



# 15.415x Foundations of Modern Finance

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## Lecture 8: Market Efficiency

## Key concepts

- Market Efficiency
- The Challenger Crash
- Market Efficiency: A Testable Definition
- Weak Form of EMH
- Semi-Strong Form of EMH
- Event Studies: Firm Announcements
- Asset Management
- Strong Form of EMH
- Discussion

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## Market efficiency vs economic efficiency

- The notion of efficiency is broadly used. It has specific meaning in finance.
- The general notion of economic efficiency has to do with allocation of limited resources: are resources used in the most productive manner possible?
  - Well-functioning financial markets play a critical role.
- Market efficiency is about how well market prices aggregate information.
- In an efficient market, prices fully reflect all available information. Need to make this precise.

## Why should markets be efficient?

- Question: Why do we expect markets to be efficient?
- Answer: Because of arbitrage.
  - If information is not incorporated into prices, there are profitable trading opportunities.
  - By exploiting these opportunities, investors impound their information into prices.

## A theory of “sharks”

- A common criticism is that markets cannot be efficient because most investors are not fully rational! Humans make mistakes.
- This criticism is largely misplaced: market efficiency does not require most investors to be rational or well informed.
- We only need a few smart agents, who are not financially constrained, to spot profitable opportunities and eliminate inefficiencies.
  - Market efficiency is a theory of “sharks,” not of the average investor.

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## Time-line of events

### January 28, 1986

- 11:39am: Space Shuttle Challenger Explodes, 73 seconds into its flight.

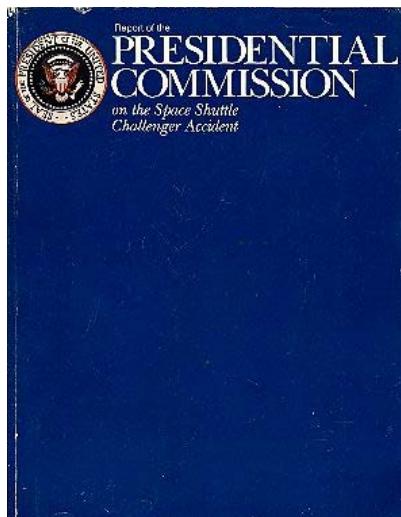
### Dow Jones News Wire

- 11:47am: “Space Shuttle Explodes”.
- 12:17pm: “Lockheed Has No Immediate Comment”.
- 12:52pm: “Rockwell Intl Has No Comment”.



## Information gathering

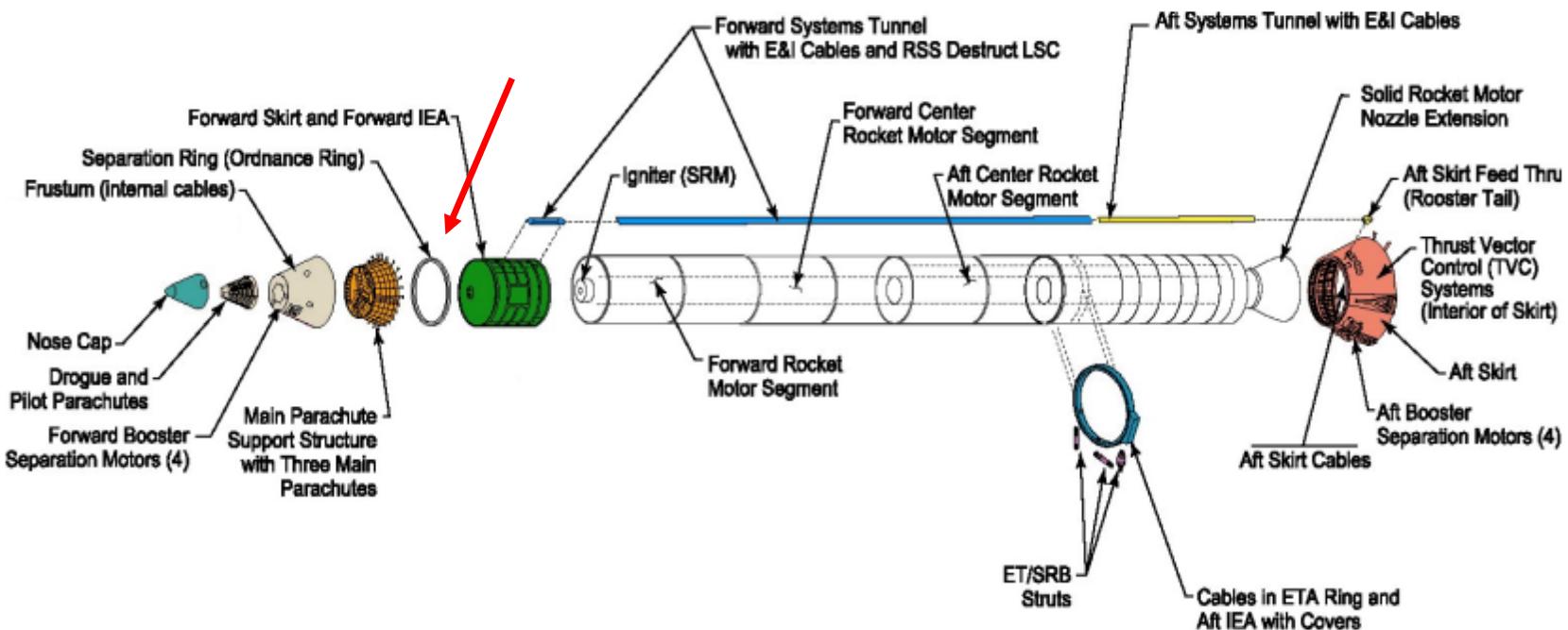
Reagan establishes presidential commission to investigate



# The O-Ring

Rogers Commission Report:

- Published June 9, 1986.
- Concluded that Morton Thiokol was at fault.



## Wisdom of the markets

market know almost immediately who was at fault when it took several months for the presidential commission to figure it out

- The stock market reflected this information within minutes:

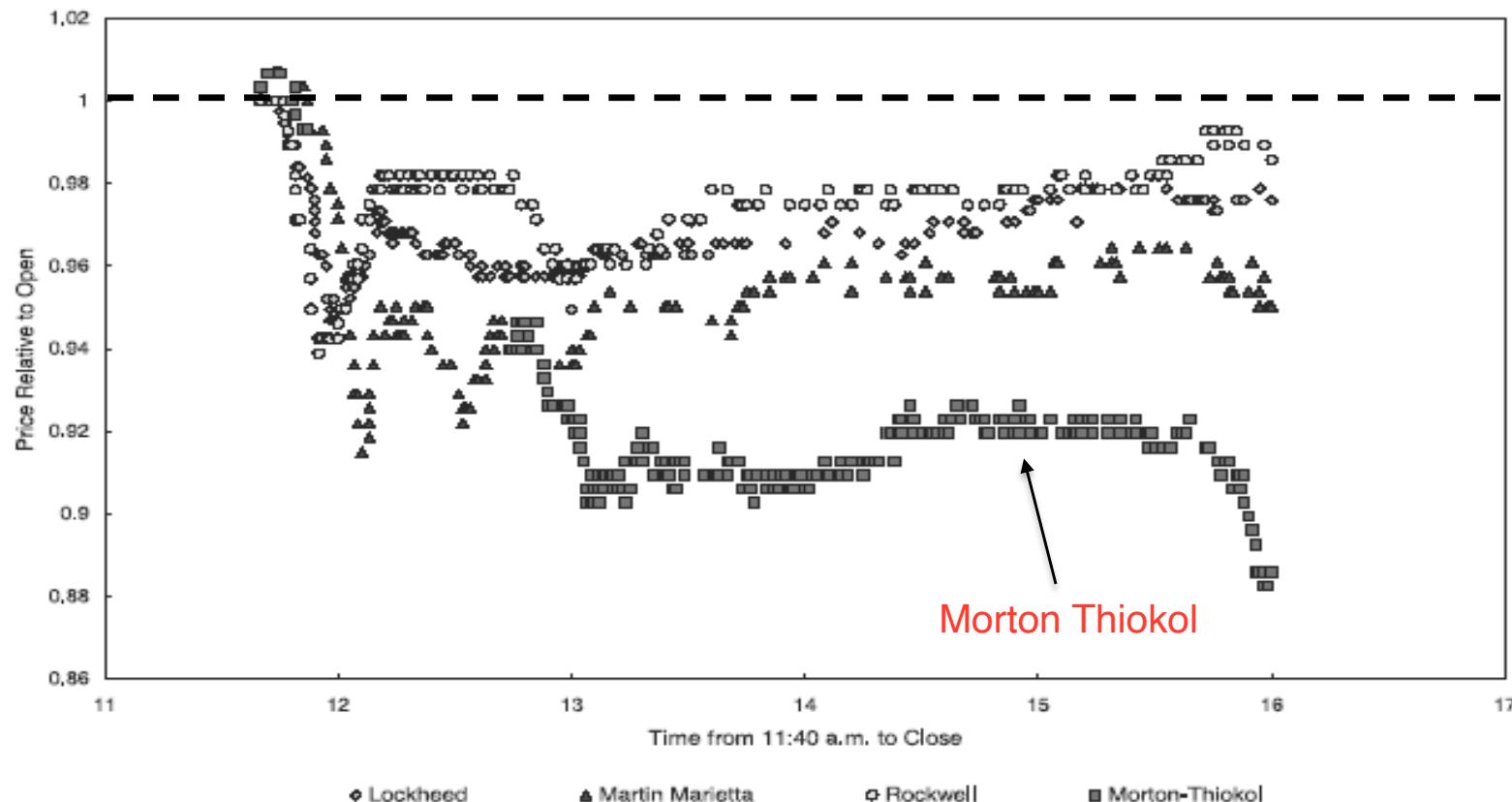


Fig. 1. Intraday stock price movements following the challenger disaster.

## Prices aggregate information

- The night before the launch, Ebeling and four other engineers at NASA contractor Morton Thiokol had tried to stop the launch.
- The night before the launch, Ebeling and four other engineers at NASA contractor Morton Thiokol had tried to stop the launch. Their managers and NASA overruled them.
- That night, he told his wife, Darlene, “It's going to blow up.”
- It appears that a number of people knew about the likely cause of the crash, and their information got revealed in the market very quickly.

Someone with the knowledge of the likely underlying cause of the accident was trading on their information.



Bob Ebeling in his home in Brigham City, Utah.  
Howard Berkes/NPR

The lesson here is that information that is available to just a few can get impacted into prices relatively quickly.

This is how markets reach efficiency.

They're very good at aggregating useful pieces of information.

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## Prices reflect information: a formal statement

- What does it mean to “reflect all available information?”
- A market is efficient if prices fully reflect **all available information**.
- **Definition:** A market is efficient if it is **impossible to make excess profits** by trading on all available information:

expected value of the price plus the

dividend next period conditional  
on all available information

where  $\bar{r}_t$  is the required return on the asset (given the risk) for period  $t$ .

- The form of market efficiency depends on what is included in “all available information” (i.e., what we include in  $\mathcal{I}_t$ ).

## Three forms of market efficiency

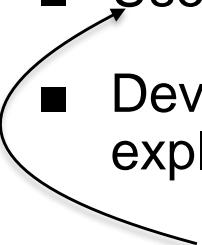
one cannot achieve abnormal risk-adjusted returns based on past prices, publicly available information, all information

- **Weak-form efficiency:** security prices reflect all information *contained in past prices*.
  - technical analysis looks at the past history of prices
- Technical analysis does not provide excess returns.
- **Semi-strong-form efficiency:** security prices reflect all *publicly available* information.
  - fundamental analysis looks at various kinds of fundamental data
- Fundamental analysis does not provide excess returns.
- **Strong-form efficiency:** security prices reflect *all* information, whether publicly available or not.
  - Inside information does not provide excess returns.

## EMH and risk models

We need to identify what is the risk premium justified by the risk exposures of the assets and what part of their excess returns is abnormal, which would be a violation of the efficient markets hypothesis.

- When testing EMH, need to differentiate “excess profits” from the risk premium.
- Need a risk model – tests of EMH are necessarily testing a composite hypothesis: EMH + a particular risk model.
- Two general approaches:
  - Use a set of common risk models to perform risk adjustment.
  - Develop a profitable trading strategy that would be very difficult to explain with any risk model.



The difficulty is that we do not have a well-accepted common set of risk models. And therefore, there is always a lingering doubt that what we are seeing is not an abnormal performance, but rather a failure to find the right risk model.

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## Empirical tests

- **Weak-form efficiency:** security prices reflect all information *contained in past prices*.
- Can signals based on past prices generate abnormal risk-adjusted returns? Are risk-adjusted returns predictable?
  - Tests of serial correlation.
  - Tests of filter rules.
  - Tests of the performance of technical analysis.

## Serial correlation of returns

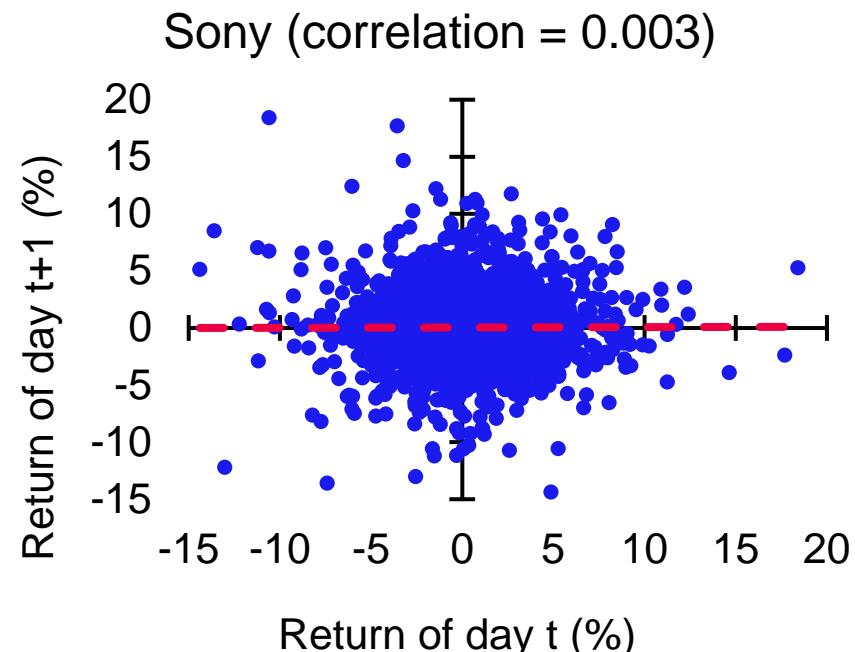
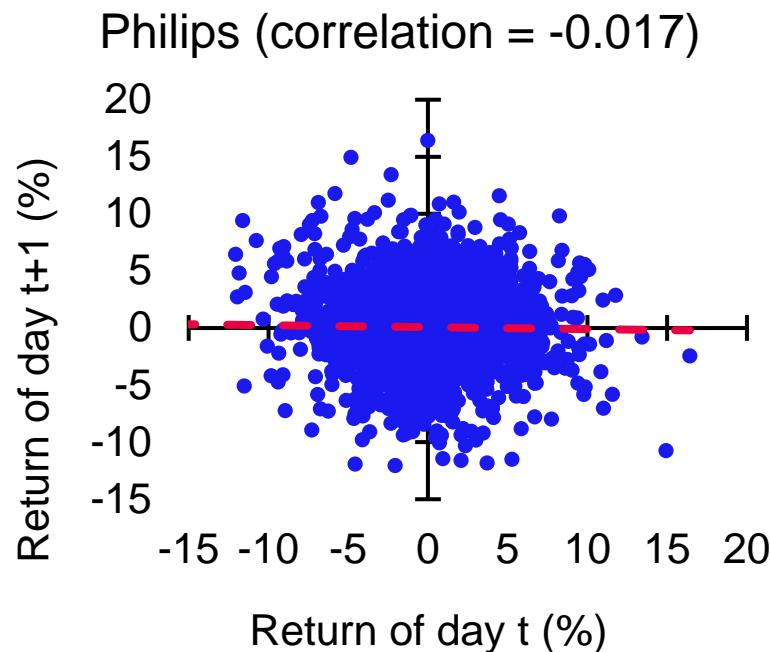
- If past prices predicted future returns, we would detect some correlation (positive or negative) between successive price changes.
- Is high degree of serial correlation inconsistent with the EMH? Can this predictability be explained by a risk model?
- This would require risk to change significantly period to period, in response to recent returns. Difficult to reconcile with common risk models.



