# Financial Markets I

## Lecture 8: Stock Market Efficiency

**Master Finance & Strategy**

**Spring 2018**

SciencesPo

# General Overview

Previous lecture (*Valuation of Stocks*):

- How to value stocks.
- How our valuation compares to that of the market.

This lecture:

- **Can we make money trading stocks?**

# Overview of Lecture 8

1. Abnormal Returns.
2. The Three Forms of Market Efficiency.
3. Market Efficiency vs. Behavioral Finance.
4. Statistical Evidence on Market Efficiency.
5. Assessing Trading Strategies: Data Mining and Transaction Costs.

# 1. Abnormal Returns

- We need to be more specific about what we mean by

  Can we 'make money' trading stocks?

- One possible interpretation:

  make money
  $\equiv$
  find riskless arbitrage opportunities.

- We will adopt a weaker definition:

  make money
  $\equiv$
  achieve an expected return which is large relative to the risk.

# Abnormal Return

- When is expected return large relative to risk?
  - To answer this question, we need to know how to adjust for risk.
- We can use the CAPM:
  - The CAPM says the expected return on an asset should be

$$R_f + \text{MRP} \times \beta,$$

    where $\beta$ is the beta of the asset, MRP is the market risk premium.
  - **Abnormal return** is

$$E(R) - [R_f + \text{MRP} \times \beta] \quad = \quad \alpha.$$

- Expected return is large relative to risk if **alpha** is large.
  - e.g., more than 0.5% per month, and statistically significant, is large.

# Market Efficiency

- Notion of market efficiency: a market is said to be **efficient** if one cannot achieve significant abnormal returns.
- In this lecture, we study whether markets are efficient.
- Remark: the definition of abnormal return depends on the model we use for risk adjustment (we choose CAPM, but there exists other models beyond the scope of this course).

  Therefore testing for the efficient market hypothesis (EMH) is really a **joint hypothesis test**: test of abnormal returns along with a model for risk adjustment.

# 2. The Three Forms of Market Efficiency

- To study whether markets are efficient, we need to specify the **information** we can use when seeking to achieve abnormal returns.
- In principle, the more information we have, the higher our chances of achieving abnormal returns.
- Three forms of market efficiency, depending on **information set**:
  - Weak form.
  - Semi-strong form.
  - Strong form.

# The Weak Form

- A market is **weak-form efficient** if we cannot achieve abnormal returns by using information contained in past prices/returns.
- e.g., weak-form efficiency implies that the following statement cannot be true:

  > *When a stock reaches its previous peak (resp., bottom), it is more likely to go down (resp., up) in the following day.*

- If a market is weak-form efficient, then technical analysis (i.e., the search for predictable patterns in prices) is a futile exercise.

# The Semi-Strong Form

- A market is **semi-strong-form efficient** if we cannot achieve abnormal returns by using publicly available information.
- Publicly available information consists of past prices, trading volume, company announcements, macroeconomic announcements, etc.
- e.g., semi-strong-form efficiency implies that the following statement cannot be true:

  *After a company announces a dividend decrease, its stock price decreases, but the decrease takes place gradually, over several days.*

# The Strong Form

- A market is **strong-form efficient** if we cannot achieve abnormal returns by using all publicly available and private information.
- Private information is information that is available to a company's insiders, but not (yet) available to all investors.
- By definition:
  - Strong form $\Rightarrow$ Semi-strong form $\Rightarrow$ Weak form.
  - However, a market can be weak-form efficient while failing to be semi-strong-form efficient.

# 3. Market Efficiency vs. Behavioral Finance

- In theory, there are good reasons to expect markets to be weak- and semi-strong-form efficient.
  - There are many sophisticated investors (arbitrageurs)—e.g., hedge funds, active mutual funds.
  - These investors have access to publicly available information.
  - They can eliminate any abnormal returns.
- However there is no reason to expect markets to be strong-form efficient.
  - Sophisticated investors may not have access to private information.
  - Insider trading is illegal.

# Behavioral Finance

Behavioral finance attempts to explain why markets may fail to be efficient. Any such attempt must rely on two ingredients.

1. Sources of mispricing:
   - "Irrational exuberance"
   - Behavioral/cognitive biases (e.g., over/under-reaction to news)
   - Non-fundamental shocks to supply & demand (noise trading).

2. Limits of arbitrage:
   - Arbitrage strategies can be (very) risky.
   - Sophisticated investors may face constraints (e.g., capital constraints, short sale constraints) that prevent them to completely eliminate abnormal returns.
   - Calling a bubble too early may result in losses and fund outflows — better ride the bubble with others than be contrarian alone.

   e.g., hedge funds did not correct mispricing during the tech bubble.

# Fuller and Thaler Asset Management

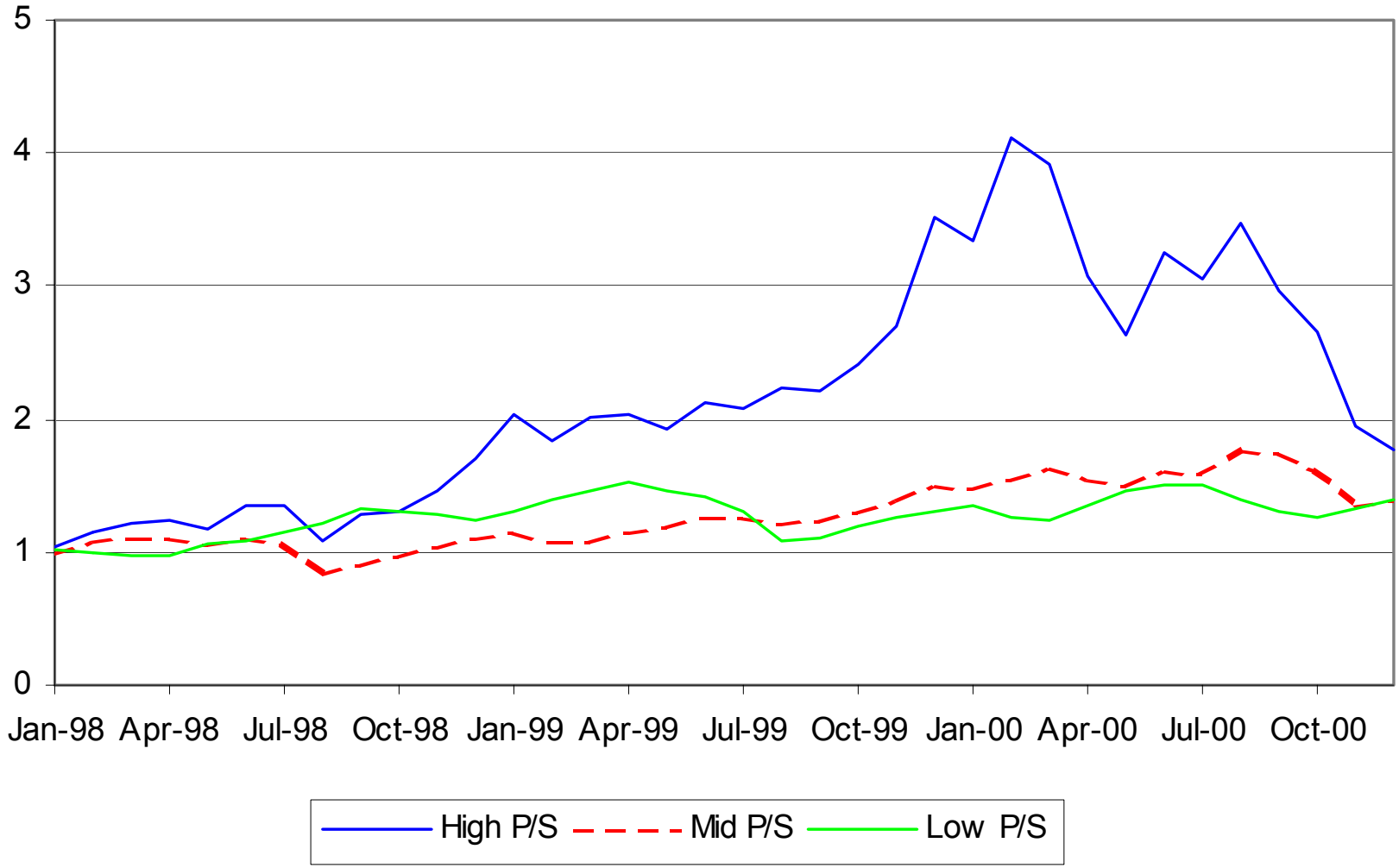
- Hedge fund started in 1993 by Richard Thaler (Nobel Prize 2017) and Russell Fuller.
  - Daniel Kahneman (Nobel Prize 2002), a pioneer of behavioral economics, is also on the team.

