	−0.15	0.36	−0.18	0.27	−0.14
	(6.77)	(−2.16)	(10.07)	(−2.97)	(10.35)	(−3.18)
1964	0.30	−0.15	0.36	−0.19	0.28	−0.13
	(6.77)	(−1.93)	(10.06)	(−2.86)	(10.40)	(−2.68)
1965	0.30	−0.13	0.36	−0.17	0.28	−0.11
	(6.78)	(−1.58)	(10.07)	(−2.42)	(10.40)	(−2.27)
				.		
				.		
				.		
1971	0.31	−0.22	0.37	−0.26	0.29	−0.28
	(6.63)	(−2.65)	(9.88)	(−3.78)	(10.02)	(−4.60)
1972	0.32	−0.21	0.38	−0.26	0.29	−0.31
	(6.64)	(−2.18)	(9.86)	(−3.24)	(9.86)	(−4.52)
1973	0.31	−0.24	0.38	−0.28	0.31	−0.27
	(6.38)	(−2.20)	(9.70)	(−3.31)	(10.17)	(−3.51)

FF-3 alpha decline 30%-90%

Correlation Structure of Returns

- How does an anomaly correlate with other anomalies across eras?

$$anomaly_{i,t} = a + b_1 Post_{i,t} + b_2 InSample\ Index_{-i,t} + b_3 PostSample\ Index_{-i,t} + b_4 Post_{i,t} \times InSample\ Index_{-i,t} + b_5 Post_{i,t} \times PostSample\ Index_{-i,t} + e_{i,t}$$

  - Motivated by Mclean and Pontiff (2016)

Correlation structure of returns: ***Post***-sample

$$anomaly_{i,t} = a + b_1 Post_{i,t} + b_2 InSample\ Index_{-i,t} + b_3 PostSample\ Index_{-i,t}$$
$$+ b_4 Post_{i,t}' \ InSample\ Index_{-i,t} + b_5 Post_{i,t}' \ PostSample\ Index_{-i,t} + e_{i,t}$$

Regressor	Coefficient	t-value
Regression 1: In-sample versus post-sample anomalies		
Intercept	0.05	4.54
Main effects		
In-sample index$_{-i,t}$	0.74	33.98
Post-sample index$_{-i,t}$	0.08	7.46
Post$_{i,t}$	−0.06	−2.23
Interactions		
Post$_{i,t}$ × In-sample index$_{-i,t}$	−0.53	−13.74
Post$_{i,t}$ × Post-sample index$_{-i,t}$	0.46	11.19
Adjusted R^2	17.9%	
N	15,152	

Correlation structure of returns: ***Pre*-sample**

$$anomaly_{i,t} = a + b_1 \Pr e_{i,t} + b_2 InSample\ Index_{-i,t} + b_3 \Pr eSample\ Index_{-i,t}$$
$$+ b_4 \Pr e_{i,t} \acute{}\ InSample\ Index_{-i,t} + b_5 \Pr e_{i,t} \acute{}\ \Pr eSample\ Index_{-i,t} + e_{i,t}$$

Regressor	Coefficient	t-value
Regression 2: In-sample versus pre-sample anomalies		
Intercept	0.07	4.35
Main effects		
In-sample index$_{-i,t}$	0.74	28.90
Pre-sample index$_{-i,t}$	0.07	3.42
Pre$_{i,t}$	−0.04	−2.09
Interactions		
Pre$_{i,t}$ × In-sample index$_{-i,t}$	−0.69	−22.72
Pre$_{i,t}$ × Pre-sample index$_{-i,t}$	0.48	13.68
Adjusted R^2	9.3%	
N	13,650	

Do In-sample Adjustments Work?

- Not really…
- Pr(Type I error) = 30%
- Pr(Type II error) = 26%

Anomaly	Significant in pre-sample	In-sample t-value > 3	Union
Gross profitability	❀	❀	❀
Operating profitability		❀	
Return on assets	❀	❀	❀
Return on equity	❀	❀	❀
Change in asset turnover		❀	
Net operating assets		❀	
Net working capital changes	❀		
Cash flow / price		❀	
Earnings / price	❀	❀	❀
Growth in inventory	❀		
Growth in sales − inventory	❀	❀	❀
Investment growth rate		❀	
Investment to capital	❀		
Investment-to-assets	❀		
Debt issuance	❀	❀	❀
One-year share issuance	❀		
Five-year share issuance	❀		
Total external financing		❀	
O-Score	❀	❀	❀
Z-Score	❀	❀	❀
Distress risk	❀	❀	❀
Piotroski's F-score		❀	
QMJ: Profitability	❀	❀	❀
Count	16	17	10

Conclusions and Future Work

- Half-empty
  - Data-snooping is severe
  - Statistical adjustments have limitations
  - → Out-of-sample testing (new data, holdout samples)
- Half-full
  - Persistent violations of common AP models
  - Appear correlated with economic fundamentals
- In-progress:
  - What is the “right” model?
  - How does this model tie into economic fundamentals?