Market efficiency

how you cannot get rich and why

Nico van der Wijst

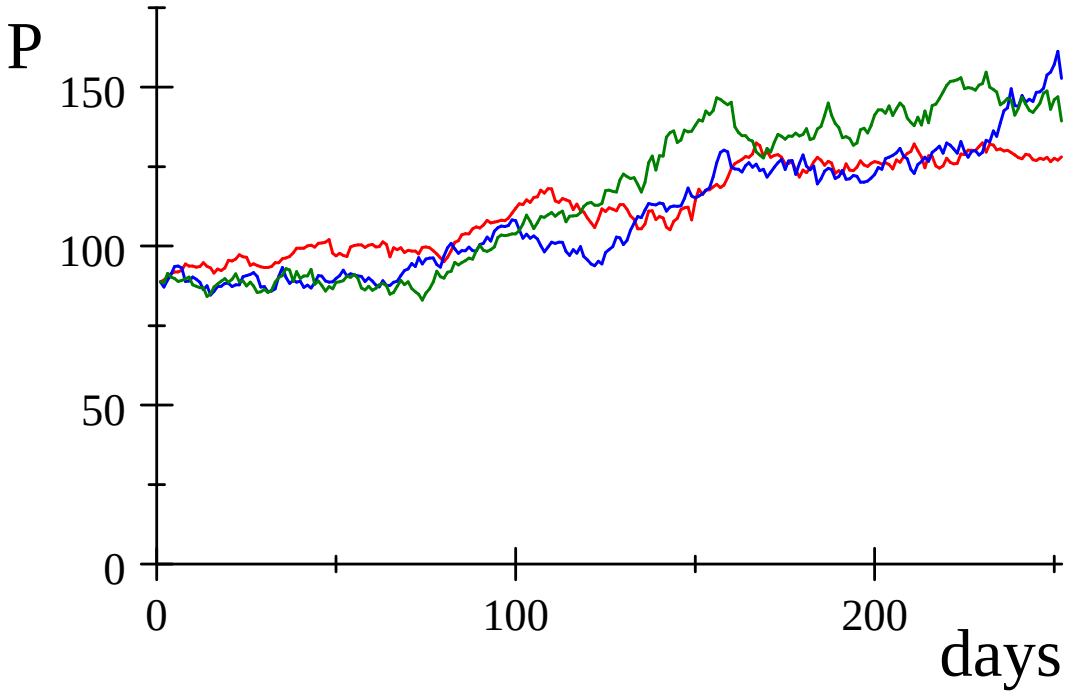
In the media, the stock market is often depicted as a casino:

- Investors are gamblers, betting on near future stock prices
- buying and selling without apparent economic reason
  - gives windfall profits to some
  - does damage to others (or the public)

Often illustrated (loudly!) by:

- comparing stock prices with random numbers
- financial economists' apparent inability to predict

Stock prices and random numbers:



Apple's adjusted daily closing prices in US dollars (P) from 25-06-2014 to 24-06-2015 (red) and two simulated price paths using Apple's starting price and a discrete approximation of a geometric Brownian motion with a drift and diffusion equal to Apple's return and risk (0.0015 and 0.0136)

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søk

MENINGER:
LESERBREV:
- Brynjulf Owren: Tidskrifter og papirforbruk
- Ivar A. Bjørgen: Retten til arbeid. Tanker omkring Brevik-saken
- Rigmor Austgulen: Morsmelk – over og ut?
- Soilikki Vettenranta: JULEGAVE MED BISMAK
- Odd W. Andersen:

- Aper like bra som finanseksperter (9.1.09, 12:29)

Det mener i alle fall NTNU-er Øyvind Eikrem, som har lite til overs for enkeltes økonomiske spåmenns og -kjerringers evner som sannsigere under finanskrisen.

En ape med penn og papir treffer gjerne like godt som medias finanseksperter:

- En del tar konsekvent feil, men når en mening gjentas mange nok ganger blir de etter hvert en sannhet.

Førsteamanuensis Øyvind Eikrem ved Psykologisk institutt har forsket på hvordan "magisk og mytisk tenking" preger finansmiljøer her i landet.

Finance holds a very different view:

- Randomly changing prices are hallmark of properly functioning markets
- On such markets:
  - investors use all available information to determine prices (what can be known and what can be predicted)
  - price discovery process aggregates all that information
  - hence, prices only react to new information
  - but new information is random (unpredictable) both in timing and nature (good or bad news)
- Hence, *prices have to change randomly* if markets function properly

Definition

A market in which prices always "fully reflect" available information is called "efficient"

- Definition by Fama (1970), still widely used
- refers to informational efficiency, i.e.
  - *speed* and *precision* of price reactions to new information
- also called Efficient Market Hypothesis (EMH)
- more general than mean-variance efficiency

Market efficiency is a deceptively simple concept, but its consequences are far reaching and hard to accept

If all available information is already included in prices, then that information cannot be used to:

- make predictive financial analyses (technical analysis or 'charting' but also advanced econometric analyses)
- develop investment strategies that earn more than fair, risk adjusted return
- make profitable management decisions in corporate finance regarding:
  - timing of new issues ('bad climate to issue stock')
  - maturity of debt issues (long-short)
  - type of securities to be issued (preferred or convertible stock or bonds)

Illustrate marked efficiency with investment project from chapter 2
Recall project details from calculation economic depreciation:

- Cyclical sales of 125, 250 and 125
- working capital built up in beginning, liquidated at the end
- cash flows fluctuate strongly
- still: expected return constant

Take argument 1 step further:

- calculate project value, not return
- assume project has constant scale
  $\Rightarrow$ cash flows can be re-invested at OCoC (25%)

Economic depreciation and return

	year	0	1	2	3
1	Cash inflows from project		72.5	134	121
2	PV cash inflows, year end	205.7	184.6	96.8	0
3	PV cash inflows, year begin	0	205.7	184.6	96.8
4	Economic depreciation (2-3)	-	-21.1	-87.8	-96.8
5	Profit from project (1+4)	-	51.4	46.2	24.2
6	Return on investment (5/3)		.25	.25	.25

At the end of year 1:

Remaining project value	184.6
cash flow	72.5
sum	257.1

$$\text{FV(PV(project))} = 205.7 \times 1.25 = \quad 257.1$$

At the end of year 2:

Remaining project value	96.8
cash flow	134.0
re-invested year 1 cash flow 72.5×1.25	90.6
sum	321.4

FV(PV(project))$=205.7 \times 1.25^2 =$ 321.4

At the end of year 3:

Remaining project value	0.0
cash flow	121.0
re-invested year 1 cash flow $72.5 \times 1.25^2 =$	113.2
re-invested year 2 cash flow $134 \times 1.25 =$	167.5
sum	401.7

FV(PV(project))$=205.7 \times 1.25^3 =$	401.7

We see that for each year:
price now = properly discounted expected price later

$$P_0 = \frac{E[P_t]}{(1+r)^t}$$

also for volatile projects

The drastic changes in:

- project sales
- working capital requirements
- project cash flows

are all anticipated and properly accounted for

What makes project value and return fluctuate randomly?

The information *not* included in calculations

- because it was unknown
  and could not be predicted

Sales, costs, interest and exchange rates can all become higher or lower than expected today

- if changes are truly new information
  they are unpredictable by definition

Succinctly formulated in title of classic paper by Samuelson:

'Proof that properly anticipated prices fluctuate randomly'

As defined, EMH too general to be testable
made precise by Fama (1970) who:

- defines what 'fully reflect' means
- specifies what available information set contains

'Fully reflect' defined with excess returns

- difference between realized and expected return given information set:

$$\varepsilon_{i,t+1} = r_{i,t+1} - E\left[r_{i,t+1} \middle| \Phi_t\right]$$

ε = excess return
r = return
Φ = information set
i, t = index for asset, time

'Fully reflect' defined (modelled) in three ways:

1. Fair game model

in a fair game all players are equally likely to win

- outcomes occur according to probability theory
  - fair coin: each side 50% probability
  - fair die: each side 1/6 probability
- deviations from expected values = zero in the long run
  all players expected to break even

Applied to market efficiency: excess returns have expectation zero

$$E[\varepsilon_{i,t+1} | \Phi_t] = 0$$

- Φ_t cannot be used to systematically earn excess returns

2. Martingale model

Consider ZXco's project again:

- what happens if coming year's costs become lower (price cut)?
  - bookkeeping profit $t+1$ will be higher
- project's market value jumps up immediately
  - cost saving immediately included
  - extra return reflected in P_t, not P_{t+1}
- what will next year's value be?
  - today's value $\times$ (1 + OCoC)

In terms of the formal model, excess returns are:

$$\begin{aligned} \varepsilon_t &> 0 \\ E(\varepsilon_{t+1}|\,\Phi_t) &= 0 \end{aligned}$$

and next period's price is:

$$\begin{aligned} E[P_{i,t+1}|\,\Phi_t] &= P_{i,t}(1+E[r_{i,t+1}|\,\Phi_t]) \quad \text{or:} \\ E[P_{i,t+1}|\,\Phi_t]/(1+E[r_{i,t+1}|\,\Phi_t]) &= P_{i,t} \end{aligned}$$

Same as before:

$$\frac{E[P_t]}{(1+r)^t} = P_0$$

We see again that:
properly discounted expected future value = present value

- dynamic process with that property is called *martingale*
- usually defined with observation history:

  X is a martingale if $E(X_{t+1} \mid X_0, ...X_t) = X_t$.
  X is a submartingale if $E(X_{t+1} \mid X_0, ...X_t) > X_t$
  X is a supermartingale if $E(X_{t+1} \mid X_0, ...X_t) < X_t$.

(patterns in) observation history $X_0, ...X_t$ no extra info beyond X_t

Applied to market efficiency:
no info in Φ_t improves forecast of $E[P_{i,t+1} | \Phi_t]$ beyond $P_{i,t}$

3. Random walk model

Fair game and martingale model only consider expectation
Random walk model uses whole distribution:

- excess returns follow random walk if
  they are independently and identically distributed (iid)

Random walks have *Markov property* of memorylessness

Applied to market efficiency:

- expected returns constant (called *drift*)
- excess returns
  - zero expectation
  - iid in all future periods

Term 'random walk' often used when fair game or martingale model are meant

Fama specifies contents of available information set in 3 categories:

- weak form market efficiency:
  all past price histories are fully reflected in current prices
- semi-strong form of market efficiency:
  prices fully reflect all publicly available information
- strong form efficiency:
  all information reflected in current prices, incl. private and inside information.

Categories overlap, strong form efficiency implies semi-strong form which implies weak form efficiency.

Empirical implications

If markets are efficient:

- returns cannot be systematically increased without systematically increasing risk

Means: cannot systematically earn positive excess returns

Popularly summarized:
markets offer no free lunch

Does *not* say that

- people cannot get lucky
- people cannot repeatedly get lucky

Luck determined by probability laws, not by investment skills

Market efficiency has 4 clear empirical implications:

1. No autocorrelation in (excess-)returns

Autocorrelation is correlation with itself 1 or more periods ago:

$$corr.(r_t, r_{t-x}) \quad x = 1, 2, ...$$

EMH implies return 1,2,.. periods ago says nothing about return this period

- all predictable cyclical movements in costs, sales etc. are already included in prices
- cannot be used to predict excess returns
- what remains are responses to (random) new information

2. Investment strategies give no positive excess returns

Many investment strategies based on return predictability:

- idea that future returns can be predicted from the past
- assumes regularity or recognizable patterns in prices and returns
- some strategies predict that price movements will persist (have "momentum")
- others that they will reverse (contrarian)
- still others base predictions on patterns in prices plotted in graphs (chartists)

If markets are efficient, all these strategies fail to consistently produce positive excess returns.