- Investment approach:

  *"Investors make mental mistakes. F&T's objective is to exploit them. Our investment approach applies insights from some of the foremost scholars in behavioral finance to identify these opportunities and gain a competitive edge over the market."*

# The Tech Bubble

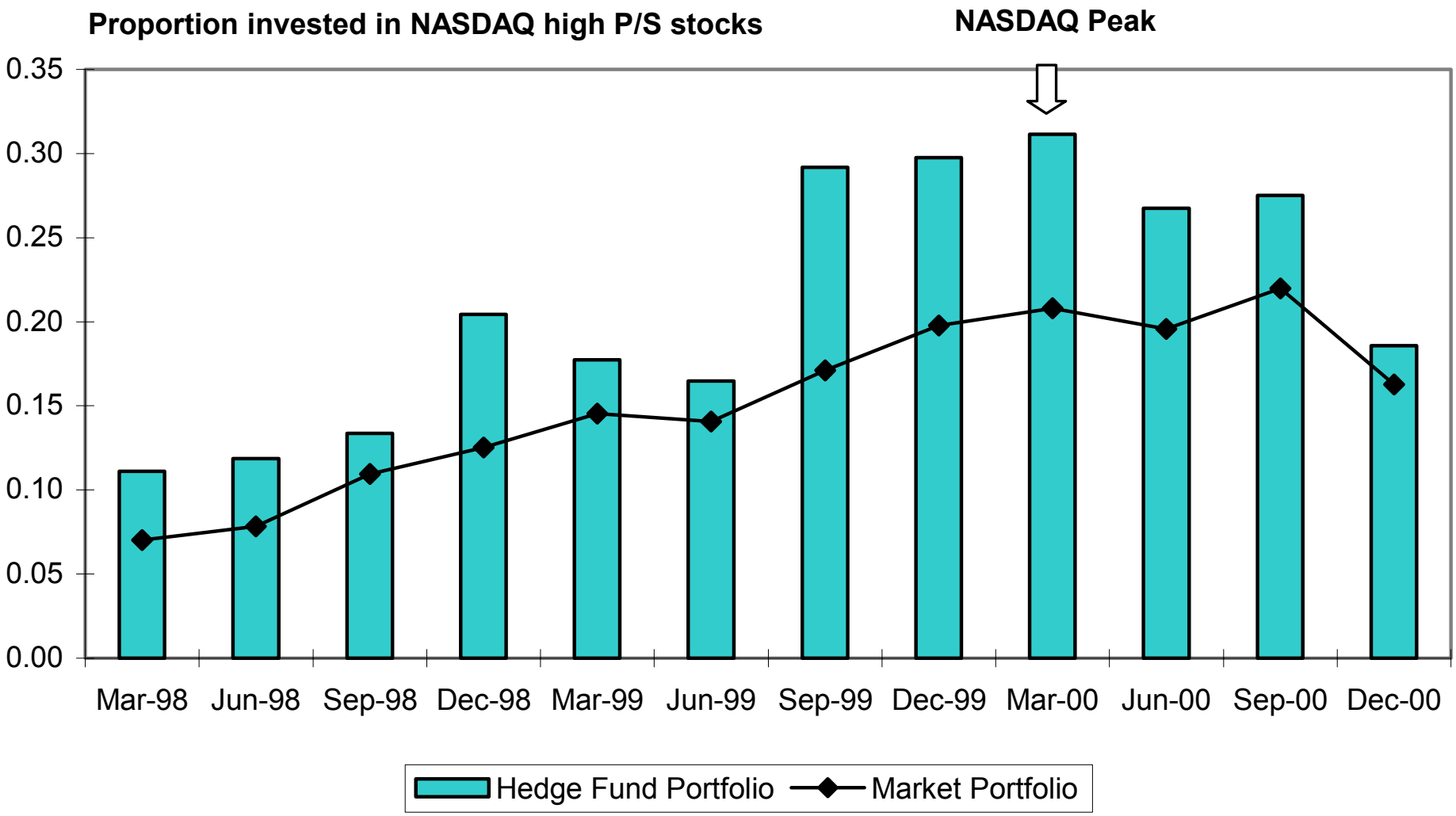
Cumulative returns on Nasdaq stocks ranked by price/sales (P/S) ratio.




Source: Brunnermeier and Nagel, *Journal of Finance*, 2004.

# Did Hedge Funds Fight the Tech Bubble?

No. Hedge funds were riding the bubble, not fighting it.




Source: Brunnermeier and Nagel, *Journal of Finance*, 2004.

# 4. Statistical Tests of Market Efficiency

To study whether actual markets are efficient, we now turn to the data.

We will consider the following tests:

- Tests of the weak form:
  - Serial correlations.
  - Momentum and Reversal.
- Tests of the semi-strong form:
  - Event studies: Price reactions to company announcements.
  - The Value Premium.
  - Performance of mutual funds.

# Serial Correlations

- One particular test of the weak form is to check whether returns exhibit serial correlation (or "auto-correlation").
  - See definition of serial correlation in Lecture 4.
- If they do, then price changes can be predicted using past prices.
- Next two slides show evidence on the serial correlation of returns for
  - individual stocks
  - country indices.

# Serial Correlation: Individual Stocks

Using monthly returns 1970-2017, we can compute:

| Stock | Serial Correlation |
|---|---|
| Apple | 0.0534 |
| Coca Cola | -0.0008 |
| Disney | 0.0589 |
| Ford | 0.0113 |
| GE | -0.0002 |
| IBM | -0.0048 |
| Xerox | 0.0032 |

Serial correlations are very small.