The challenge when trying to explain serial correlation with the risk model is that one would need to argue that the conditional risk of an asset changes rapidly over time in relation to past returns. Most common risk models do not have that property, at least not at the high frequency, such as daily.

## Serial correlation of returns

- Two stocks. Each dot shows a pair of returns for a stock on two consecutive days between Dec 1991 and Dec 2019.
- No significant relation between returns on successive days. This is the case for most/all stocks.



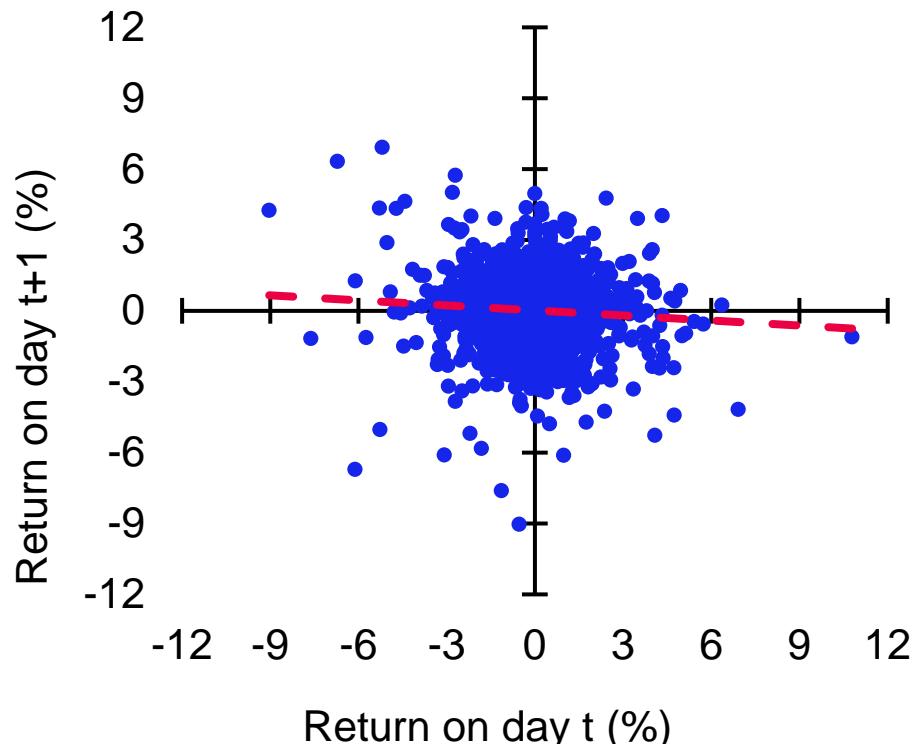
## Serial correlation of individual stock returns

- E. Fama, “The behavior of Stock-Market Prices”, *Journal of Business* 1965, vol. 38, pp.34-105.
- The fact that these coefficients are all close to zero indicates that returns are not predictable in the short term.
- Here is a summary of his results about the serial correlation of stock returns at different intervals:

Interval	Serial Correlation
1-day change	0.03
4-day change	-0.04
9-day change	-0.05
16-day change	0.01

## Serial correlation of index returns

- Daily returns on the S&P 500 index between Jan, 2008 and June, 2019.
- Again, there is no apparent relationship between returns on successive days.

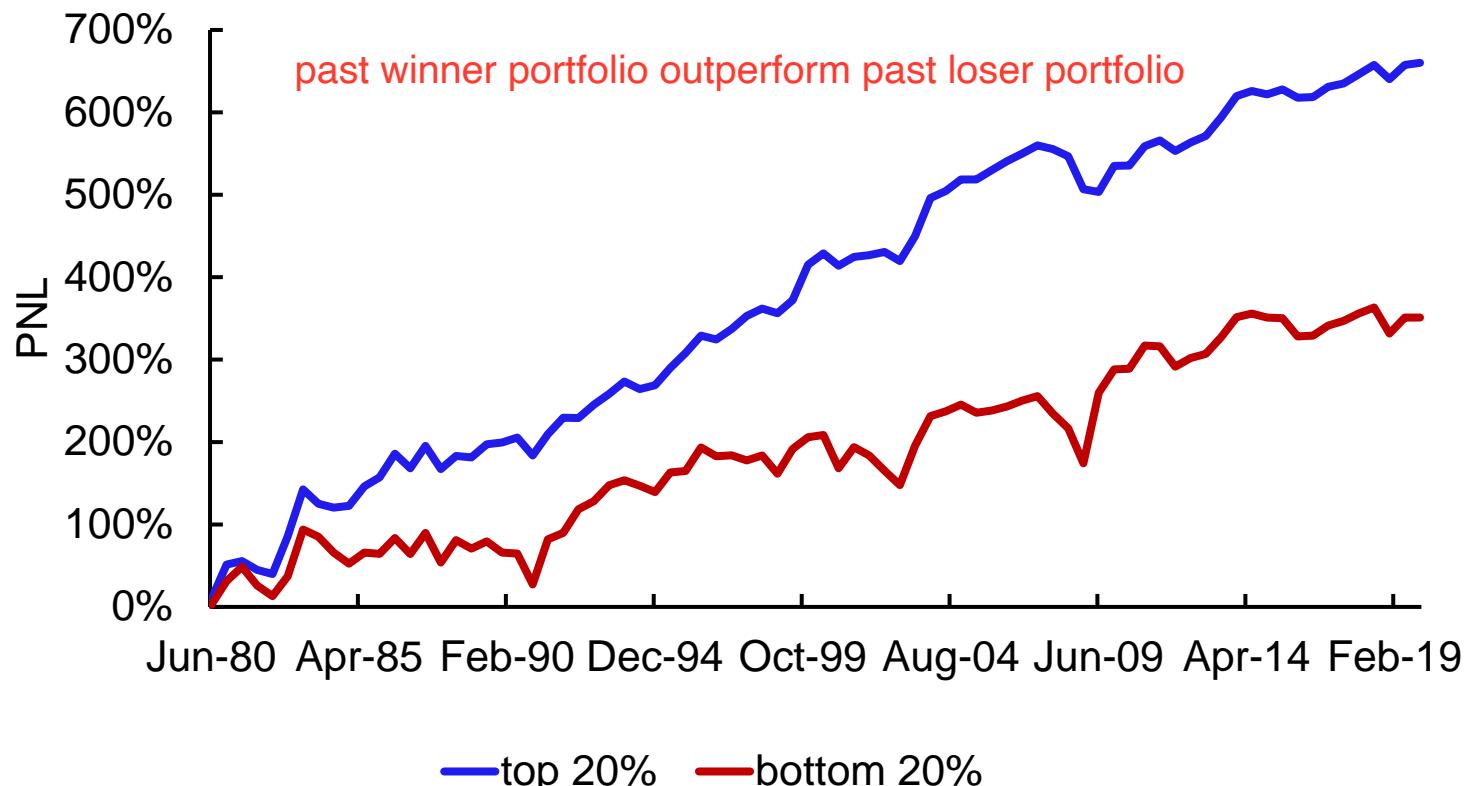


## Momentum and reversals

- A few studies have cast some doubt on the lack of predictability.
- Jegadeesh and Titman (1993) document medium-horizon **momentum**. “Winners” over the past 6 months subsequently outperform 6-month past losers. This phenomenon is known as momentum. Strong returns tend to continue, and weak returns tend to continue at certain horizons of several months.
- Hong, Lim and Stein (2000): Momentum is particularly present in small stocks with low analyst coverage.
- De Bondt and Thaler (1985) find evidence of long-horizon **reversal**. “Losers” over the past 36 months subsequently outperform 36-month past winners.