3. Investment funds and (groups of) investors do not systematically differ in excess returns

Large fraction of investments made collectively

- in mutual funds or pension funds, etc.
- funds have different strategies:
  - hedge funds can take large risks to earn high returns
  - pension funds should be more conservative

If markets are efficient:

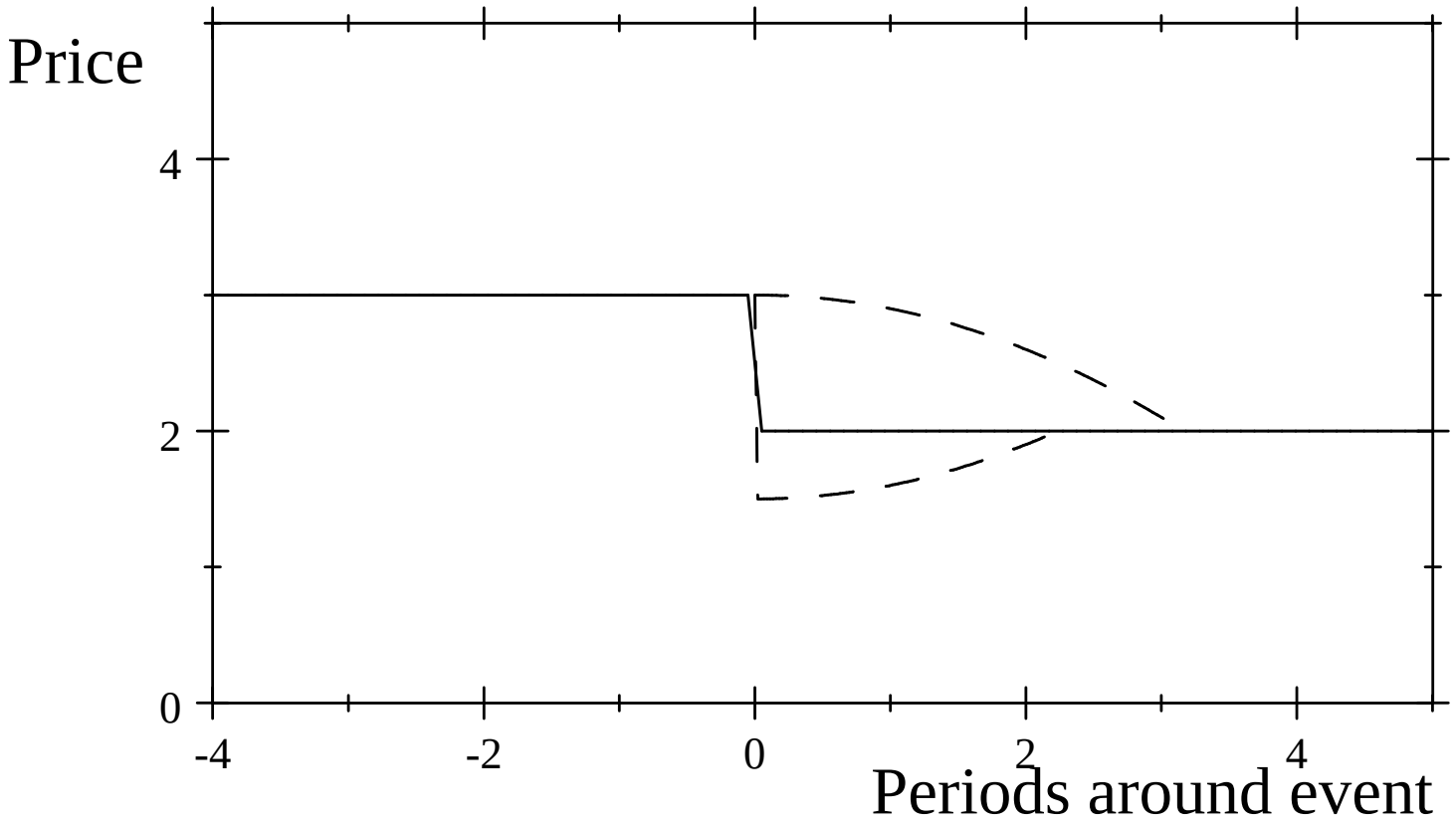
- no fund can systematically earn positive excess returns
- differences in risk adjusted performance are random
- hence: differences are not persistent

4. Prices adjust to new information in an efficient way

Efficient means: quickly and unbiassed
no predictable pattern after news becomes known:

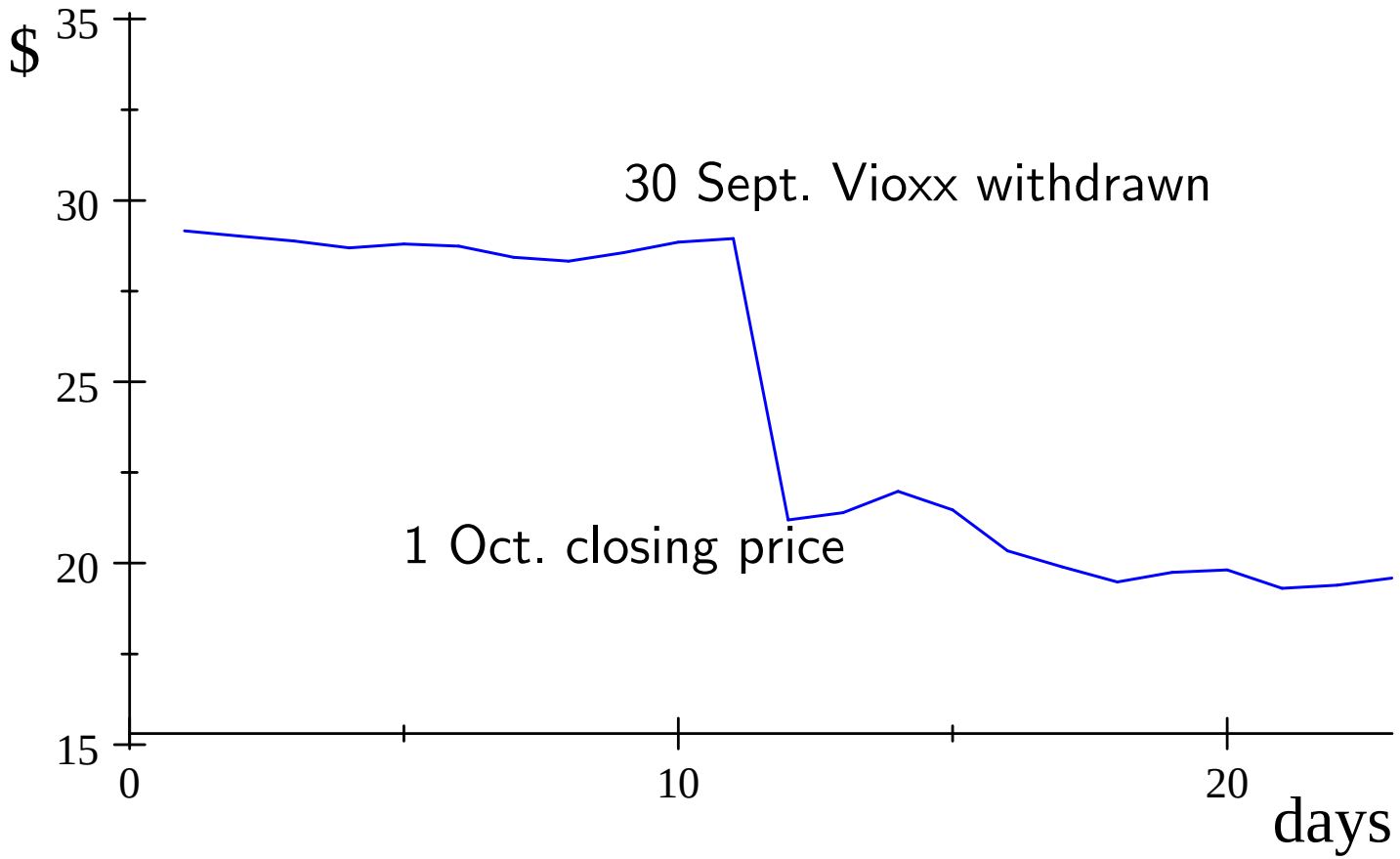
- no *underreaction*:
  news slowly incorporated over several periods
- no *overreaction*:
  first reaction too strong, corrected in later periods

Systematic under- or overreaction would give profitable investment opportunities



Efficient (solid) and inefficient (dashed) price adjustments

Example of an efficient reaction:



Adjusted closing prices Merck from 15 Sept. 2004 to 15 Oct. 2004

Value of foresight

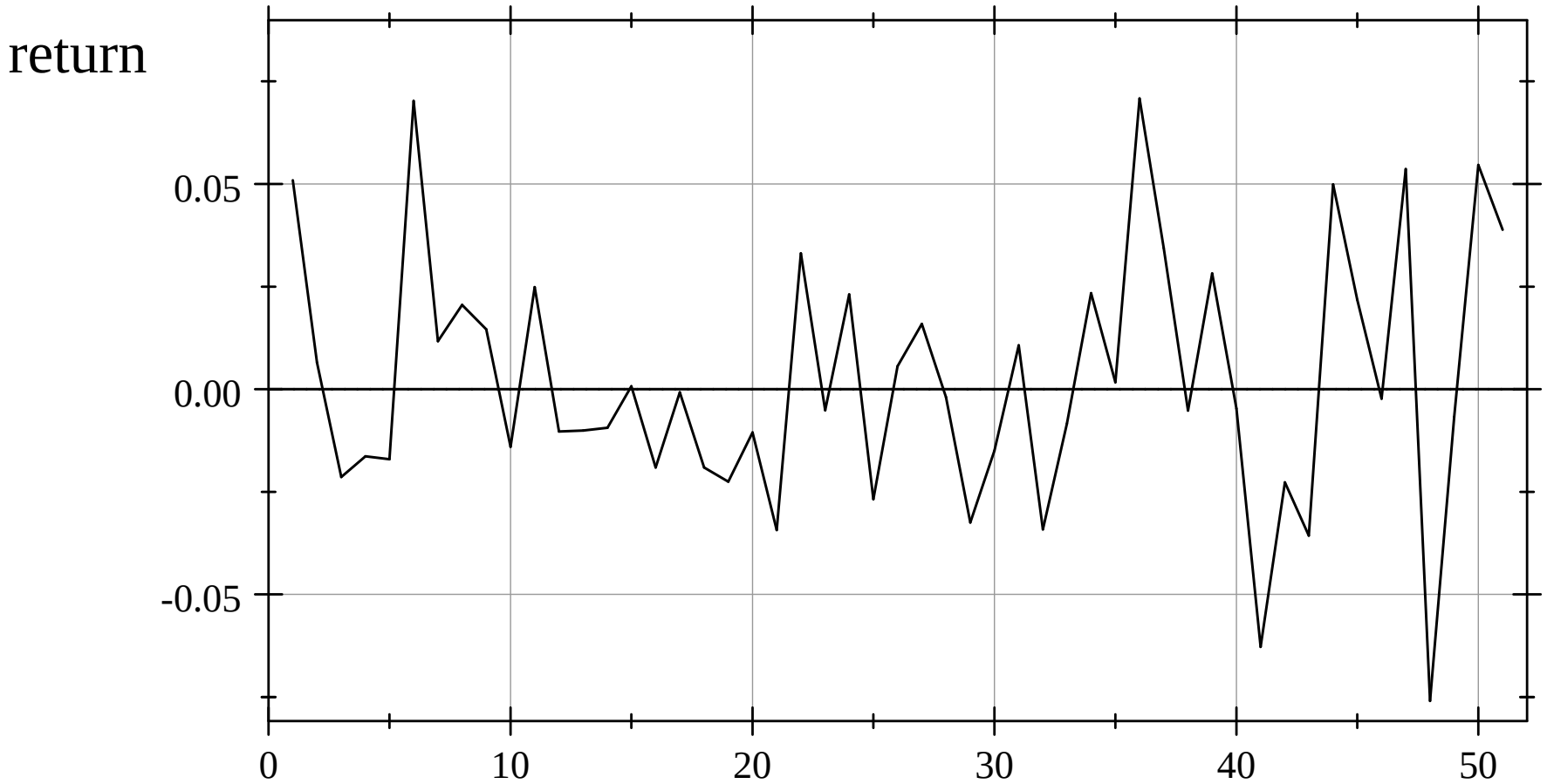
Market efficiency usually received with disbelief

- many believe 'experts' can predict stock returns
  just too greedy to tell other people

Illustrate value of foresight with simple example

- weekly returns Microsoft 29-10-2010 to 14-10-2011
- arithmetic average return 0.2358% per week
- compound return 1.002358^{52}=1.1276 or 12.8% per year

These are good, but ordinary returns on ordinary stock in ordinary period



Weekly returns Microsoft, 29 October 2010 to 14 October 2011

Now suppose we have foresight:

- can predict accurately whether next week's return is positive or negative, no more
- also suppose foresight can only be used to avoid weeks with negative return:
  - if we own stock, sell it just before a loss week
  - money kept in account with no interest
  - if we don't own stock, buy it just before a profit week
  - means we have to sell and buy around 10 times

What would the return be with such foresight?

1.3049% per week or 1.013049^{52}=1.9371 or 93.7% per year

Value of foresight is enormous

- would send your wealth through the roof in no time
- even predictions $<100\%$ accurate can still be very profitable
- that is why financial markets are researched and analysed on a very large scale

Obvious consequence:

- excess returns will be hard to find
- and there is an entire industry looking for them...