# Serial Correlation: Country Indices

Using monthly returns 1975-2009 we can compute:

| Country | Serial Correlation |
|---|---|
| Canada | 0.0217 |
| France | 0.0320 |
| Germany | -0.0157 |
| Japan | 0.0751 |
| Switzerland | 0.0708 |
| UK | 0.0830 |
| US | 0.1011 |

Serial correlations are again very small.

# Momentum

- For a given universe of stocks:
  - Form a portfolio of stocks that performed very well in the recent past (i.e., in the last 3 to 12 months), the **"winner" portfolio.**
  - Form a portfolio of stocks that performed poorly over the same past period, the **"loser" portfolio**.
- Over the short run, the winners typically outperform losers.
- Momentum strategy: buy the winners, sell the losers.
  - A zero-cost strategy that buys winners and sell losers from the past 6 months earns more than 11% (annualized) over the next 6 months.
  - Momentum also works outside the U.S.

# Momentum Profits

Returns on portfolios grouped by six-months momentum and held for six months, over the period 1965-1989 in the US.

| **Momentum-Ranked Portfolios (by decile)** | **Average Annualized Rate of Return (in %)** |
|---|---|
| Portfolio 1 (minimum momentum) | 9.48 |
| Portfolio 2 | 13.44 |
| Portfolio 3 | 15.00 |
| Portfolio 4 | 14.88 |
| Portfolio 5 | 15.36 |
| Portfolio 6 | 16.08 |
| Portfolio 7 | 16.32 |
| Portfolio 8 | 17.16 |
| Portfolio 9 | 18.36 |
| Portfolio 10 (maximum momentum) | 20.88 |
| Portfolio 10 minus Portfolio 1 | 11.40 |

Source: Jegadeesh and Titman, *Journal of Finance*, 1993.

# Is Momentum Explained by CAPM?

No. If anything, winners (P10) have less systematic risk than losers (P1).

| | Beta |
|---|---|
| P1 | 1.36 |
| P2 | 1.19 |
| P3 | 1.14 |
| P4 | 1.11 |
| P5 | 1.09 |
| P6 | 1.08 |
| P7 | 1.09 |
| P8 | 1.12 |
| P9 | 1.17 |
| P10 | 1.28 |
| P10–P1 | −0.08 |

Source: Jegadeesh and Titman, *Journal of Finance*, 1993.

## Gains & Losses on a Long-Short Zero-Cost Strategy

- Denote by $R_t^{\text{long}}$ and $R_t^{\text{short}}$ the rates of return on the long and short portfolios in period $t$, respectively.
- Say you 'scale' your positions to $\kappa$ dollars.
  - i.e., initial amount of short sales = initial cost of long buys = $\kappa$ dollars.
  - Zero net cost to enter the combined position.
- Gain/loss at the end of the period is

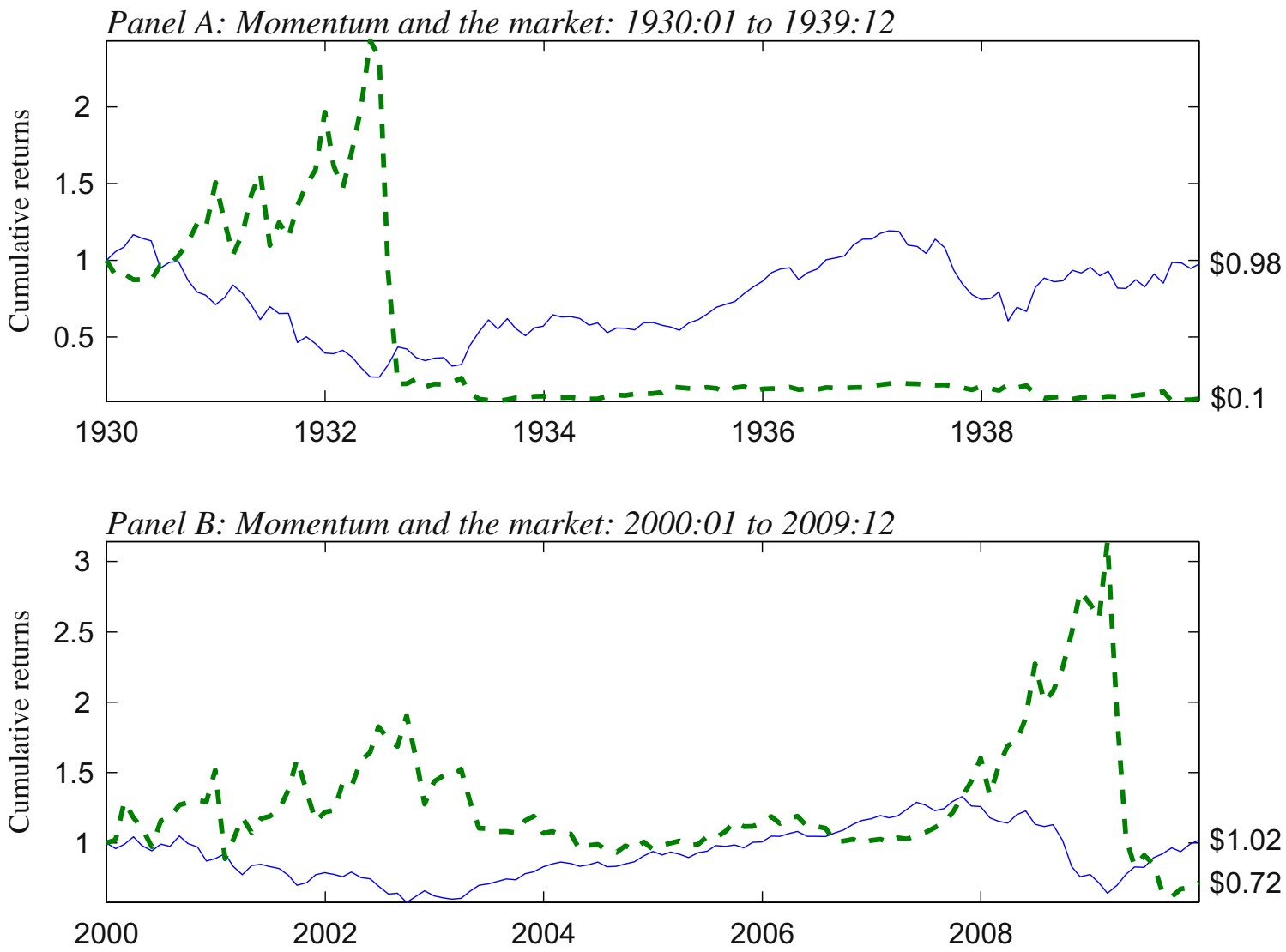
$$\kappa\big(1+R_t^{\text{long}}\big)-\kappa\big(1+R_t^{\text{short}}\big)=\kappa\big(R_t^{\text{long}}-R_t^{\text{short}}\big).$$

- Expected gain is $\kappa\big(E(R^{\text{long}})-E(R^{\text{short}})\big)$ and standard deviation is

$$\kappa\sqrt{V^{\text{long}}+V^{\text{short}}-2\text{Cov}^{\text{long, short}}}.$$

Can choose $\kappa$ to control the volatility of your strategy.