## Winners vs losers

- Performance of equal-weighted portfolios, top 20% vs bottom 20% of stocks. Every 6 months sort stocks on their recent 6-month performance.  
profitable portfolio strategy
- PNL is the cumulative sum of monthly returns.



## Discussion: evidence on the weak form of EMH

- Do results on momentum and reversals pose a challenge to the weak form of the EMH?
- Can we explain this evidence on return predictability by predictable variation in risk?
  - Momentum: are past winners more risky than the past losers?
  - Reversal: Are long-term past losers more risky than the long-term past winners?
- When we compute abnormal returns, we need define what level of average returns is justified by return risk.

risk adjustment is a must for EMH

## Discussion: evidence on the weak form of EMH

Market efficiency use abnormal risk-adjusted returns, not the raw returns. un-adjusted raw returns may be predictable.

- The challenge of explaining momentum under the EMH: stocks often move across the portfolios sorted on recent returns.
- This means that systematic risk of a stock must change quickly, in relation to recent stock performance.
- Momentum strategies are well known and commonly used, yet their profitability does not get fully arbitrated away.
- This suggests that momentum strategies are risky, and that is why investors do not exploit them more.

Part of the challenge with the momentum strategy in particular is that membership in the winner and loser portfolios changes over time. This means that if we wanted to explain momentum based on risk exposures, we would have to argue that the risk of stocks changes at relatively high frequency over time.

The fact that their profitability does not tend to disappear over time suggests that these returns may not be purely abnormal and may indicate some kind of risk exposure. And that is the reason why they don't get arbitrated away.

## Key concepts

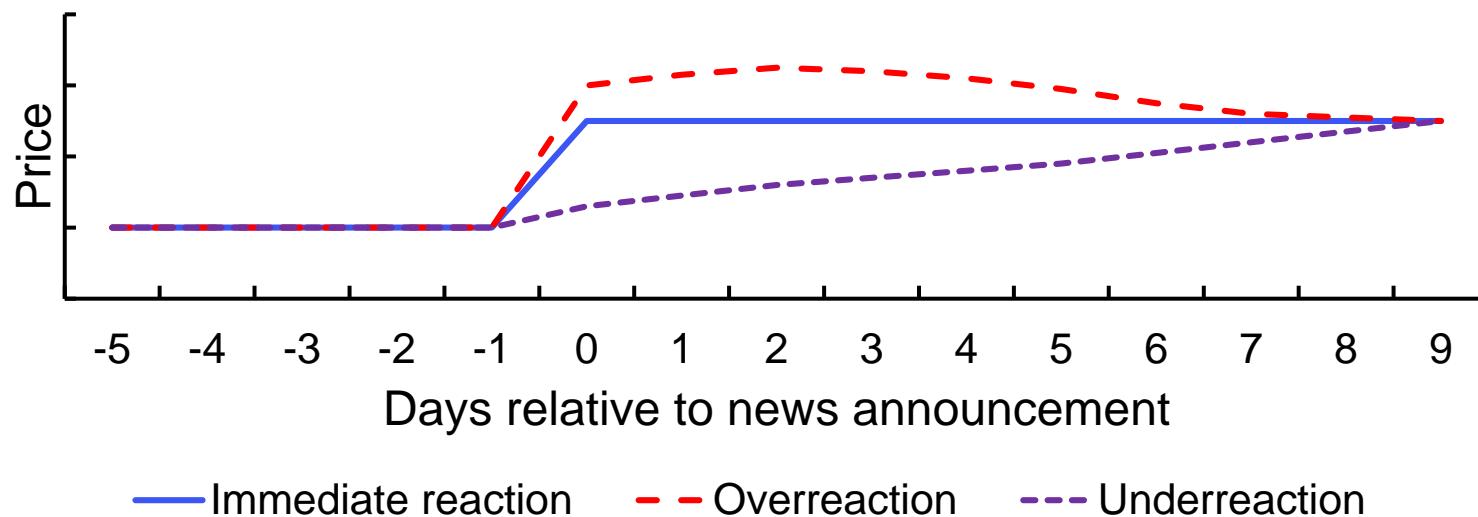
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# Fundamental analysis

- **Semi-strong-form efficiency:** security prices reflect all *publicly available* information.
  - Fundamental analysis does not provide excess returns.
- The purpose of fundamental analysis is to exploit opportunities when some public information about firms is not reflected in prices immediately.
- The idea is to use all publicly available information about firms in order to select securities.
- This information includes:
  - Firm's financial statements;
  - Firm's recent announcements (e.g., earnings, dividends, share repurchases, debt issues, stock splits, etc.);
  - Mergers, acquisitions, and takeovers.

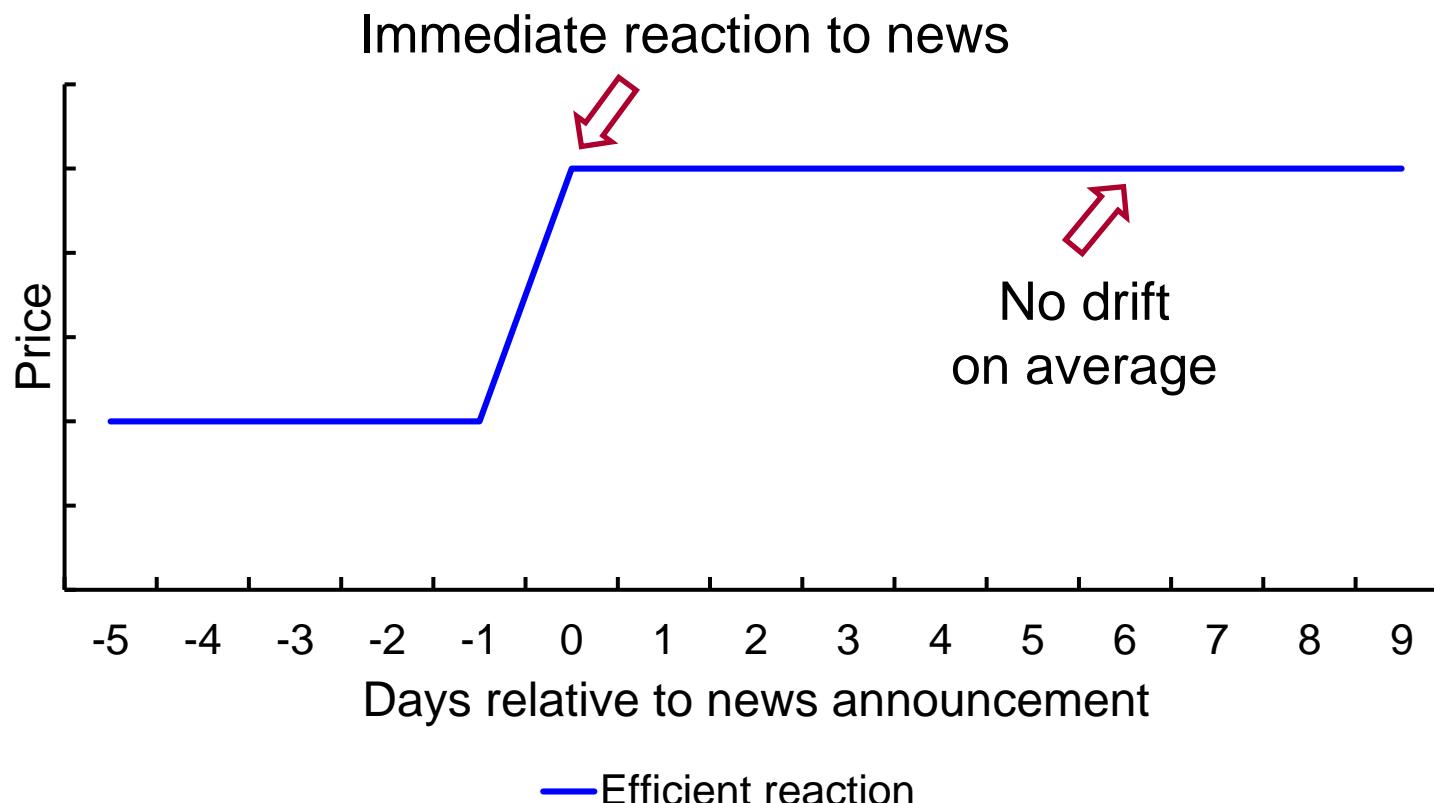
## Price reaction to new public information