Empirical tests

use a less strict version of EMH:
'information set cannot be used to make excess returns, *adjusted for risk and net of all costs'*

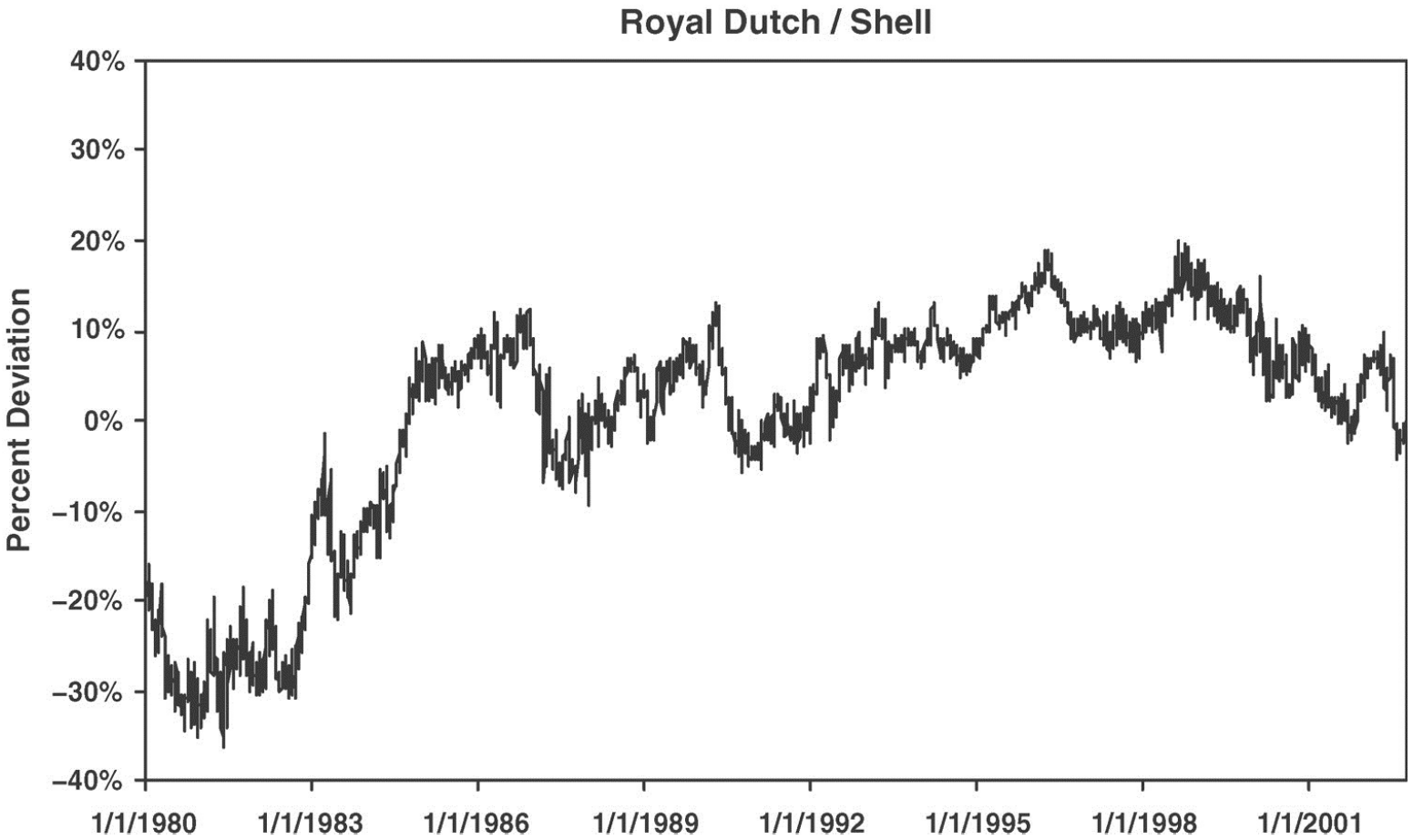
Market efficiency in strictest sense is impossible

- requires zero trading- and information costs
- i.e. costs that are necessary to make prices reflect all information

Costs allow for a margin

- excess returns can be statistically significant
- but profiting from them can be quite expensive (Shell example)

Deviations from parity RDS Amsterdam and Shell London



Source: Review of Finance, July 2009, v. 13, iss. 3, pp. 495-520

Caveat 1: empirical tests incomplete

- look at the relation between limited number of variables
- other variables can play a role or interfere
- test is not the final answer

Caveat 2: statistical tests have to be placed in efficiency context

- Suppose you find many significant autocorr. coeff. but:
  - about as many positive as negative ones
  - cannot predict when + or - will occur
    neither for which stocks nor for which periods
- then returns are still unpredictable

The combination of inefficiencies can be efficiency

1. Autocorrelation in (excess-)returns

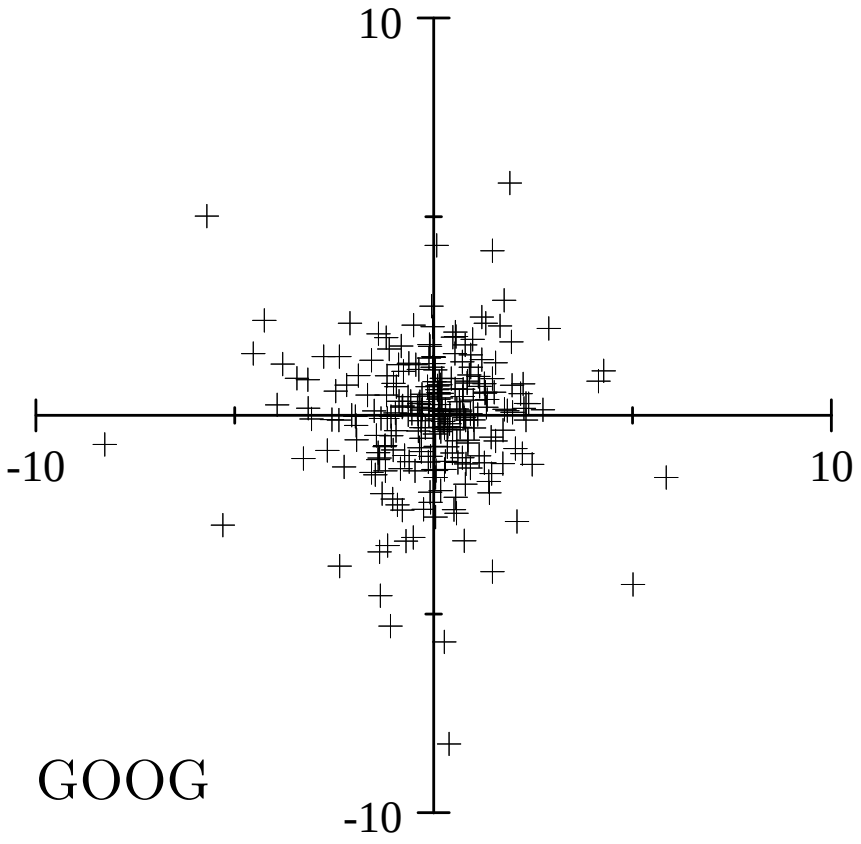
Over short periods of time:

- expected return close to zero: $E[r_{i,t+1}|\Phi_t] \approx 0$
  - if $E[r_{i,t+1}|\Phi_t] = 20\%$ per year
    and year has 250 trading days
  - $E[r_{i,t+1}|\Phi_t] \approx 20/250 \approx 0.08\%$ per day
- means we can use returns $r_{i,t+1}$ instead of excess returns $\varepsilon_{i,t+1}$:
  - definition: $\varepsilon_{i,t+1} = r_{i,t+1} - E[r_{i,t+1}|\Phi_t]$
  - if $E[r_{i,t+1}|\Phi_t] \approx 0$, then $\varepsilon_{i,t+1} \approx r_{i,t+1}$

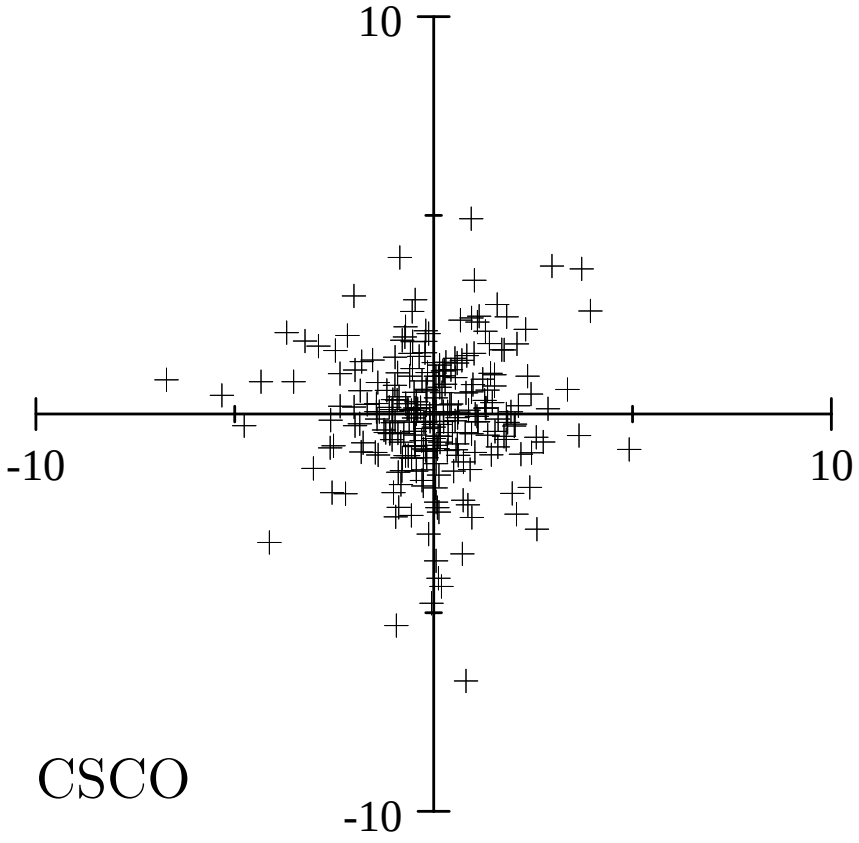
Procedure to visualize autocorrelation:
plot this period's returns against next period's

- with positive autocorrelation
  - positive returns tend to be followed by positive returns
  - negative returns tend to be followed by negative returns
  - observations in upper right and lower left quadrant
- with negative autocorrelation
  - positive returns followed by negative returns
  - negative returns followed by positive returns
  - observations in upper left and lower right quadrant

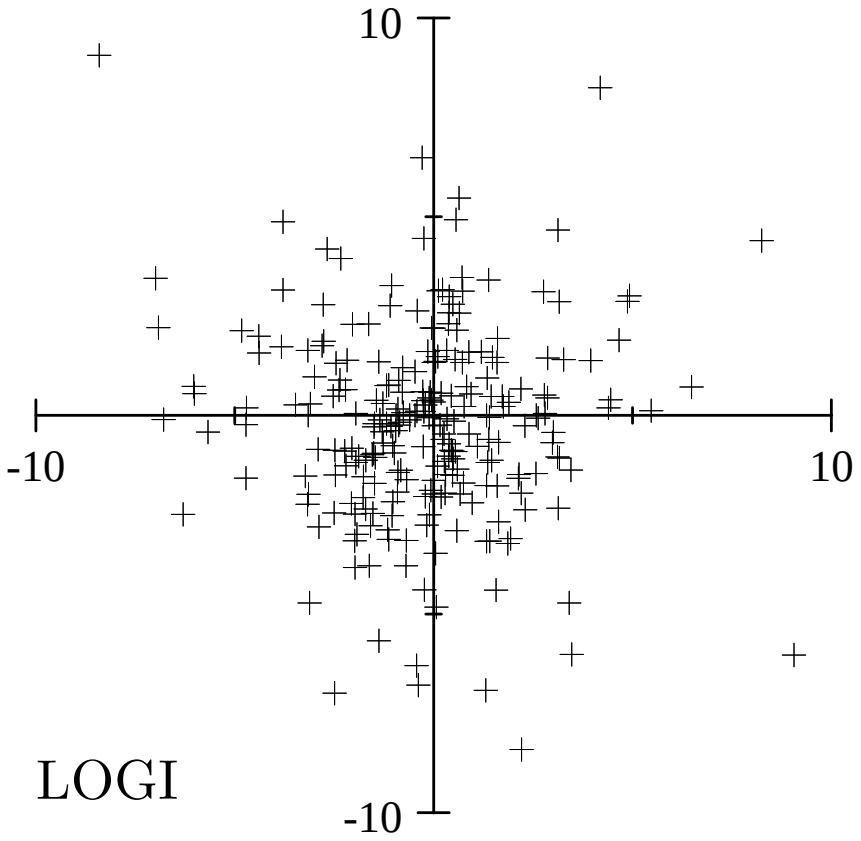
Make such plots for a few stocks + indices



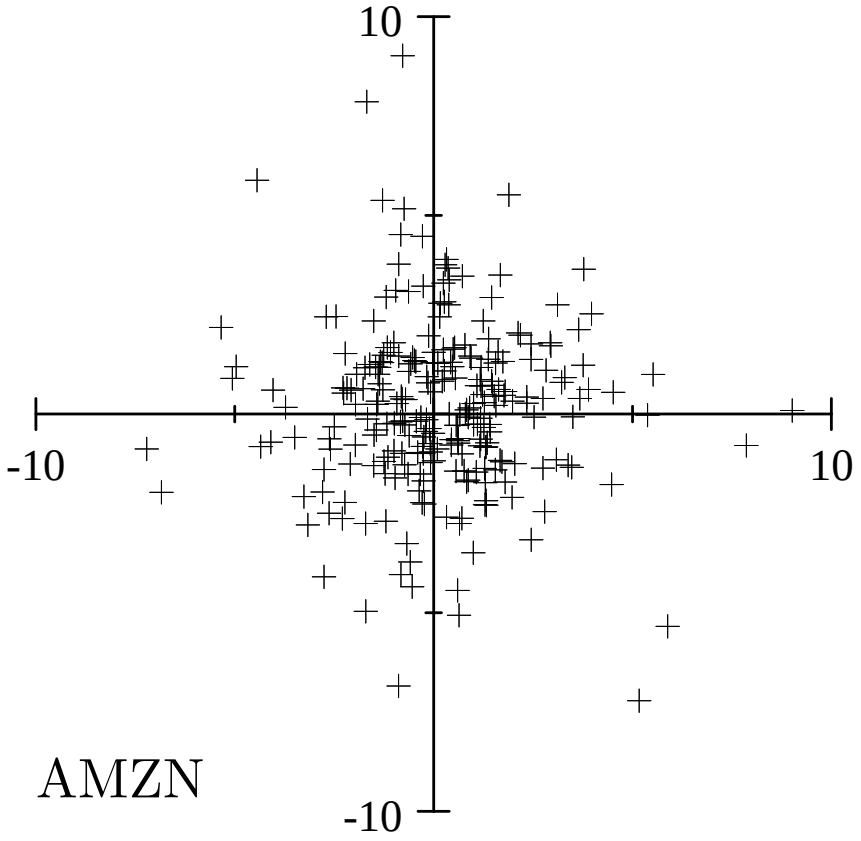
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Google