# Caveat: Momentum Crashes



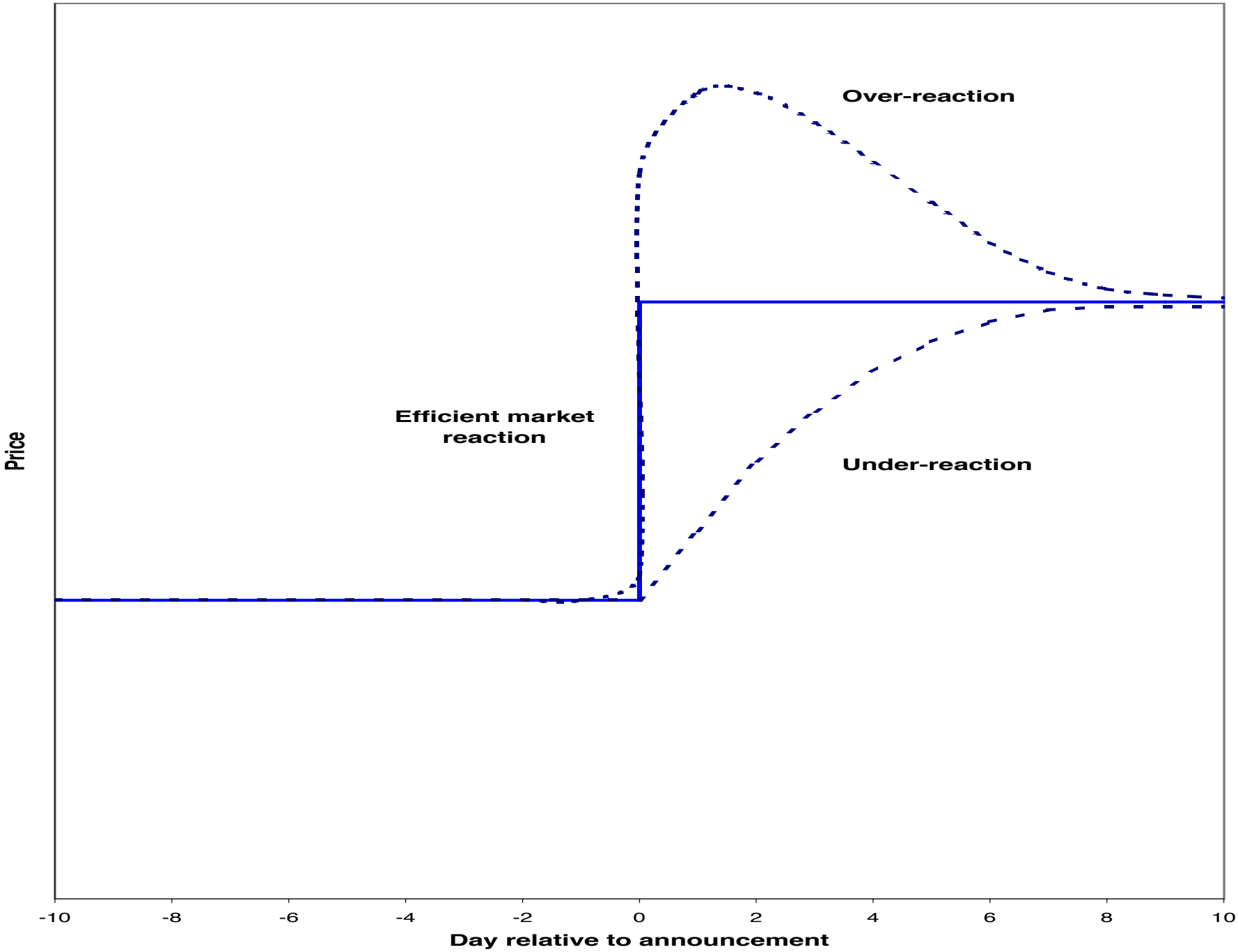

The dashed green (solid blue) line represents performance on momentum strategy (the market index). Source: Barroso and Santa-Clara, *Journal of Financial Economics*, 2015.

# Reversal Strategy

- Consider the opposite ("contrarian") strategy.
  - Rank stocks on the basis of their performance over past 3-5 years.
  - Form a winner portfolio of the best-performing stocks (e.g., top 10%) and a loser portfolio of the worst-performing stocks (e.g., bottom 10%).
- Over the subsequent 3-5 years, past losers tend to outperform past winners.
  - Not inconsistent with the success of momentum strategy.
  - Cannot be explained by CAPM: loser (resp., winner) portfolio exhibits positive (resp., negative) abnormal returns.
- The good performance of the reversal strategy was initially documented by DeBondt and Thaler (*Journal of Finance*, 1985).

# Event Studies

- One way to test the **semi-strong form** is to look at how stock prices react to company announcements.
- If prices under- or over-react to news, then price changes can be predicted using publicly available information.
  - Under- and over-reaction patterns are depicted on the figure next slide, assuming that good news is released at $t = 0$.
- We will consider price responses to
  - Takeover announcements.
  - Earnings announcements.


Over-reaction
Efficient market reaction
Under-reaction
Price
-10
-8
-6
-4
-2
0
2
4
6
8
10
Day relative to announcement

# CAR Methodology: Motivation

- The previous picture is a bit over-simplified: Under the EMH, the price should not remain constant before and after the announcement.
  - Price evolution should be such that average return is "in line with risk".
- Let $R_{Mt}$ and $R_{it}$ denote daily returns on the market and on the firm concerned by the announcement, and $R_f$ the daily riskfree rate.
- Can write and estimate regression equation at daily frequency

$$R_{it} - R_f = \alpha_i + \beta_i(R_{Mt} - R_f) + \epsilon_{it}, \quad \text{with } E(\epsilon_{it}) = 0.$$

- Can rewrite as $R_{it} - [R_f + \beta_i(R_{Mt} - R_f)] = \alpha_i + \epsilon_{it}$, implying that

$$E\Big(R_{it} - [R_f + \beta_i(R_{Mt} - R_f)]\Big) = E(\alpha_i + \epsilon_{it}) = \alpha_i.$$

CAPM says $\alpha_i = 0$. That is, $R_{it} - [R_f + \beta_i(R_{Mt} - R_f)]$ should be *near* zero on average (over finite sample of observations indexed by $t$).

# CAR Methodology: Abnormal Returns

- Consider many **announcement events**, indexed by $i = 1, \ldots, N$.
- For each event, let $t = 0$ correspond to the day the news is released.
- Consider daily stock returns $R_{it}$ around the announcement day.
  - e.g., one month before/after: $t = -30, -29, \ldots, -1, 0, 1, 2, \ldots, 30$.
  - $R_{it}$ is the return on the firm concerned by announcement event $i$.
- For all $i$ and $t$, compute **"realized daily abnormal returns"**

$$AR_{it} \equiv R_{it} - [R_f + \beta_i(R_{Mt} - R_f)].$$

- For each 'day $t$', compute average $AR_{it}$ over all events in the sample

$$AR_t \equiv \frac{1}{N}\sum_{i=1}^{N} AR_{it} \quad \text{(i.e., average abnormal return "on day } t\text{")}.$$

# CAR Methodology: EMH Predictions

- What do EMH & CAPM jointly predict?
- If we are looking at positive announcements (i.e., good news) released after market close on day 0, then we should see

$$AR_{i1} > 0 \quad \text{for all } i, \qquad \text{and} \qquad AR_1 > 0.$$

  Interpretation: upward jump in price on the day following the news release translates into positive (average) abnormal return on that day.