- **Immediate reaction:** The price instantaneously adjusts to and fully reflects new information; there is no tendency for subsequent increases and decreases.
- **Delayed reaction:** The price partially adjusts to the new information; a few days elapse before the price completely reflects the new information.
- **Overreaction:** The price over-adjusts to the new information; there is a bubble in the price sequence.



## Efficient price reaction to new public information

- Under the semi-strong form of EMH, we should observe an immediate adjustment of prices to public information: there should be no predictable subsequent increases and declines.



## Event studies

- Objective: Examine if new (company specific) information is incorporated into the stock price in one single price jump upon public release.
- Empirical strategy:
  1. Define as “day zero” the day the information is released.
  2. Calculate the daily returns  $R_{it}$  during the 30 days around day zero:  $t = -30, -29, \dots, -1, 0, 1, \dots, 29, 30$ .
  3. Calculate the daily returns  $R_{mt}$  for the same days **comparison group** (market portfolio, same industry, similar firms, etc.)

## Event studies

dividend info announcement is not equal to dividend release

stock daily return should consider dividend

- Empirical strategy, continued:

4. Define abnormal returns as the difference  $AR_{it} = R_{it} - R_{mt}$  risk adjustment
5. Calculate average abnormal returns over all  $N$  events in the sample for all 60 reference days.

in recitation, just N stocks

$$AAR_t = \frac{1}{N} \sum_{i=1}^N AR_{it}$$

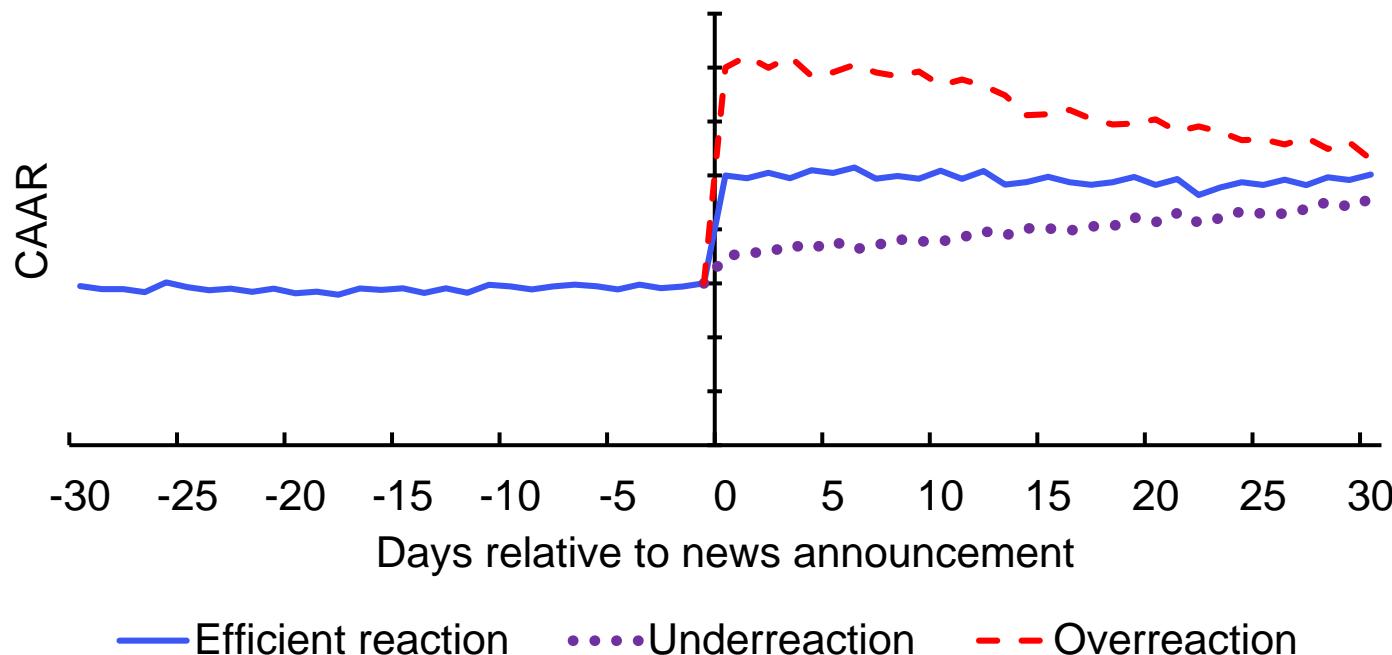
6. Cumulate the average abnormal returns on the first  $T$  days to

$$CAAR_T = \sum_{t=-30}^T AAR_t$$

## Event studies

- CAAR process that we might observe in each of the three news-reaction scenarios.

$$CAAR_T = \sum_{t=-30}^T AAR_t$$



## Market efficiency and trading on public information

- Under the semi-strong form of the EMH, we cannot benefit from trading following a public news release.
- Price responds efficiently: expect zero risk-adjusted returns following the announcement
- If the market under-reacts to news, buying after the announcement is profitable. **abnormal profits**.
- If the market over-reacts to news, selling after the announcement is profitable. **abnormal profits**.

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## Announcements of takeovers offers

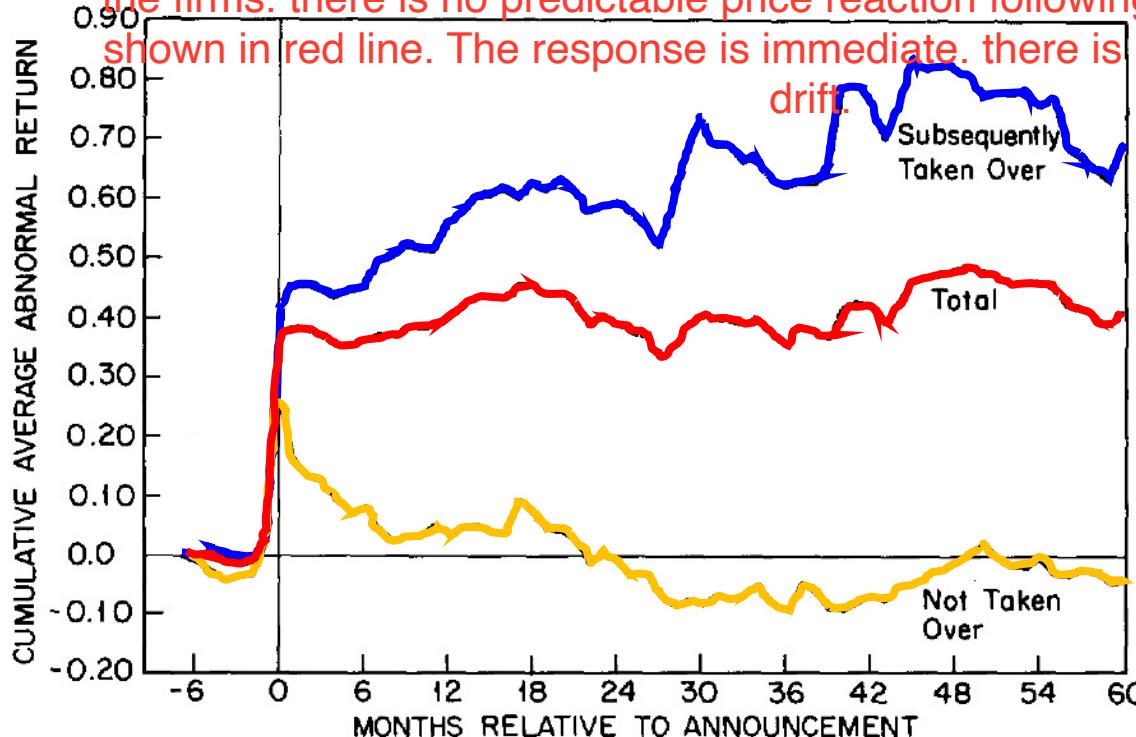
- One of the biggest news events for a firm is being the target of a takeover offer.
- Typically, the offer is for a significant premium to the target's current price.
- The target's stock price typically jumps, but not all the way to the offer price.
  - This does not necessarily create a profitable trading opportunity.
  - There is usually remaining uncertainty regarding whether the deal will occur at the initially offered price, at a higher price, or fail to occur at all.