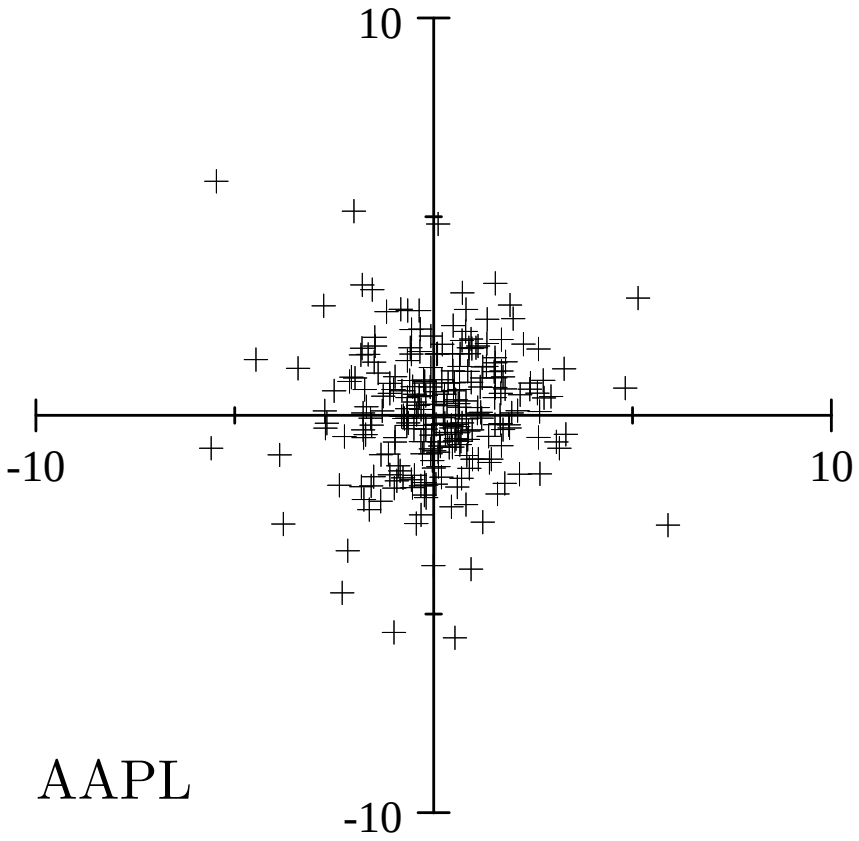
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Cisco



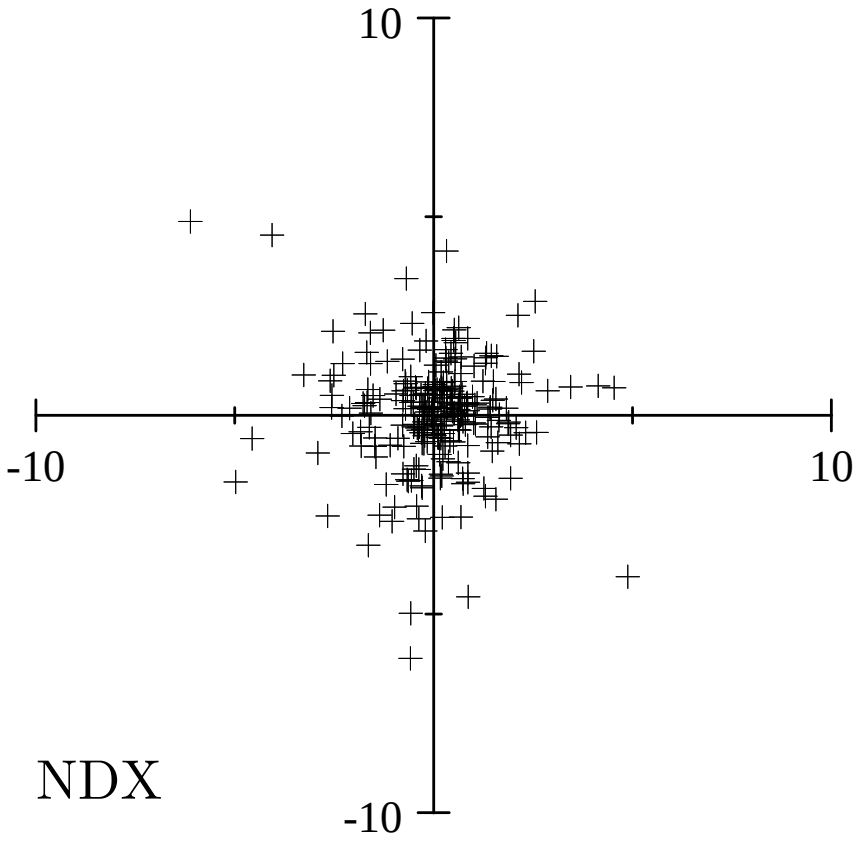
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, LogiTech



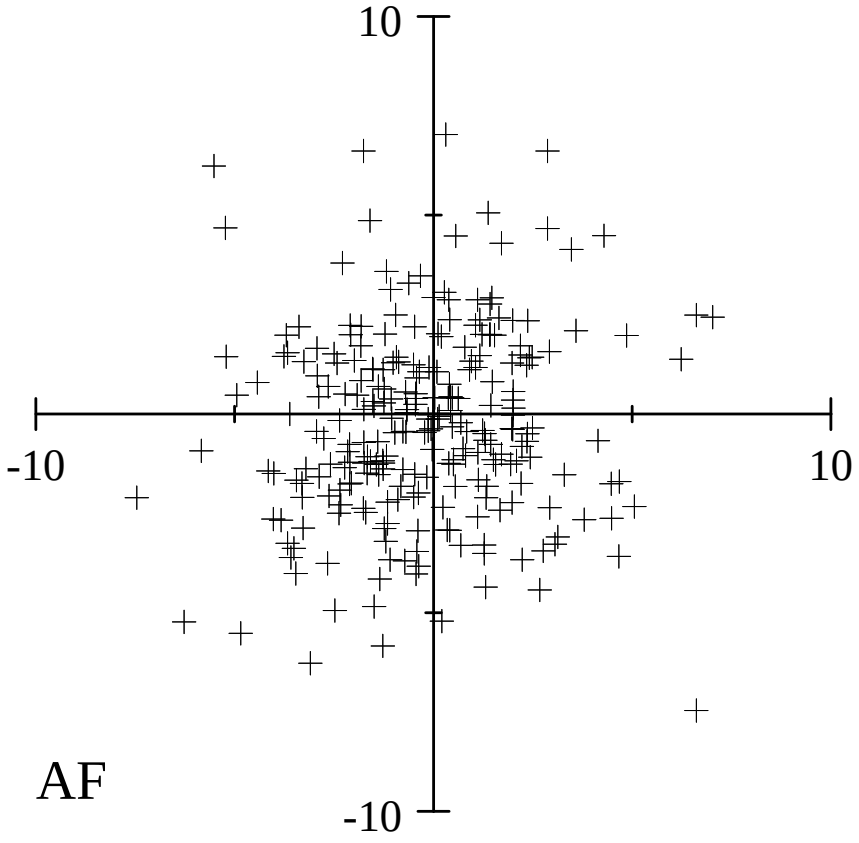
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Amazon



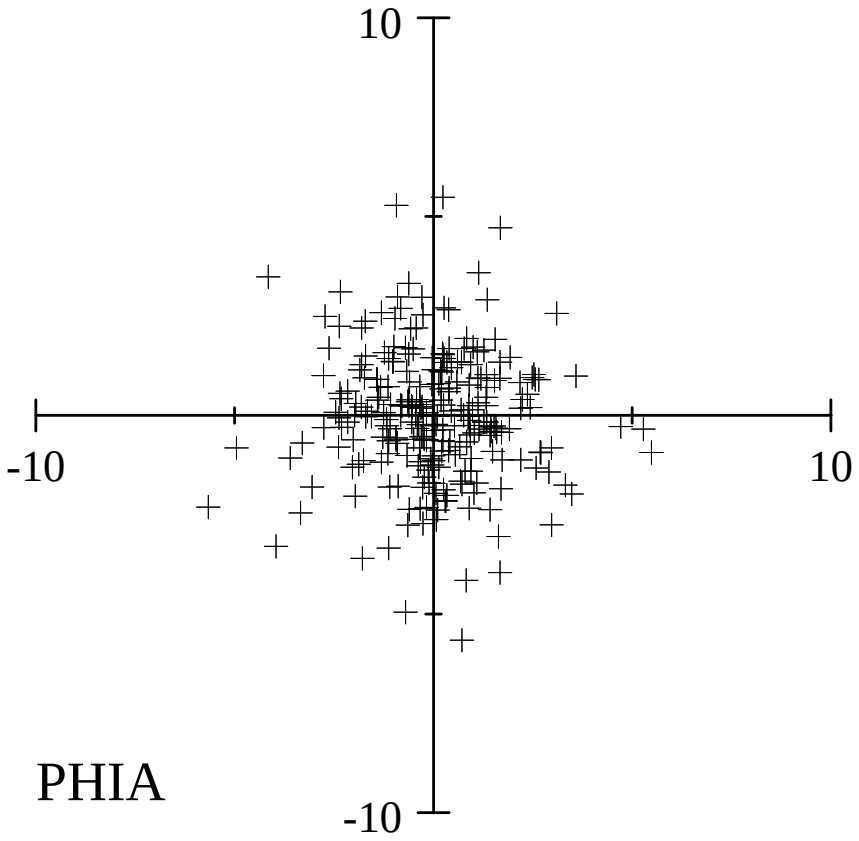
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Apple



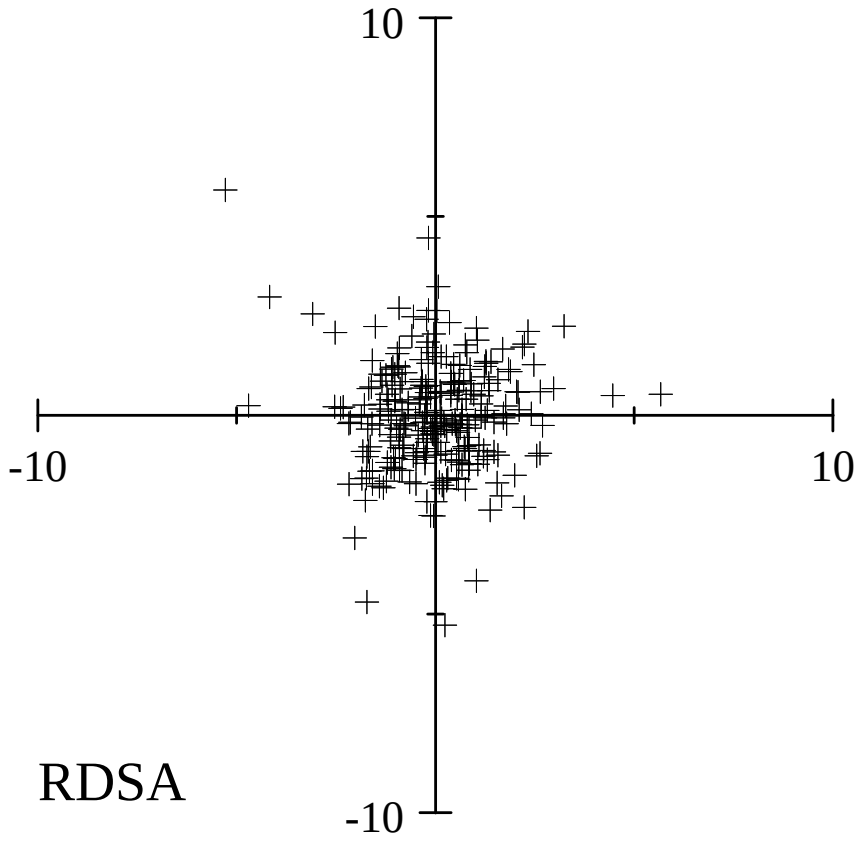
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Nasdaq-100 index