- On any other day $t \neq 1$, CAPM says $R_{it} - [R_f + \beta_i(R_{Mt} - R_f)]$ should be *near* zero on average (over finite cross-section of events), i.e.,

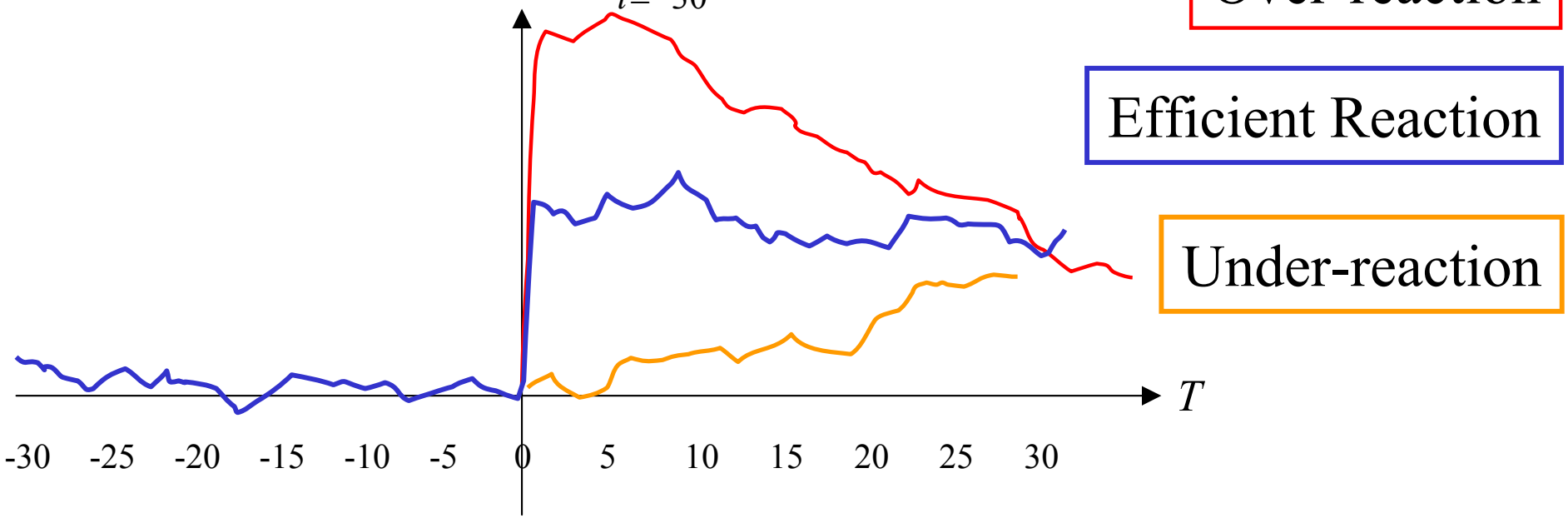
$$AR_t \approx 0.$$

- Can look at the series of **cumulative (average) abnormal returns**

$$CAR_T \equiv \sum_{t=-30}^{T} AR_t \qquad \text{for} \quad T = -30, \ldots, 30.$$

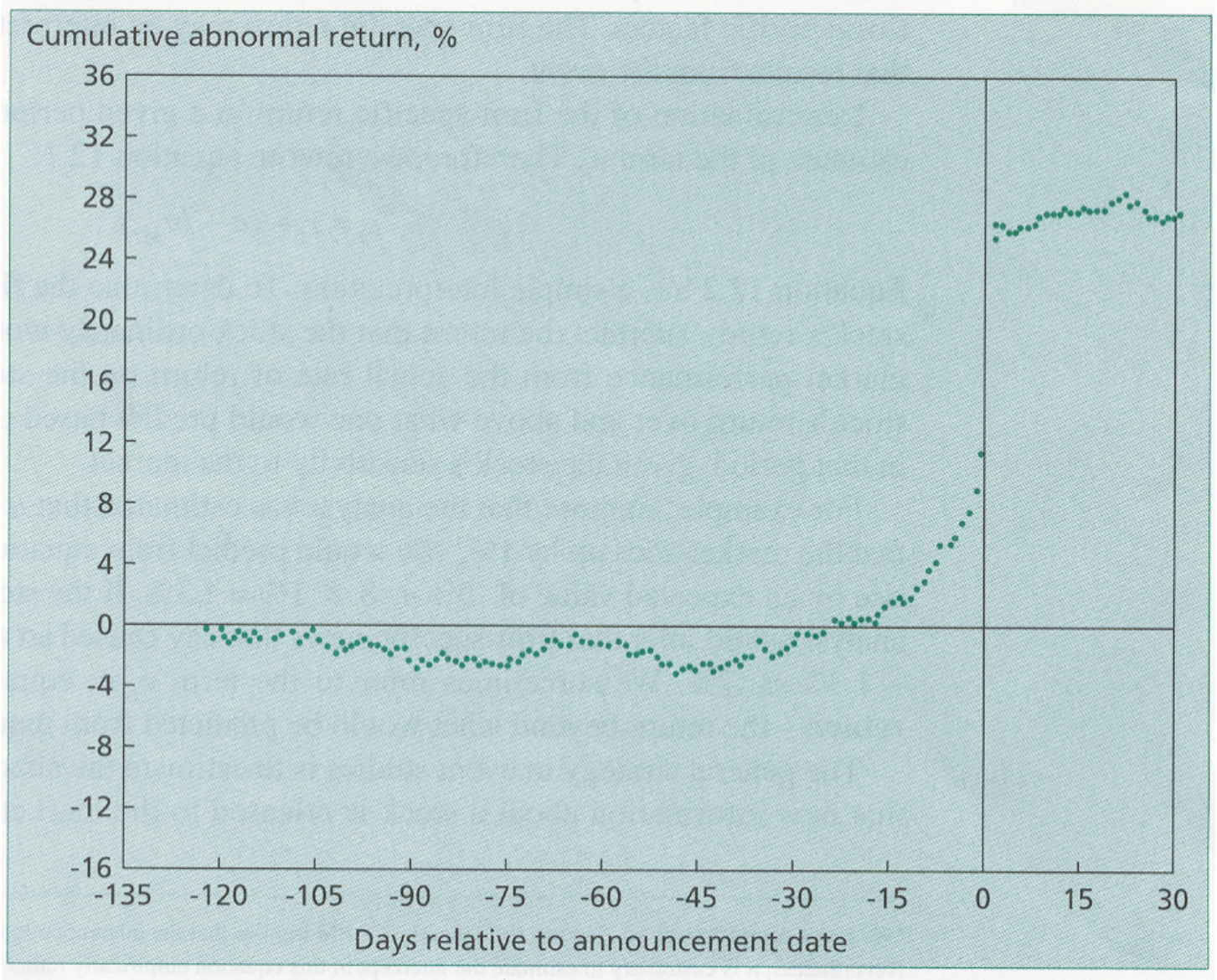
# Interpreting CAR Plots

$$CAR_T = \sum_{t=-30}^{T} AR_t$$




$AR_t$ is average abnormal return on "day $t$". $CAR_T$ is the sum of average abnormal returns from day $-30$ until day $T$. Note that $CAR_T - CAR_{T-1} = AR_T$.