## Announcements of takeovers offers

markets seem to respond to the information about a takeover offer in an efficient manner, as predicted by the efficient markets hypothesis.

- Average response to many such takeover announcements, as measured by the target stock's cumulative abnormal return (relative to the broad market return).
 

We don't know at day zero, which of the firms are going to end up on the blue or the yellow lines. What we see instead is the average pattern across all of the firms. there is no predictable price reaction following the announcement shown in red line. The response is immediate, there is no subsequent price drift.



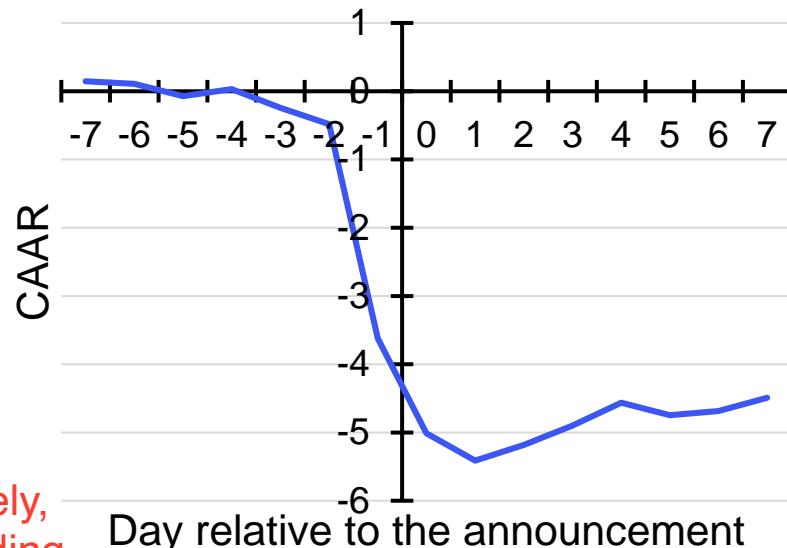
M. Bradley, A. Desai, E. Kim, "The rationale behind interfirm tender offers : Information or synergy?"  
 Journal of Financial Economics 11,183-206.

## Dividend omissions

- Since firms tend to omit dividends when future cash flows are not expected to be sufficient to sustain a particular level of payout, this leads to a fall in the stock's price.

Price response to the announcement immediately, and there is no room for achieving abnormal trading profits by trading following the announcement.

CAAR for Companies Announcing Dividend Omissions



"Do Dividend Omissions Signal Future Earnings or Past Earnings?" S. Szewczyk, G. Tsetsekos, and Z. Zantout, *The Journal of Investing* Spring 1997, 40-53

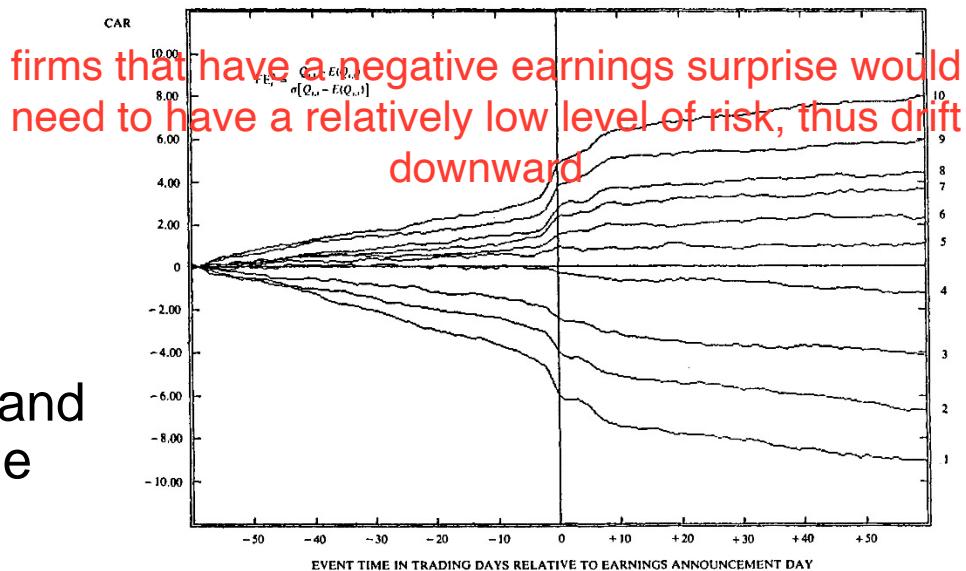
there is no clear pattern of price drift up or down following the announcement. what we see is that price behavior around dividend omissions is consistent with the semi-strong form of market efficiency.

## Earnings announcements

Bernard and Thomas (1989) analyze stock returns around earnings announcements.

- Classify stocks into ten deciles according to their earnings surprise.
- Prices jump on announcement, and then **continue drifting** in the same direction.
- Difficult to find a risk-based explanation: similar to momentum, need recent returns to forecast future risk.
- No consensus on whether this is consistent with the EMH.

firms that deliver a positive earnings surprise have a relatively high level of risk going forward, thus drift upward.



V. Bernard, J. Thomas, "Post-Earnings-Announcement Drift: Delayed Price Response or Risk Premium?" *Journal of Accounting Research* 1989, 27, 1-36.

the result of the test of the semi-strong form of the EMH may depend on the choice of the comparison group (a group of stocks with similar risk) for announcing firms. The choice of the reference group affects what we define to be risk-adjusted returns, and may alter the outcome of the test.

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## Asset management

find evidence against the MEH:

find a trading strategy using public information that achieves abnormal returns

- Instead of exploring specific trading strategies, look for evidence of abnormal performance by professional asset managers.
- Asset managers use a broad range of trading strategies based on public information, including fundamental analysis.
- Performance of equity fund managers helps assess whether exploiting public information generates additional returns (i.e., whether financial markets are semi-strong form efficient).
- **risk-adjusted** Abnormal returns by equity fund managers would indicate that managers are able to take advantage of the slow reflection of public information in prices.

If active managers are not able to outperform on a risk-adjusted basis, we're going to conclude that all sorts of public information that these managers may be looking at are not useful for achieving abnormal performance.

## Active equity funds vs. Index

- One (somewhat crude) way of adjusting for risk is to compare the return of a mutual fund to the return on a market index.
- This approach is rather popular in practice, probably due to its simplicity.
- Mutual funds underperform the market in 60-70% of the years.

## Active equity funds vs. Index

risk adjust each fund based on their particular risk exposure

- The conclusion is unchanged if we properly account for risk and fund expenses.  
asset management fees
- The funds perform close to the benchmark *before expenses*.
- The funds tend to trail the benchmark *after expenses*.
- Performance of professional investment managers suggests that value added, if any, is captured by the investment managers in the form of fees, and not by the investors.  
And any type of value added they seem to be able to produce using public information accrues to the managers themselves and not to the investors.