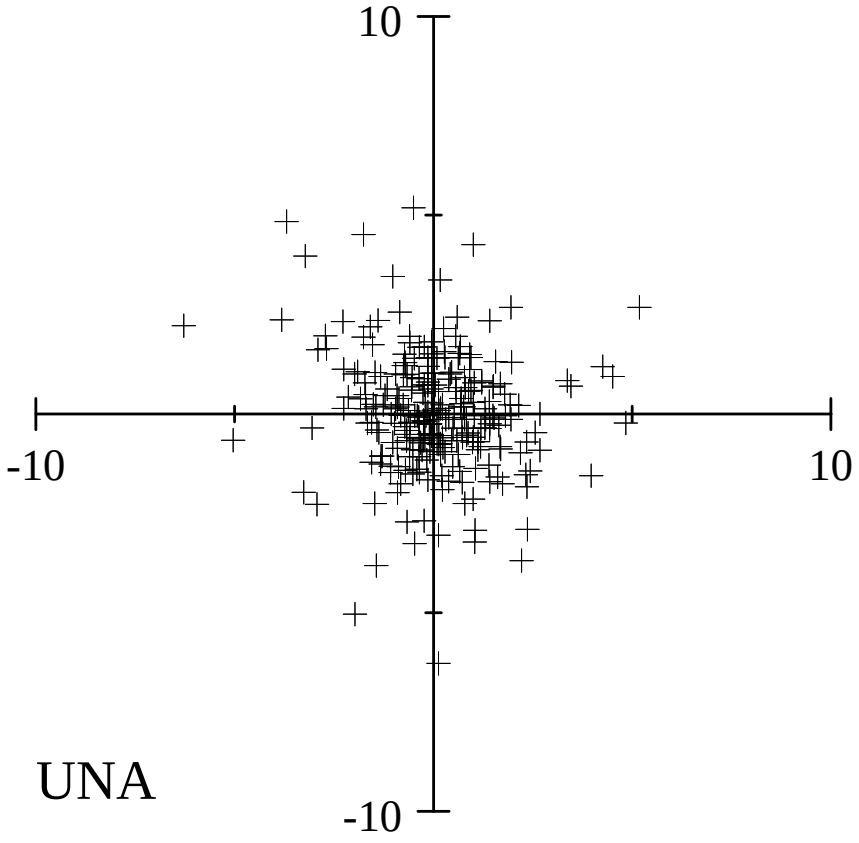
Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, Air France-KLM



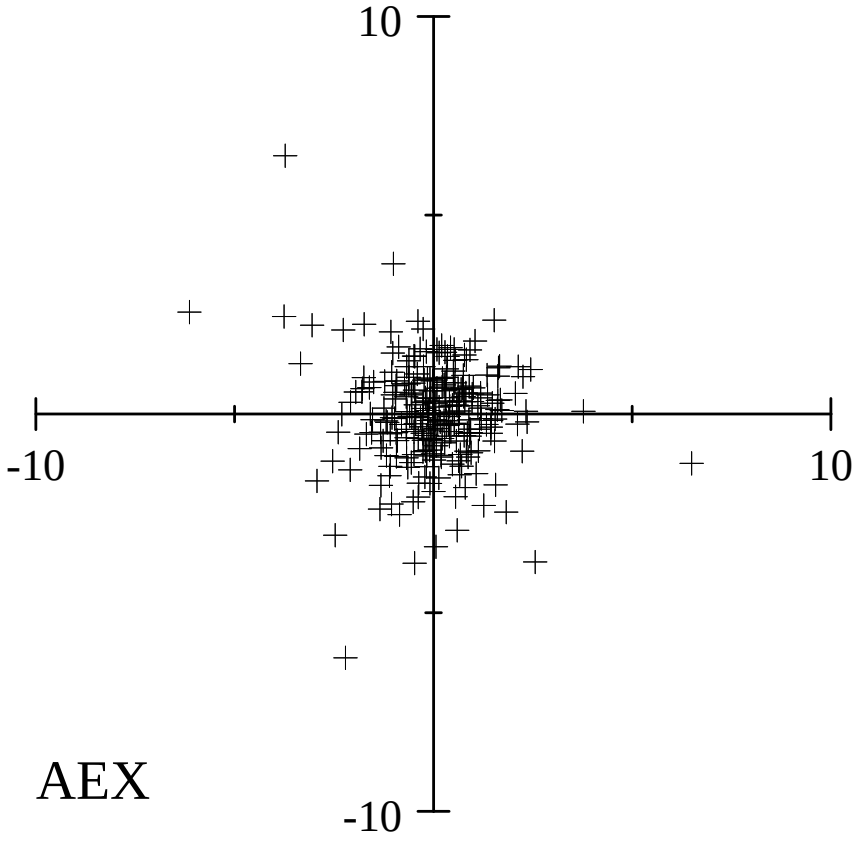
Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, Philips



Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, Royal Dutch Shell



Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, Unilever



Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, AEX index

Conclusion: no visible autocorrelation

- similar plots made by the hundreds
  using long time series, variety of stocks, indices
- same conclusion: no visible autocorrelation

Autocorrelation can also be tested statistically

- calculate correlation coefficient r_t, r_{t+1}
- allows for statistical test of significance

Results for our example stocks:

Stock	ticker	$\rho_{r_t,r_{t-1}}$
Google	GOOG	-0.038
Cisco Systems	CSCO	0.019
Logitech International	LOGI	-0.032
Amazon.com	AMZN	-0.028
Apple	AAPL	0.026
NDX index	NDX	-0.056

- No significant coefficients
- Explained variance (measured as ρ^2) $< 0.5\%$

Alternative test procedure uses regression analysis:

- explains returns this period
  with returns 1,2,3,... periods ago:

$$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-2} + \gamma_3 r_{t-3} + \gamma_4 r_{t-4} + \gamma_5 r_{t-5} + u_t$$

- allows standard t-test for regression coefficients
- significant t-values reject EMH

Results for our example stocks:

Stock	γ_0 constant	γ_1 r_{t-1}	γ_2 r_{t-2}	γ_3 r_{t-3}	γ_4 r_{t-4}	γ_5 r_{t-5}
Google	-0.062	-0.018	0.082	-0.091	0.071	-0.089
Cisco Systems	-0.145	0.026	0.009	-0.074	-0.015	-0.20*
Logitech Int.	-0.290	-0.001	0.096	-0.090	0.011	0.032
Amazon.com	0.167	-0.013	0.064	-0.055	0.022	-0.075
Apple	0.101	0.032	0.100	-0.119	0.039	-0.100
NDX index	0.035	0.016	0.075	-0.20*	0.082	-0.118

*significantly $\neq 0$ (5% level, 2-tailed test)

- 2 significant coefficients reject EMH
- probably not persistent, too small to exploit

Another alternative test procedure is 'runs test'

- uses order in which positive and negative returns appear

Suppose you flip a fair coin 20 times

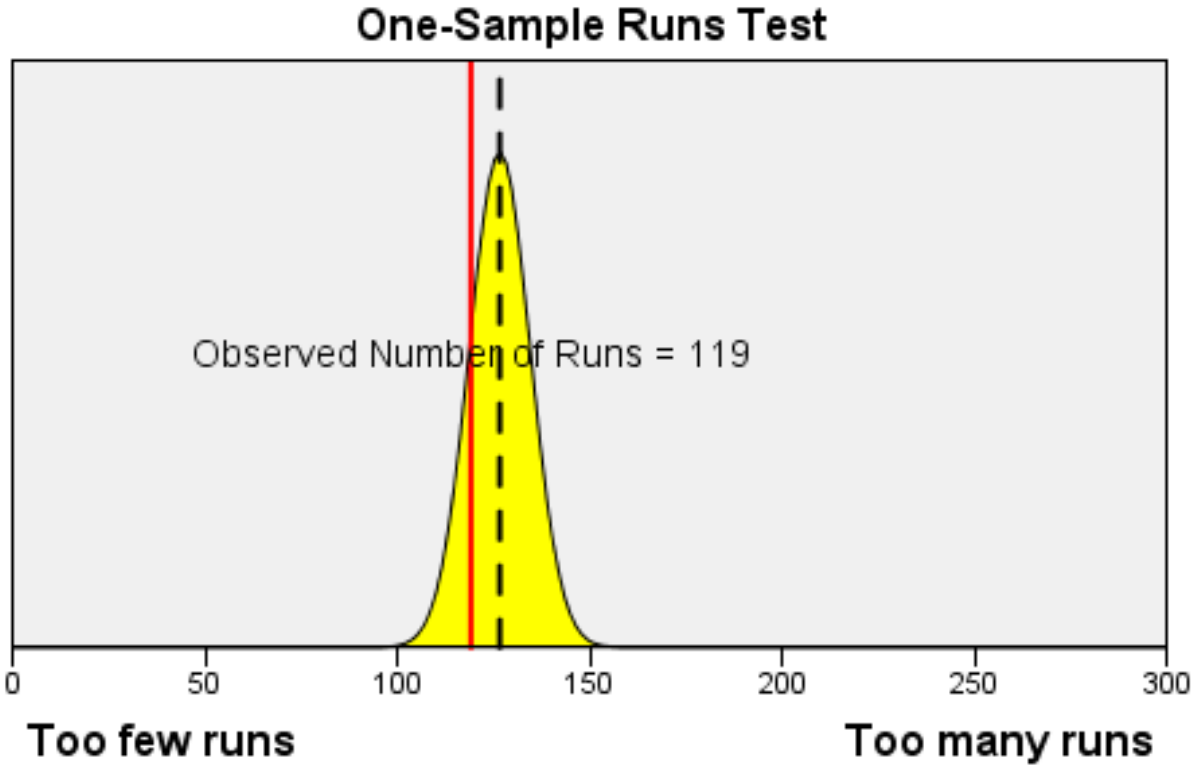
- highly unlikely that you get:
  - HHHHHHHHHHTTTTTTTTTT
  - HTHTHTHTHTHTHTHTHTHT
- series of same outcomes is 'run'
  - first series has 2 runs, too few to be random
  - second series has 20 runs, too many to be random
- statistical properties of runs are known, can be used to test for randomness

Runs test results for our example stocks:

Stock	runs	Z	P(Z)
Google	118	-1.136	0.256
Cisco Systems	127	0.001	0.999
Logitech Int.	120	-0.884	0.377
Amazon.com	122	-0.631	0.528
Apple	121	-0.757	0.449
NDX index	120	-0.884	0.377

- tests use series of 252 returns
- no significant deviation from randomness

Tests in literature come to same conclusion



Example of a runs test (Apple)

Summarizing:

- correlation coefficients very low
- some are significant, but:
  in approximately equal proportions positive and negative
- past returns typically explain only a very small proportion of the variance in today's returns
- runs tests do not reject randomness

Conclusion: autocorrelation tests do not reject EMH

2. Investment strategies

Because foresight has enormous value, all sorts of predictive devices have been tried:

- Moonreading:
  prices go up and down with phases of the moon
- Astrology:
  prices depend on alignment of planets
- Chartreading:
  try to see patterns in sequence of random changes

We will have a look at some of the more serious strategies

Filter rules

- Assume small prices changes have no information value
- but when prices change with more than x%
  - important new information has arrived
  - prices must 'find a new level'
- strategy is:
  - buy when prices go up $>$x%
  - sell and short when prices go down $>$x%
- timing strategy based on underreaction

Filter rules have been tested extensively, repeatedly

- different markets, stocks, periods, filter sizes (x)
- with and without trading volume as additional variable

General result:

- few profitable strategies found
- to the extent that they are:
  - unclear whether they persist (also found next period)
  - usually profit $<$ transaction cost

Conclusion: filter rules do not reject EMH

Momentum and contrarian strategies

Momentum strategies based on underreaction:

- once prices move up or down
  they continue to move up or down (have 'momentum')
- strategy: buy past winners, sell past losers

Contrarian strategies based on overreaction:

- price developments overshoot
  corrected in later periods
- strategy: buy past losers, sell past winners

Both strategies implemented in similar way:

- observe returns over 'sorting' period of e.g. 3 years
- sort stocks according to returns
- make portfolios of winners and losers
  e.g. best and worst decile or quartile
  - momentum buys winners, sells losers
  - contrarian buys losers, sells winners
- repeat 1 year later, etc. (rolling window)
- compare portfolio performance with buying and holding the index

Obvious problem:
strategies cannot possibly both be profitable

Most frequently mentioned reason for their coexistence:

- effect determined by time scale considered
  - contrarian profitable for (very) long periods
  - momentum works on shorter time scales

Empirical evidence is mixed:

- over short periods (weeks, months) both contrarian and momentum effects founds

	Contrarian	Momentum
de Bondt and Thaler (1985, 1987)	3-5 years	
Lo and MacKinlay (1988)		weekly
Zarowin (1990)	3 years	
Lehmann (1990)	weekly	
Jegadeesh (1990)	monthly	12 months
Chopra et al. (1992)	5 years	
Jegadeesh and Titman (1993)		3-12 months
Rouwenhorst (1998)		3-12 months
Chan et al. (2000)		1-26 weeks
Lee and Swaminathan (2000)	2-5 years*	3-12 months*
Connolly and Stivers (2003)	weekly*	weekly*

*=effect depends on trade volume

Methodological problem: omitted variable bias

- implementation procedure does not control for other variables
- momentum, contrarian effect can be caused by omitted variable(s)

Example: size

- tests of CAPM show small firms have higher returns
- if losers are smaller, they will outperform winners
- is sample selection effect, not contrarian
- found to be the case in some studies

Literature reports other omitted (intervening) variables as well:

- changes in risk
  - causes changes in expected return
  - excess return may be constant (zero)
  - found to explain most of contrarian effect in some studies
- rules and mechanisms of stock trading (market micro structure)
  - bid-ask bounce gives illusion of price reversal (no contrarian)
  - infrequently traded stocks have high transaction costs (underestimates costs of momentum strategies)
  - e.g. 10 August 2009, bid-ask according to Finansavisen
    NHY: 37.45 - 37.49
    AF Gruppen: 100.50 - 115.00

What is the verdict on momentum and contrarian strategies?