# Takeover Announcements



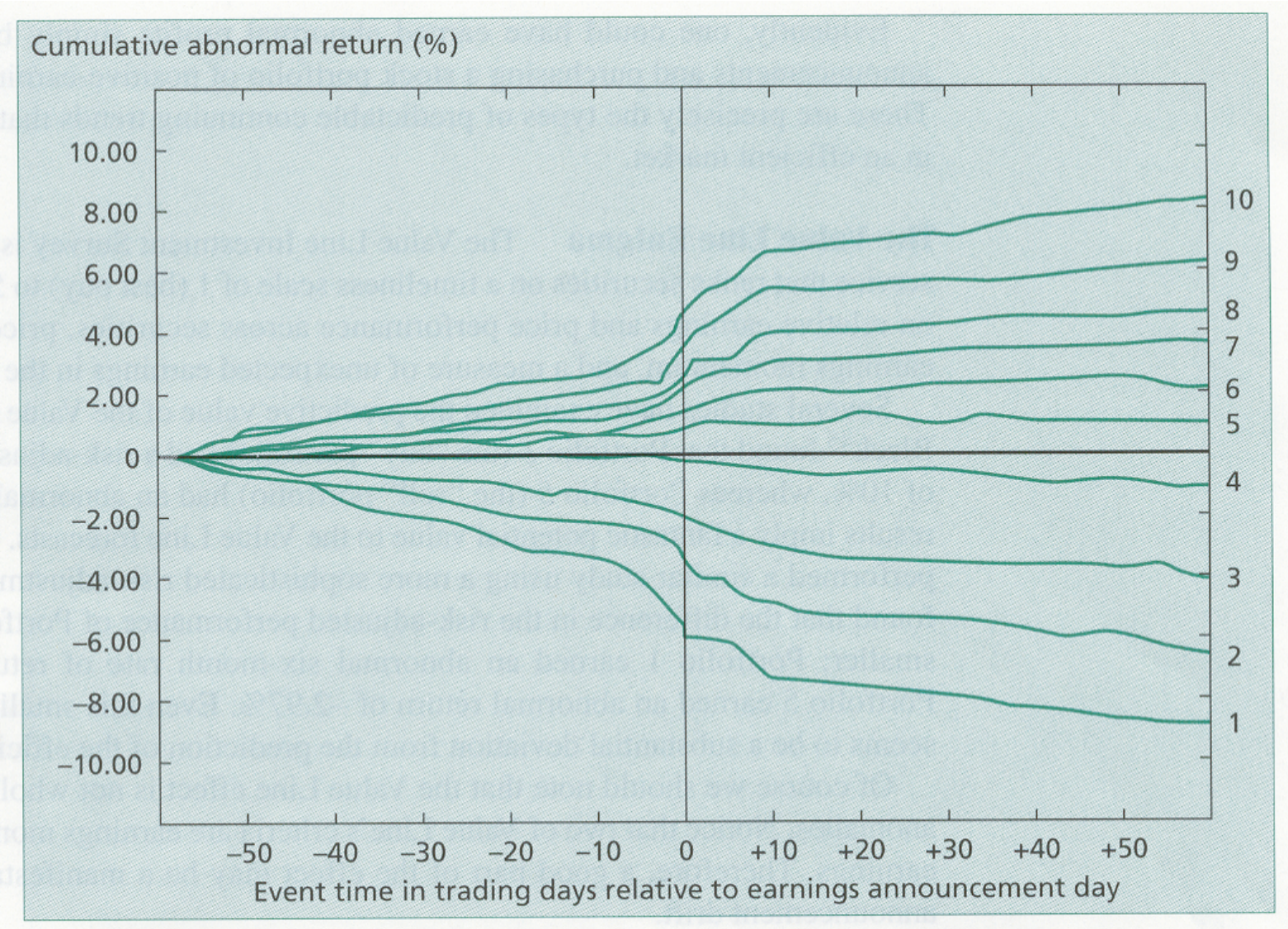

Source: *Investments*, Bodie, Kane, and Marcus.

# Assessment

- The evidence on takeover announcements is favorable to the semi-strong form.
  - After the announcement date, the CAR stays approximately constant. Therefore, we cannot achieve abnormal returns using publicly available information.

- The evidence seems unfavorable to the strong form.
  - Before the takeover announcement, the CAR increases. This suggests that there is information leakage, and company insiders achieve abnormal returns.

# Earnings Announcements




Portfolios 1-10 are formed based on earnings surprise, i.e., announced earnings minus expected earnings. Source: *Investments*, Bodie, Kane, and Marcus.

# Assessment

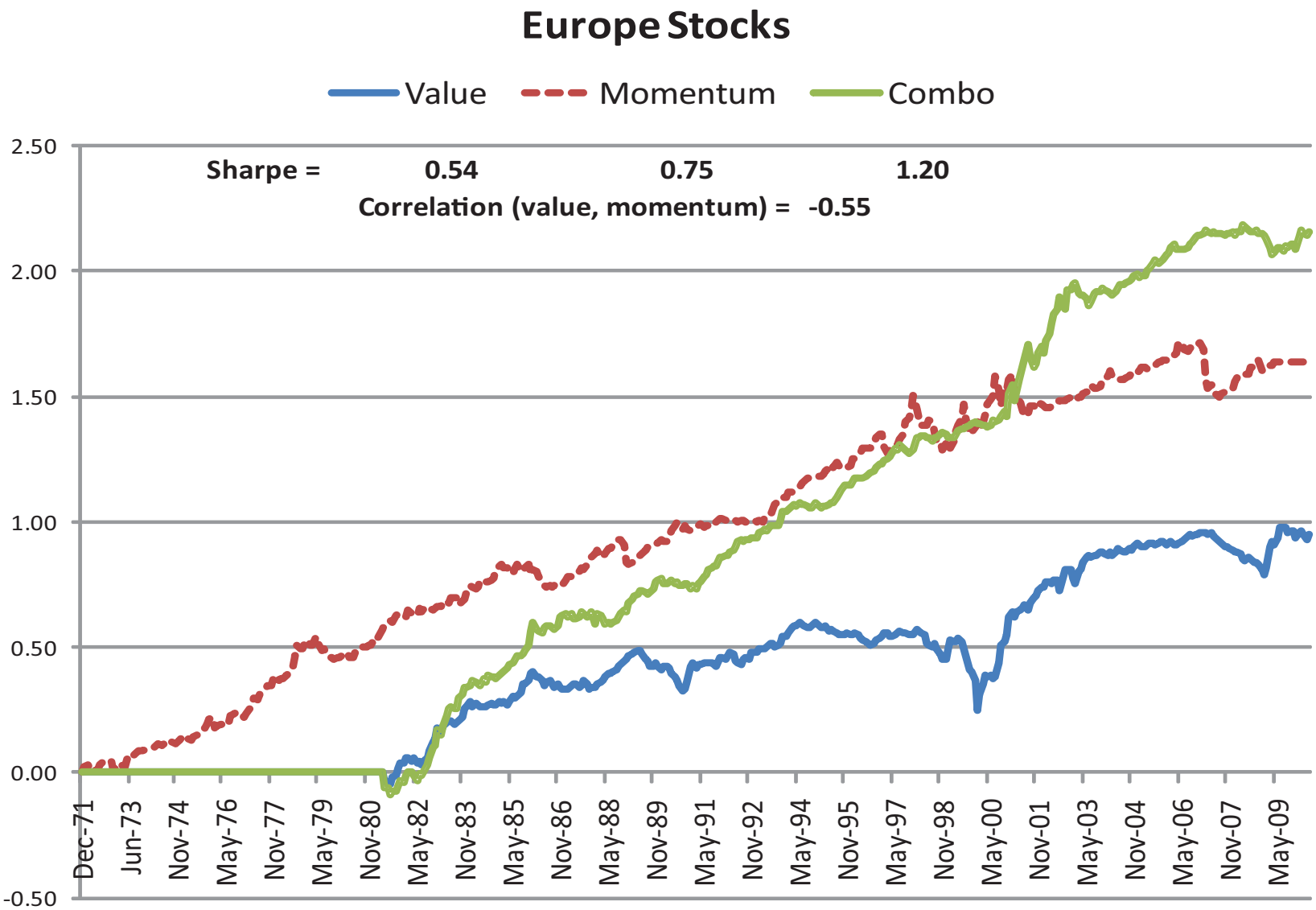
The evidence on earnings announcements is not fully favorable to the semi-strong form.