## Active equity funds vs. Benchmarks

- The following table shows that most US equity mutual funds underperform relative to their benchmarks. **93.55% of equity funds are outperformed by benchmark**

Report 1: Percentage of U.S. Equity Funds Outperformed by Benchmarks – Risk-Adjusted Returns

FUND CATEGORY	COMPARISON INDEX	NET OF FEES (%)			GROSS OF FEES (%)		
		5-YEAR	10-YEAR	15-YEAR	5-YEAR	10-YEAR	15-YEAR
All Domestic Funds	S&P Composite 1500	88.22	96.57	93.55	81.22	90.90	77.36
All Large-Cap Funds	S&P 500	83.92	96.81	91.88	73.95	89.20	69.23
All Mid-Cap Funds	S&P MidCap 400	65.29	80.28	86.31	51.47	67.52	68.16
All Small-Cap Funds	S&P SmallCap 600	76.64	89.12	86.90	64.42	73.47	69.00
All Multi-Cap Funds	S&P Composite 1500	88.45	95.81	91.81	79.96	90.46	74.80
Large-Cap Growth Funds	S&P 500 Growth	84.62	100.00	99.51	75.38	96.99	89.81
Large-Cap Core Funds	S&P 500	90.58	97.38	94.30	79.87	90.70	66.78
Large-Cap Value Funds	S&P 500 Value	80.24	82.43	76.38	70.66	74.66	48.74
Mid-Cap Growth Funds	S&P MidCap 400 Growth	58.54	82.32	87.43	46.34	69.70	68.57
Mid-Cap Core Funds	S&P MidCap 400	84.21	84.89	89.52	67.54	71.94	70.48
Mid-Cap Value Funds	S&P MidCap 400 Value	66.13	78.72	88.61	51.61	58.51	55.70
Small-Cap Growth Funds	S&P SmallCap 600 Growth	72.40	90.50	92.82	60.94	80.09	70.17
Small-Cap Core Funds	S&P SmallCap 600	86.01	94.26	88.27	73.25	78.69	72.45
Small-Cap Value Funds	S&P SmallCap 600 Value	84.96	86.29	85.54	70.80	67.74	57.83
Multi-Cap Growth Funds	S&P Composite 1500 Growth	90.32	97.56	96.64	81.72	95.61	81.21
Multi-Cap Core Funds	S&P Composite 1500	95.51	97.13	91.43	89.89	91.98	74.92
Multi-Cap Value Funds	S&P Composite 1500 Value	90.10	92.03	86.34	82.18	83.33	63.35
Real Estate Funds	S&P United States REIT	54.88	74.71	80.28	35.37	51.72	45.07

Source: S&P Dow Jones Indices LLC, CRSP. Data as of Dec. 31, 2019. Past performance is no guarantee of future results. Table is provided for illustrative purposes.

## Performance persistence

past performance does not predict which funds will end up as future winners,

Quintile	No. of funds	Excess return ranking (5 years ended 12/31/2009)	Quintile ranking in subsequent nonoverlapping 5-year period ended 12/31/2014 (percentage of funds)						
			Highest quintile	High	Medium	Low	Lowest quintile	Merged/closed	Total
1	1,091	Highest quintile (1)	13.5%	16.6%	20.3%	16.2%	23.5%	9.9%	100.0%
2	1,083	High (2)	12.4	13.5	16.0	20.6	15.5	22.1	100.0
3	1,084	Medium (3)	14.9	13.9	14.2	17.7	13.4	25.9	100.0
4	1,085	Low (4)	13.8	15.1	11.0	12.3	10.0	37.9	100.0
5	1,032	Lowest quintile (5)	13.8	11.5	10.9	10.6	8.7	44.6	100.0

Notes: The first two columns rank all active U.S. equity funds within each of the Morningstar style categories based on their excess returns relative to their stated benchmarks during the period cited. The shaded columns show how the funds in each quintile performed over the next five years.

Sources: Vanguard and Morningstar, Inc.

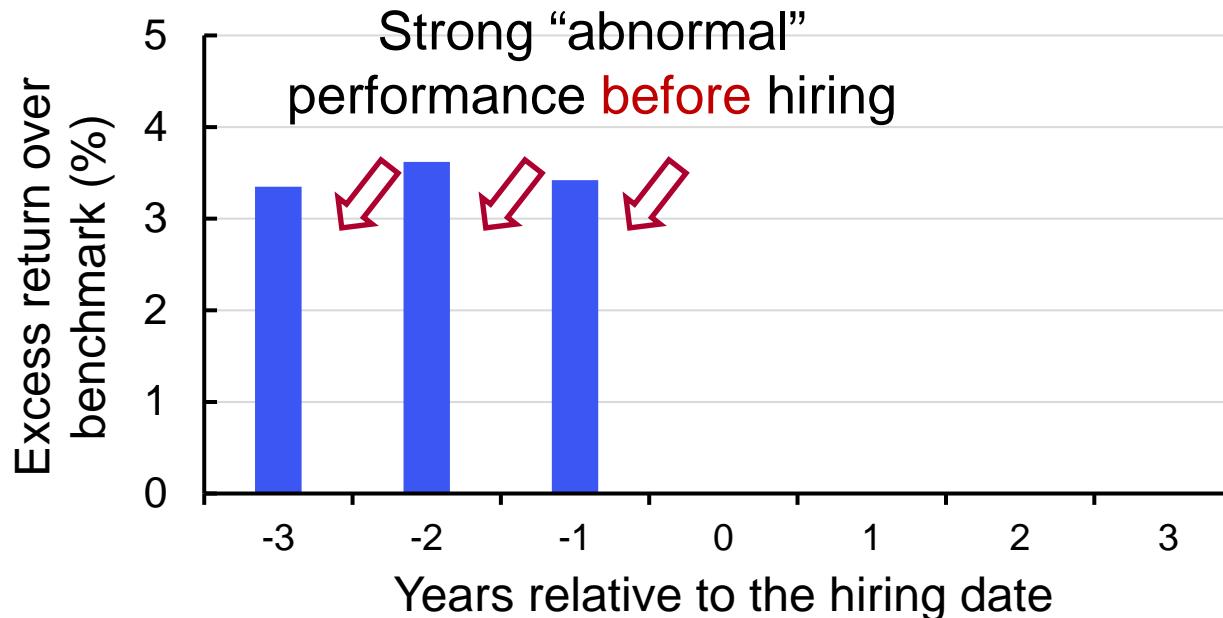
- There is very little performance persistence in actively managed mutual funds, as the following table (from Vanguard) shows.

## Pension fund managers

- Plan sponsors pick managers that have significantly outperformed their benchmarks historically. Once hired, however, the performance of these managers is nothing special.
- Goyal and Wahal (2008) use data from 1994-2003 on the 8,755 hiring decisions of 3,400 plan sponsors.

## After-hiring performance

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- Goyal and Wahal (2008) use data from 1994-2003 on the 8,755 hiring decisions of 3,400 plan sponsors.



A. Goyal, S. Wahal, "The Selection and Termination of Investment Management Firms by Plan Sponsors,"  
*Journal of Finance* 2008, 63, 1805-1847.

## After-hiring performance

- After-hiring performance is similar to the excess return of the average mutual fund (0.64% on a value-weighted basis).
- Excess returns are roughly equal to management fee (which tends to range from 0.5% to 0.7% a year).



## Conclusion

Backtesting assesses the viability of a trading strategy by discovering how it would play out using historical data. If backtesting works, traders and analysts may have the confidence to employ it going forward.

- There exist examples of strategies that appear to deliver abnormal risk-adjusted performance in backtests.
- Need to be careful interpreting such evidence: it is based on backtests.
- Live performance of professional asset managers suggests that many of such strategies fail to perform in real markets.
- The gap between theoretical and actual performance is due in part to various investment frictions and statistical biases.