- overreaction about as common as underreaction
- continuation of returns about as frequent as reversal
- is in line with random nature of stock prices changes

Hence: we cannot confidently predict whether next period will show contrarian or momentum returns

- Even if we find excess returns, could be fair risk premium for some omitted effect (size, varying risk)
- main protagonist of contrarian strategies, Richard Thaler, invested most of his retirement assets in index funds

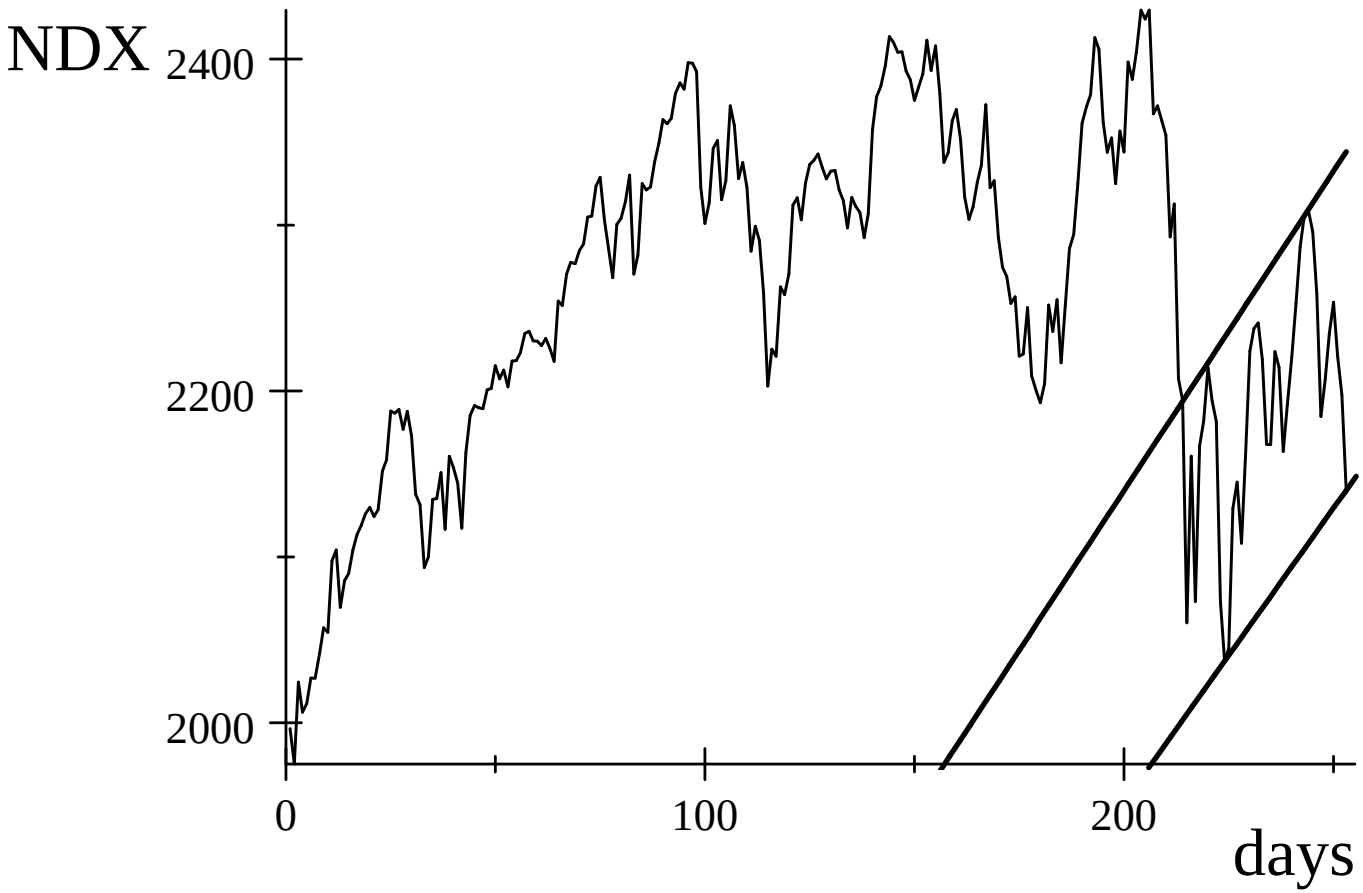
Conclusion:
Contradictory evidence makes it difficult to reject market efficiency the many reported momentum and/or contrarian effects, remain puzzling

Technical analysis (charting)

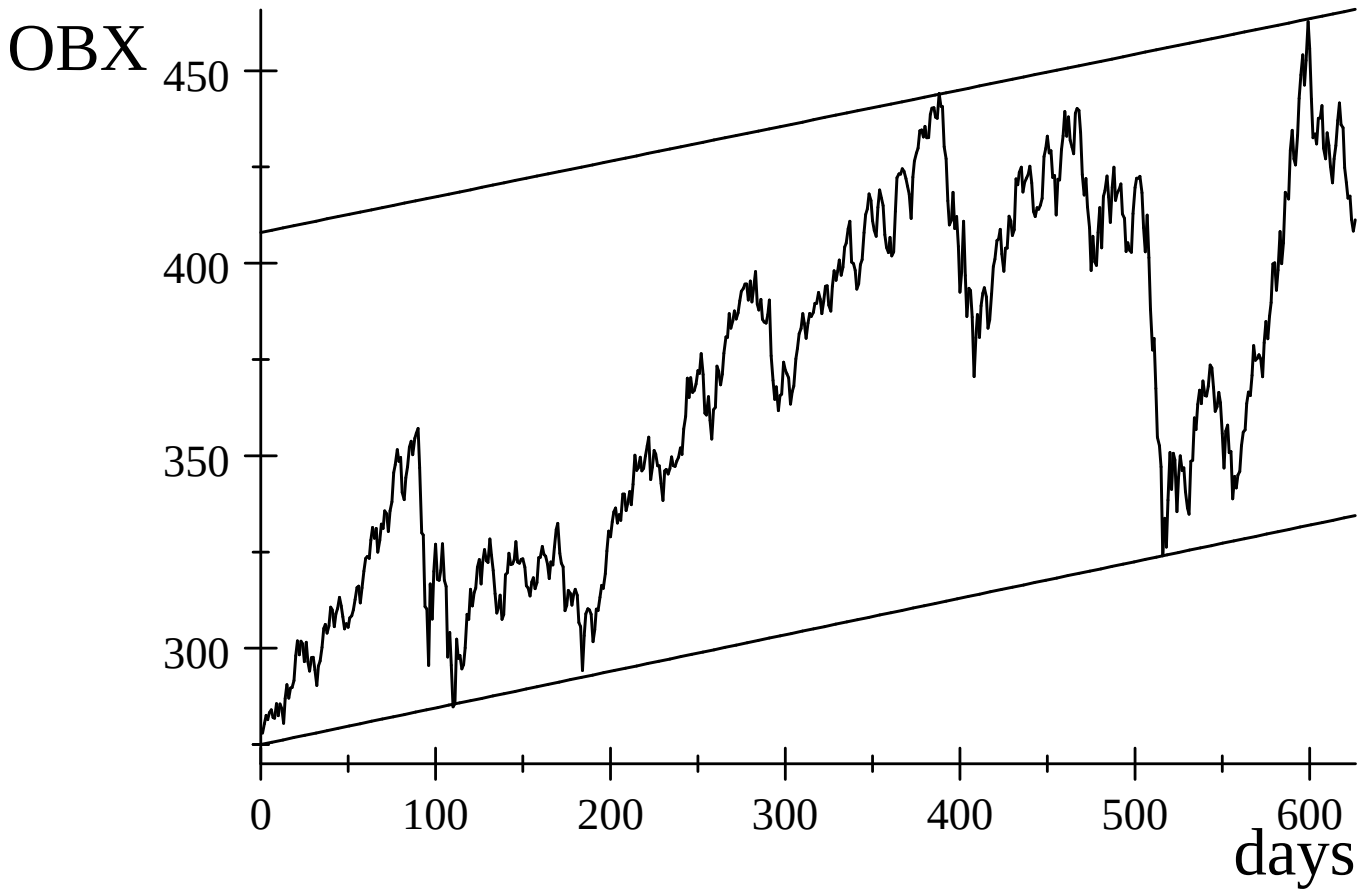
- Based on perceived regularities (pattern recognition) in price plots
- at best: based on incomplete logic

Example: support and resistance levels

- suppose price increased more than once to some level, say €75
- investors conclude: unlikely to rise above €75
- everyone willing to sell will do so when price is again €75
- makes €75 'resistance level'
- similar effect on downside: 'support level'
- levels can depend on time: lines in plot



Nasdaq-100 index, daily closing prices from 1 Oct. 2010 to 30 Sept. 2011 with resistance line (top) and support line (bottom)

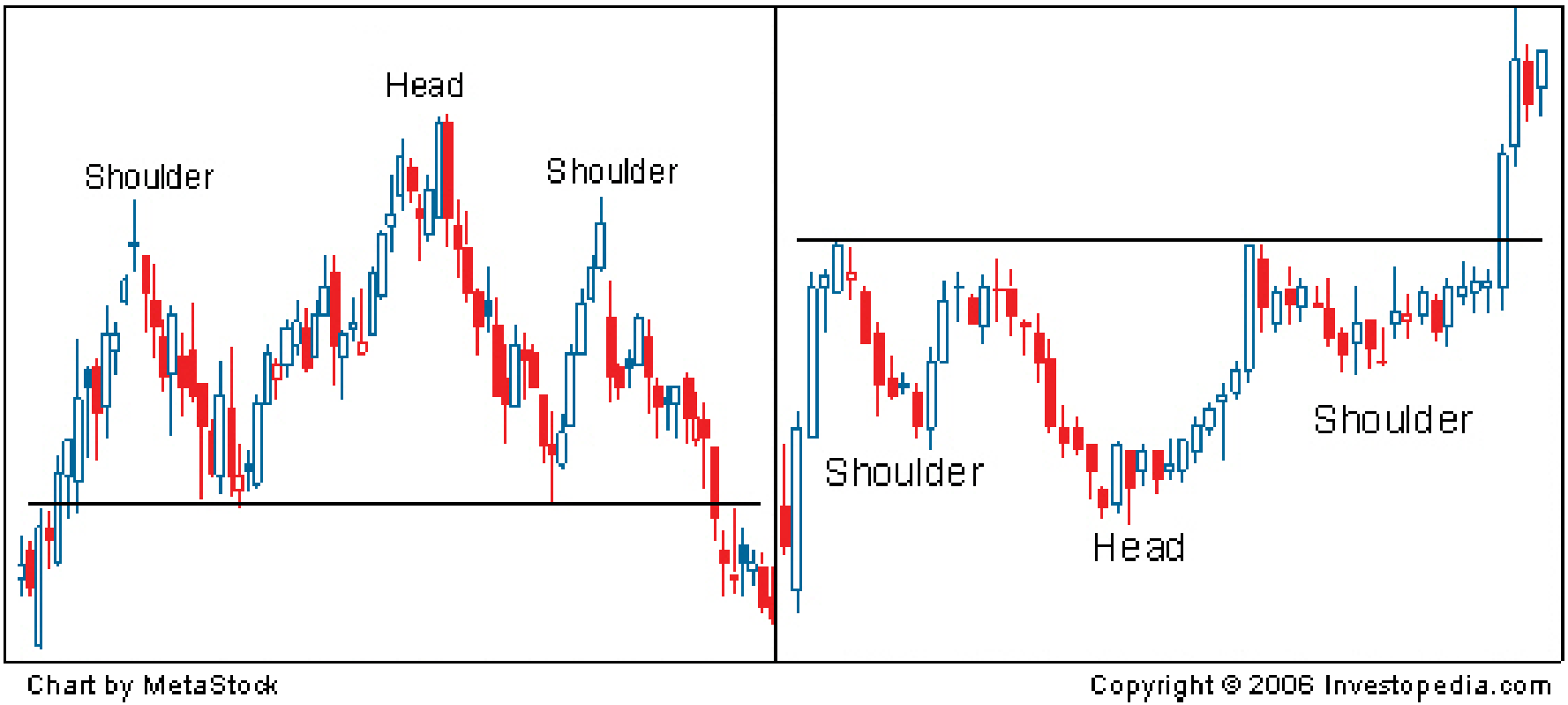


OBX Total return index, daily closing prices from 03-01-2006 to 30-06-2008 with resistance line (top) and support line (bottom)