- On the announcement date, the CAR is positive (negative) for stocks with positive (negative) earnings surprises.
  - This is consistent with the semi-strong form.
- But after the announcement date, the CAR increases (decreases) for stocks with positive (negative) earnings surprises.
  - This **Post-Earnings Announcement Drift** is inconsistent with the semi-strong form.

# The Value Premium

- Rank stocks by their Book-to-Market ratio (defined as book value of assets divided by market value of assets).
  - **Value stocks** with high Book-to-Market ratio.
  - **Growth stocks** with low Book-to-Market ratio.
- The value premium refers to the fact that value stocks consistently earn higher returns on average than growth stocks.
- Yet value stocks typically have lower beta. Hence, a long-short zero-cost strategy consisting in buying value stocks and selling growth stocks delivers profits that cannot be explained by CAPM.
- Joint-hypothesis problem: it is not entirely clear whether this is evidence against semi-strong efficiency or against the CAPM...

# Value and Momentum in Europe

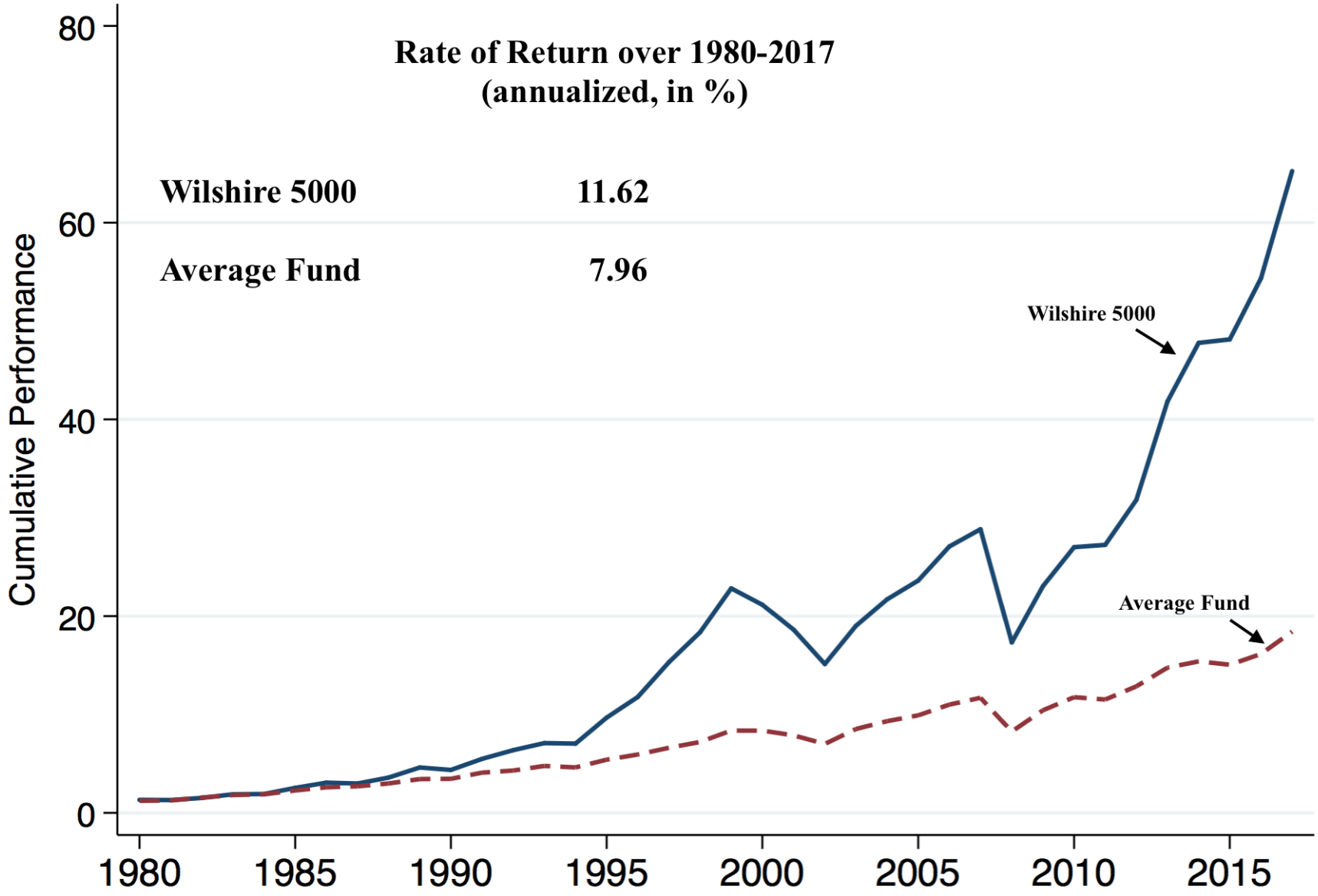



Source: Asness, Moskowitz, and Pedersen, *Journal of Finance*, 2013.