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## Strong-form efficiency

- **Strong-form efficiency:** security prices reflect *all* information, whether publicly available or not.
  - Inside information does not provide excess returns.
- Most academics and practitioners believe that markets are not strong-form efficient.
- Academic studies document that insiders often obtain superior returns by trading on their information.
- Most developed countries have stringent insider trading rules. In the U.S., much of the legislation is in the U.S.'s Securities Exchange Act (1934).
  - Direct prohibitions on trading on private information.
  - “Chinese walls” dividing investment banking from sales, trading and research.

# Performance of insider trades

## Cumulative Abnormal Return (CAR) of Insider Trading

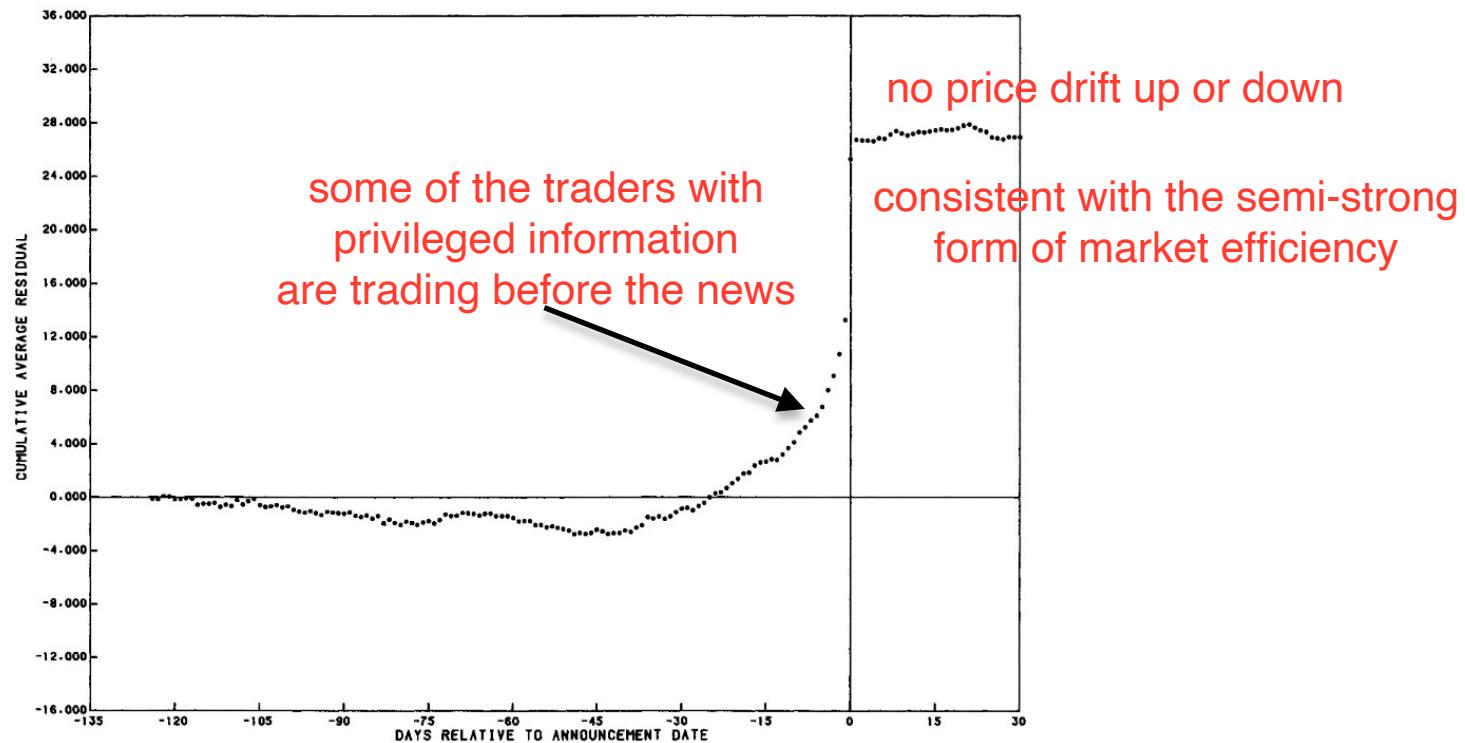
Type of inside information	N	Insider holding period (# of trading days)	CAR over holding period (%)
Takeover related	145	12.5 (1.4)	29.9 (1.5) <span style="color:red">high abnormal return by insiders</span>
Negative earnings	12	18.4 (7.6)	30.0 (4.7)
Positive earnings	3	21.3 (11.2)	3.3 (4.2)
Bankruptcy	10	26.4 (14.6)	73.9 (12.0)
Misc. good news	11	11.2 (7.7)	34.8 (6.9)
Misc. bad news	2	10.0 (7.0)	28.1 (2.5)
Total	183	13.7 (1.6)	32.2 (1.7)

L. Meulbroek, "An Empirical Analysis of Illegal Insider trading." *Journal of Finance* (December 1992).

Note: The insider holding period begins with the first insider purchase or sale, and ends when the insider information becomes public. Standard errors are in parentheses.

## Mergers and insider trading

### Cumulative Abnormal Returns (CAR) before and after Takeover Attempts: Target Companies



A. Keown and J. Pinkerton, "Merger Announcements and Insider Trading Activity." *Journal of Finance* (1981)

## Key concepts

- Market Efficiency
- The Challenger Crash
- Market Efficiency: A Testable Definition
- Weak Form of EMH
- Semi-Strong Form of EMH
- Event Studies: Firm Announcements
- Asset Management
- Strong Form of EMH
- Discussion

## Questions about EMH

Prices reflect information because various traders

act on the information that they have

one cannot achieve abnormal performance for free by looking at the easily available information

If prices reflect all available information, who has the incentive to collect costly information? after accounting for the costs of gathering information, there is no remaining room for abnormal performance as a result of intense competition between various traders.

Practical Issues about EMH -- misidentification and market imperfections:

- Missing risk factors;
- Time variation in risk loadings and risk premia;
- Transactions costs, liquidity, taxes, constraints; absence of arbitrage: investors pursue profitable trading opportunities, and they eliminate mispricing as a result. This argument works best at the micro level.
- Micro vs. macro efficiency...

The conclusion is that markets appear to be fairly efficient in a weak sense. It is difficult to achieve abnormal performance using historical information on prices. Markets also pretty close to being semi-strong form efficient. it is hard to achieve abnormal performance based on public information. But there is evidence that private, inside information could be used to achieve abnormal performance.

## Lessons from EMH

1. Trust market prices: buy and sell financial assets at the market prices achieve zero net present value. Market prices are fair. We neither make abnormal returns, nor do we lose money when we trade at market prices.

- Buying and selling assets are zero NPV activities.
- Market prices give best estimate of value for projects.
- Firms receive “fair” value for securities they issue.

2. Read into prices:

- If market price reflects all available information, we can extract information from prices.

EMH does not assume that markets are frictionless. EMH is a statement about profitability of trading strategies available to investors, and such strategies must account for all relevant frictions. Otherwise, apparent violations of the EMH may exist only on paper and not materialize in practice because of the effect of trading frictions on the profits from the strategy

## Lessons from EMH

### 3. There are no financial illusions:

- Market price reflects value only from an asset's payoff.
- It is not easy to trick the market.

We cannot simply add value by buying and selling financial securities.

### 4. Need an economic edge to generate a positive NPV:

- Superior information.
- Superior technology.
- Access to cheap resources ...

if you trade in the financial markets, every transaction is a fair transaction. It has zero net present value. In order to create the project which adds value, which has a positive net present value, we need to either have superior information, or superior technology, or access to cheap resources, some kind of competitive advantage or economic edge that translates into a positive net present value.

## Summary

- Market Efficiency
- The Challenger Crash
- Market Efficiency: A Testable Definition
- Weak Form of EMH
- Semi-Strong Form of EMH
- Event Studies: Firm Announcements
- Asset Management
- Strong Form of EMH