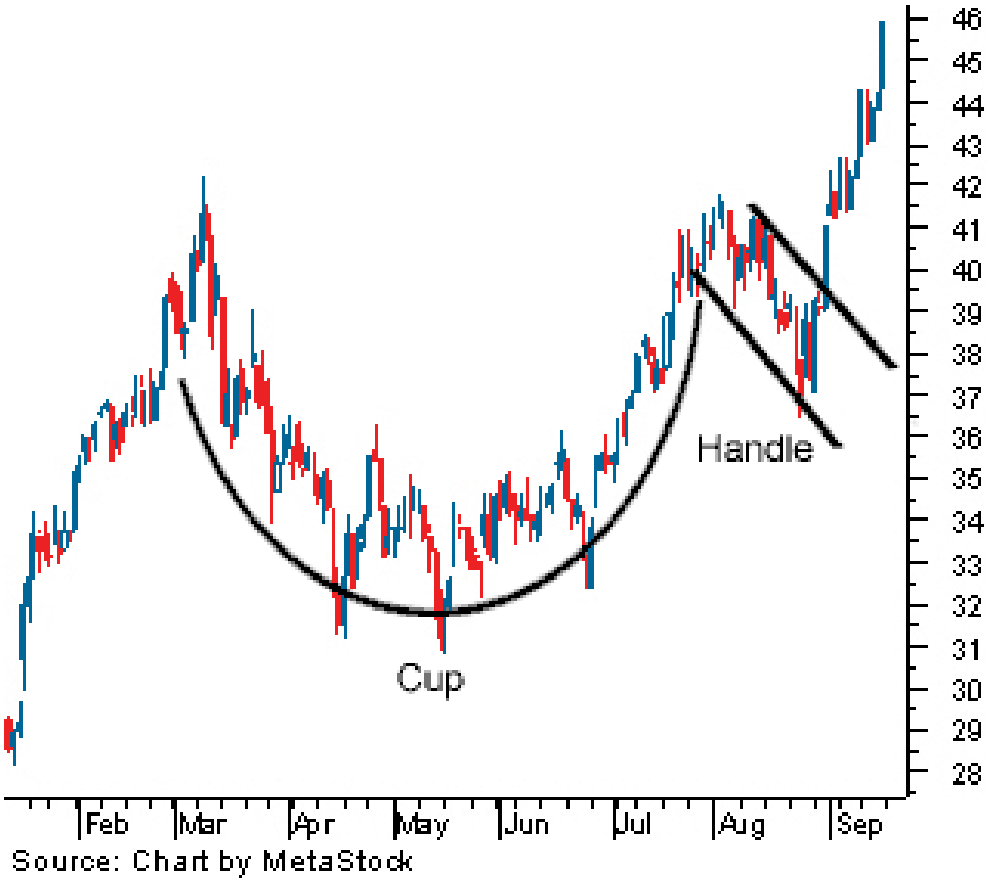
Logic is faulty:

- if €75 really was price ceiling
  nobody would buy for, say, €74.50
  - possible profit only €0.50
  - possible loss much larger
- but that would make €74.50 the new price ceiling
  nobody would buy for, say, €74
- etc.

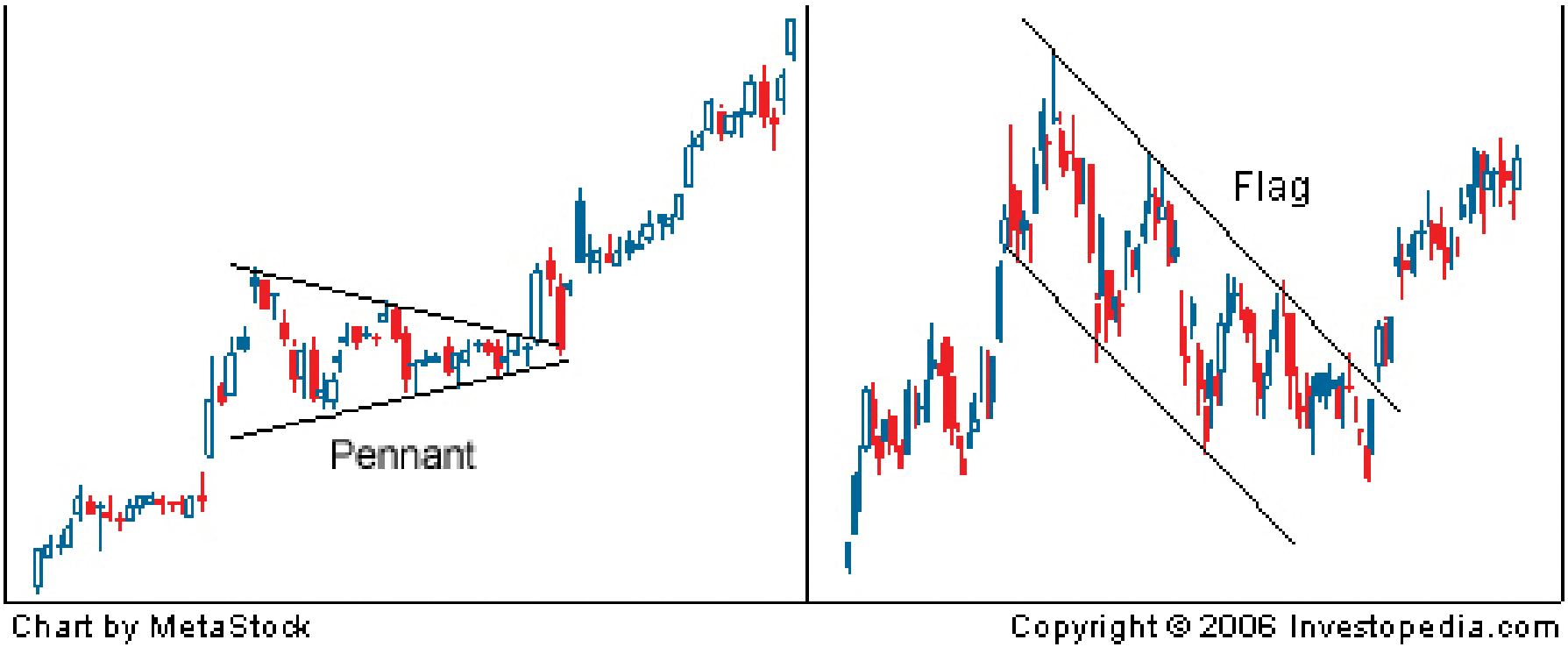
Chartists also recognize other patterns
some exotica from http://www.investopedia.com/



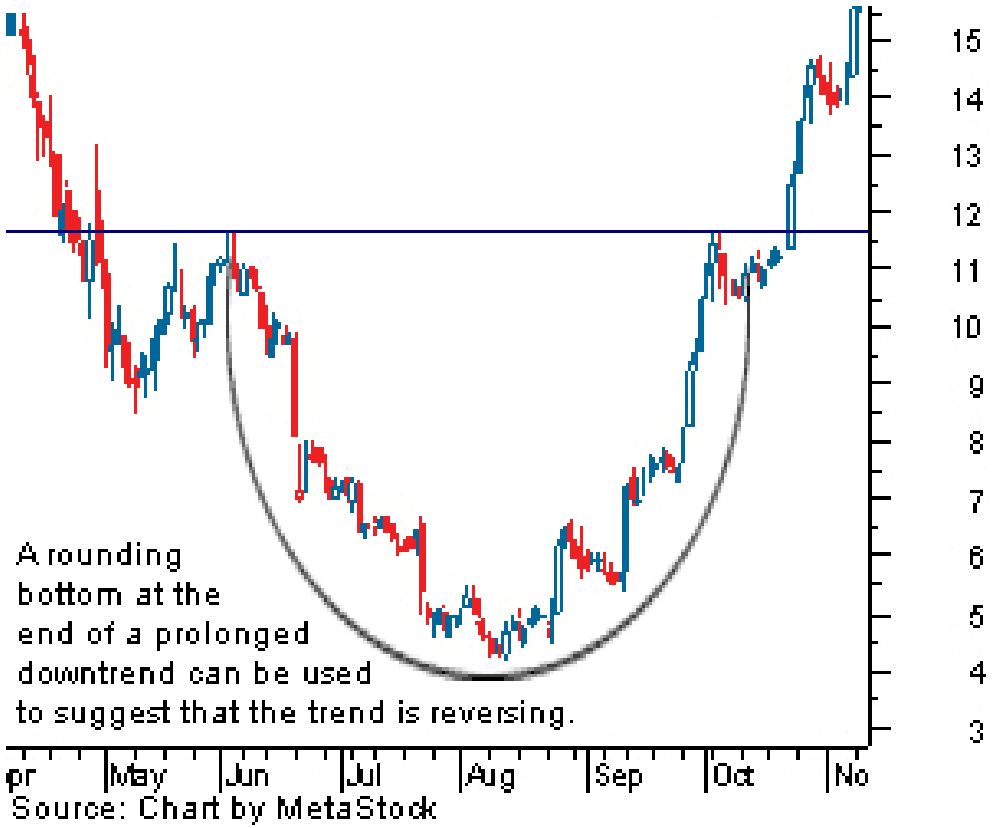
'Head and shoulders' pattern



'Cup and handle' pattern



'Pennant' and 'flag' pattern



'Rounding bottom' pattern

Technical analysis also tested scientifically

- majority of technical trading rules do not earn excess returns
- some may have (limited) practical value

Conclusion:
technical analysis does not reject EMH

charting seems to survive anyway
practised and published on a wide scale

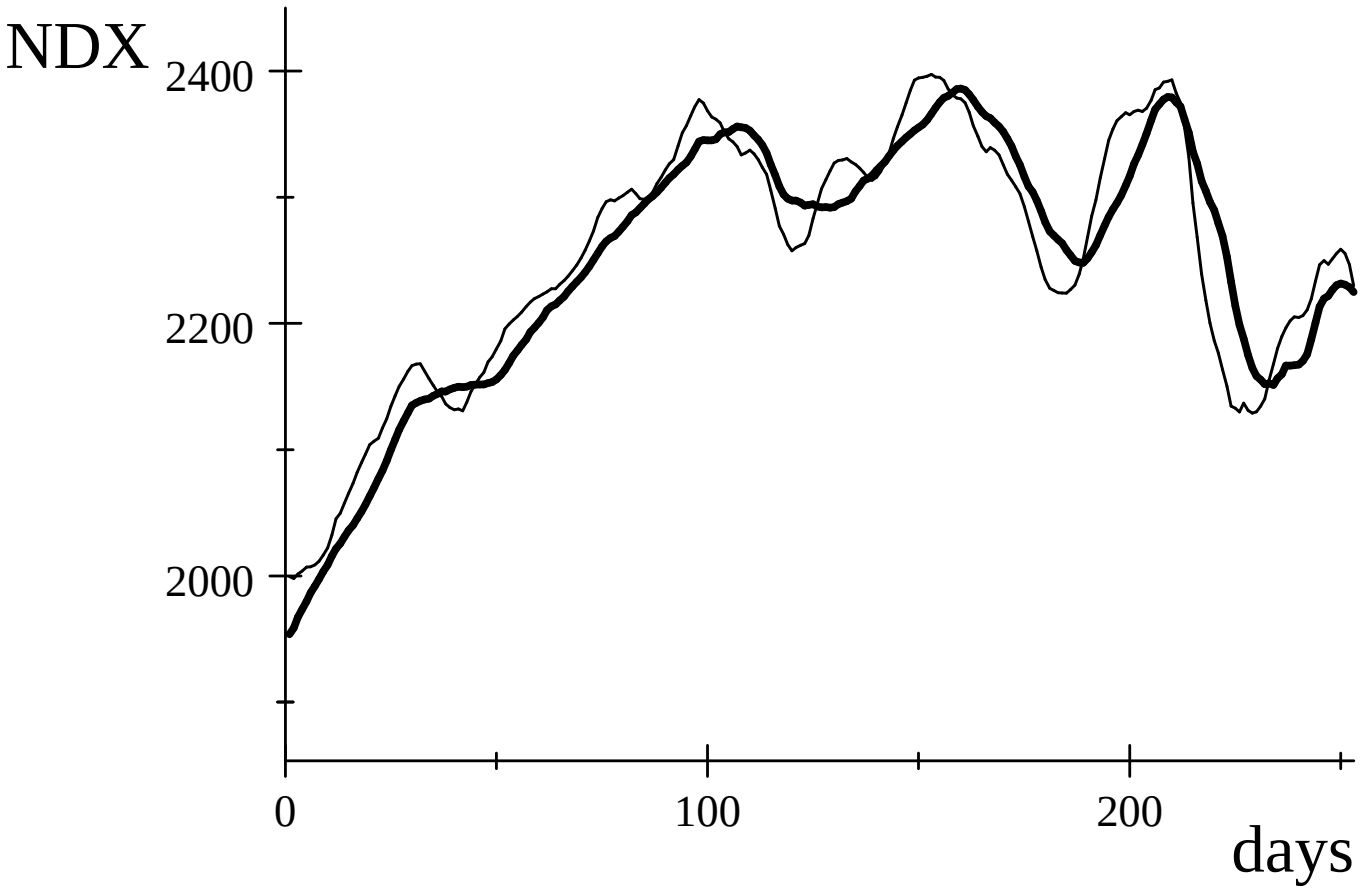
Moving Average strategies

- MA is statistical smoothing technique
- 15 day MA calculates average of
  - day 1 to day 15
  - day 2 to day 16, etc.
- gives momentum $\Rightarrow$ most observations in common