# Performance of Mutual Funds

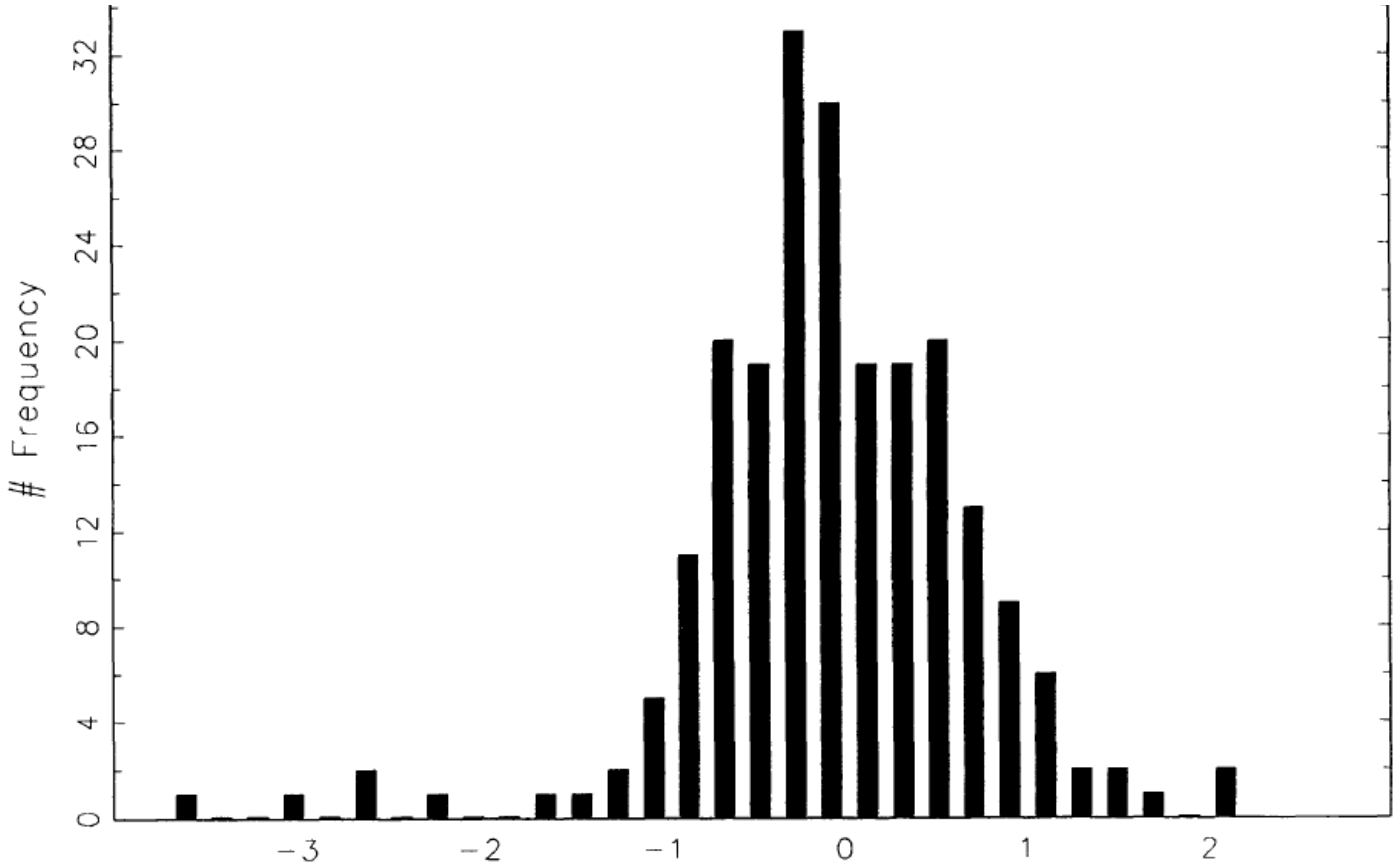
- Mutual funds are sophisticated investors, who have access to publicly available information.
- A simple test of the semi-strong form is whether mutual funds can achieve abnormal returns.
- The evidence suggests that they don't.

# Mutual Fund vs. Index Performance



# Mutual Fund Alphas

For fund $j$, run regression $R_{jt} - R_f = \alpha_j + \beta_j(R_{Mt} - R_f) + \epsilon_{jt}$.




Frequency distribution of estimated alphas for US equity mutual funds over 1972-1991. Source: Malkiel, *Journal of Finance*, 1995.

# Individual Fund Performance

- Are there particular mutual funds that achieve abnormal returns? In other words, is there consistency in mutual fund performance?
- Some mutual funds under-perform consistently.
- Very few mutual funds over-perform consistently.

# Summary of Statistical Evidence

- The statistical evidence regarding weak- and semi-strong forms of market efficiency is mixed.
  - Some trading strategies using publicly available information (past prices, accounting data, corporate announcements) deliver high profits that do not seem to be just fair compensation for risk exposure.
  - However, evidence on mutual fund performance shows that it is hard to consistently "beat the market".
- The empirical analysis of illegal insider trading provides evidence against strong form efficiency.
  - It seems possible to achieve abnormal returns using private information.

# 5. Data Mining and Transaction Costs

- There are good theoretical reasons to expect markets to be weak- and semi-strong-form efficient.
- Although the statistical evidence is mixed, one should a priori be skeptical of trading strategies that can purportedly achieve abnormal returns by using only public information.
- When assessing a trading strategy, one needs to bear in mind two important issues.
  - **Data mining/Hindsight bias:** Does the trading strategy work only for the data base on which it was constructed?
  - **Transaction costs:** Are the abnormal returns adjusted for transaction costs?

# Technical Analysis: An Example

- Suppose we are back in December 1986, and we want to construct a *"momentum-based" market timing strategy*.
- We consider **five strategies**.
  - The first strategy works as follows. At the beginning of each month, we invest all our money in the S&P500 or in T-bills. We invest in the S&P500 if it performed better than T-bills last month, otherwise we invest in T-bills.
  - The second strategy compares the S&P500 to T-bills two months ago.
  - And so forth, looking back three, four, or five months ago.
- We will compare the five strategies over the period 1977-1986 (this is called **back-testing**). Then we will look at the **out-of-sample** performance of the "best" strategy.

# The Five Strategies in 1977-1986

We compute how many dollars we would have on December 31, 1986, if we started with \$1 on January 1, 1977.

| Strategy | Dollars on 12/31/1986 |
|---|---|
| 1 | 3.72 |
| 2 | 2.78 |
| 3 | 2.26 |
| 4 | 3.02 |
| 5 | 5.40 |
| S&P500 | 3.67 |

Strategy 5 is the best by a wide margin.

# Data Mining

Strategy 5 works well for the period 1977-1986 (based on which it was constructed)... but does not consistently beat the market out-of-sample.

| Years | Strategy 5 | S&P500 |
|---|---|---|
| 1957-1966 | 1.83 | 2.43 |
| 1967-1976 | 2.52 | 1.91 |
| 1977-1986 | 5.40 | 3.67 |
| 1987-1996 | 2.80 | 4.17 |

# Transaction Costs

Strategy 5 involves frequent trading relative to the "buy-and-hold" strategy, and is therefore sensitive to transaction costs.

Suppose that trading the S&P500 involves transaction costs that are proportional to the value traded. Ignore transaction costs for T-bills.

| Years | TC=0 | TC=0.5% | TC=1% | S&P500 |
|---|---|---|---|---|
| 1957-1966 | 1.83 | 1.38 | 1.05 | 2.43 |
| 1967-1976 | 2.52 | 1.95 | 1.50 | 1.91 |
| 1977-1986 | 5.40 | 4.16 | 3.20 | 3.67 |
| 1987-1996 | 2.80 | 2.04 | 1.48 | 4.17 |