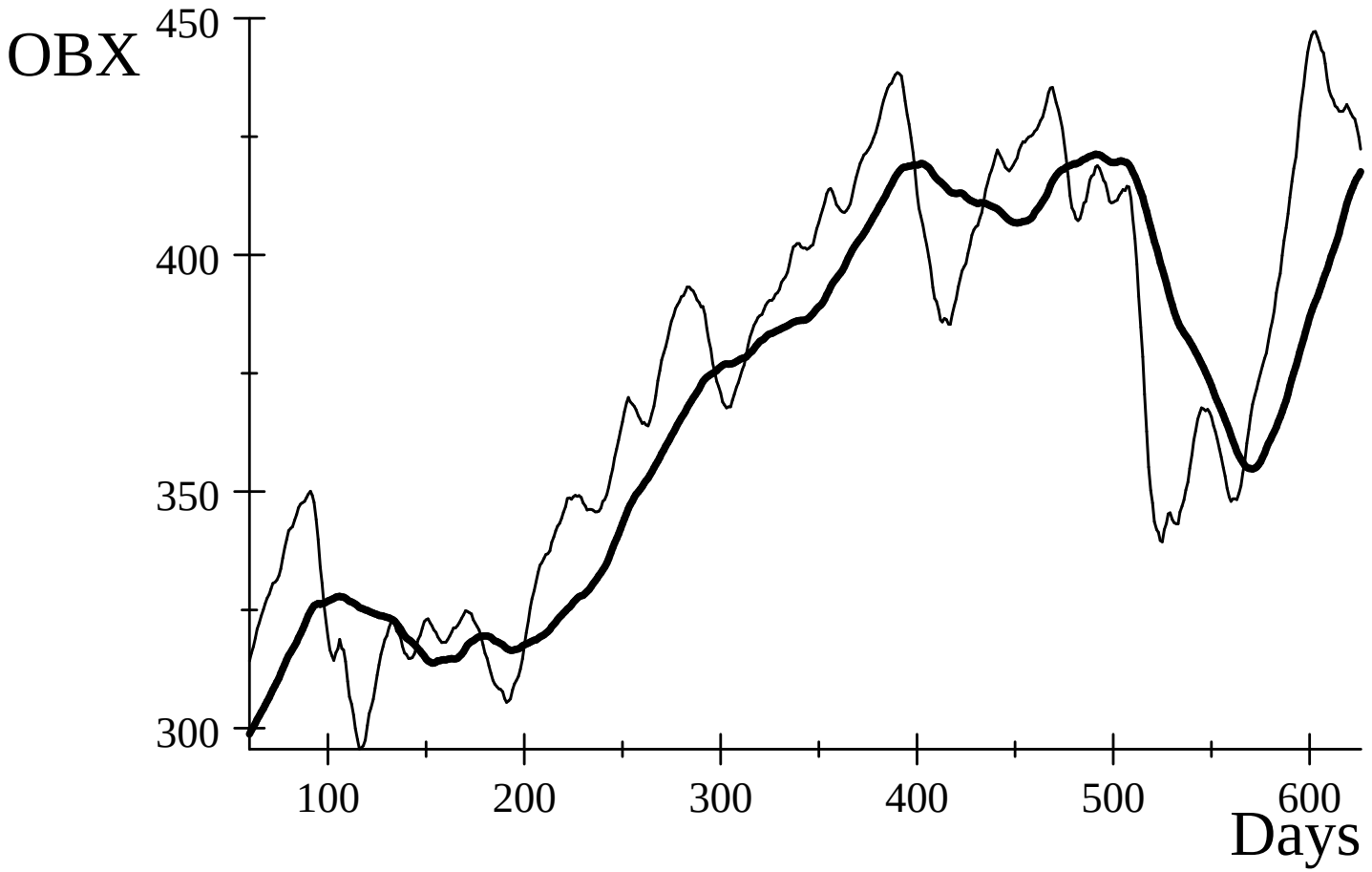
Investment strategy uses 2 MA, long and short

- buy signal if short rises above long
- sell signal if short falls below long

Not shown to earn excess returns $>$ transaction costs



10-days (thin) and 20-days (thick) moving averages of daily closing prices, Nasdaq 100 index, 1 October 2010 to 30 September 2011



10-days (thin) and 60-days (thick) moving averages of daily closing prices, OBX Total return index, 24-03-2006 to 30-06-2008

Pairs trading strategy

Developed on Wall street in 1980's

- select 2 stocks that used to form a pair:
  - prices moved together in the past
  - but recently diverged
- strategy is a bet that they will converge again:
  - buy the loser
  - short the winner
- implicitly assumes overreaction to firm specific news
- first test shown positive results, decreasing over time
- extend to matched portfolios, wrongly called statistical arbitrage

Monkey strategy

When other news is scarce, strategy appears in the press

- put list of stocks on the wall
- have monkey throw darts at it
- select the stocks that get hit

Randomly selecting stocks on efficient market:

- on average reproduce equally weighted index
- equal probabilities of under-, overperformance

Conclusion:

- Investment strategies do not systematically produce excess returns
- some profitable strategies found:
  - equal proportions long-short, over-underreaction
  - not, or only marginally, above trading costs
- possibly/likely to be result data snooping
- result is to be expected: profitable strategies will self-destruct

Investment strategies do not reject market efficiency

3. Investment funds and (groups of) investors do not systematically differ in excess returns

- not systematically means:
  - excess returns should be caused by chance, not skill
  - hence: not be persistent
- Usually tested with (mutual) investment funds

Investment funds can

1. provide different services
2. be structured in different ways
3. have different investment policies

Funds aimed at general public

- are regulated (limits borrowing, short selling)
- provide some administrative services (registration, dividends)
- allow full diversification of small amounts
- allow small increases - decreases
- *actively managed* funds also provide investing expertise
  - stock picking: selecting stocks with superior performance
  - timing: buying before a rise, selling before a fall
  - compete on performance: excess return
  - charge management fee of $\pm 2\%$
- *passively managed*, or *index* funds
  - follow, don't try to beat, the market
  - compete on costs (low fees) and tracking error

Funds can be structured as:

- Open-end (or mutual) fund
  - not traded on exchange but by issuer self
  - creates shares when investors want to buy
  - redeems shares when investors want to sell
  - no fixed number of shares
  - transactions at net asset (intrinsic) value
- Closed-end fund
  - issues fixed number of shares
  - that are traded on exchange
  - price can differ from net asset value

Term 'mutual fund' also used loosely as collective name for both open-end and closed-end funds

- Hedge fund
  - exempted from most regulations
  - not aimed at general public
    but at few (≤ 100) or 'qualified' (rich) investors
  - charge incentive fee of 20% of profits above certain level
    (high water mark)
  - also charge management fee of 2%

There is a wide variety of hedge funds:

- J.M.Keynes was a pioneer with Chest Fund of King's College Cambridge
- many are very risky (incentive structure)
- some exploit specific expertise, e.g. mergers or bankruptcies

Funds have different investment policies:

- Choice of assets: stocks, bonds, real estate, mixed
- further specialization within stocks:
  - growth $\Leftrightarrow$ income
  - high $\Leftrightarrow$ low risk
  - regional (EUR, US, China, Africa)
- most companies run families of funds
  - Robeco (large Dutch co.) has 150 funds

Question is:
Do actively managed funds systematically generate excess returns?

Powerful test of EMH, funds are managed by full time professionals with best available resources

Fund performance tested extensively, 2 early studies:

- Sharpe (1966) 34 funds, 10 years
  - use Sharpe ratio, Treynor ratio
  - funds on average underperform index (Dow-Jones)
  - 23 worse, 11 better than index
  - reason: costs, no underperformance before costs
- Jensen (1968) 115 funds, 20 yrs.
  - uses Jensen's alpha
  - funds on average do not outperform market
  - only 3 funds significant better than market
  - same conclusion if costs are disregarded

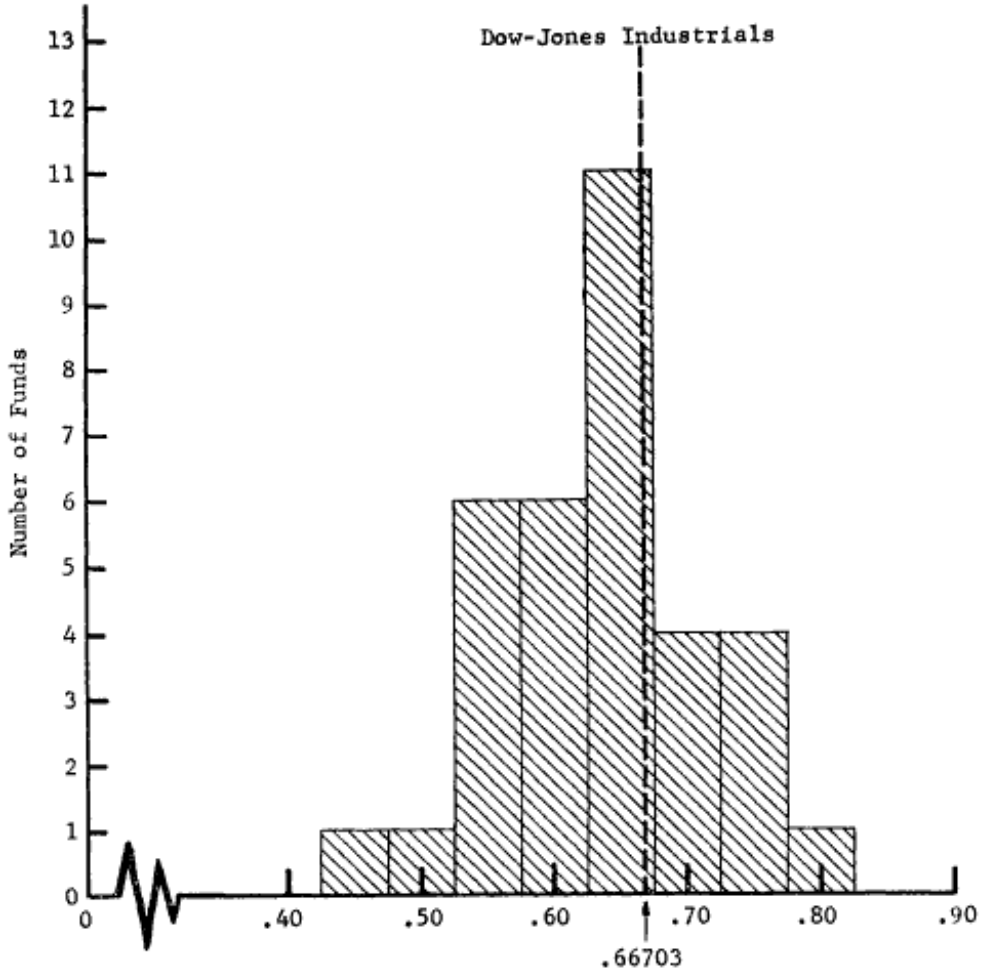


FIG. 9.—Mutual fund performance versus Dow-Jones Industrials, 1954–63

Sharpe's (1966) results

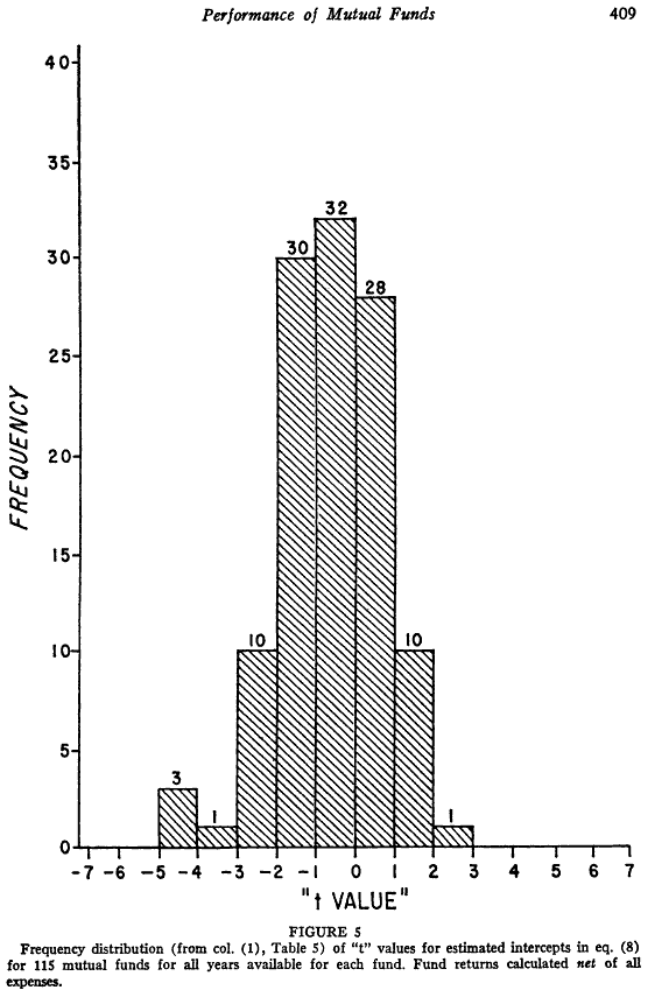


FIGURE 5
Frequency distribution (from col. (1), Table 5) of "t" values for estimated intercepts in eq. (8) for 115 mutual funds for all years available for each fund. Fund returns calculated *net* of all expenses.

Jensen's (1968) results, t $>$ 2 overperformance, t $<$ -2 underperformance

Some local evidence:

- Take all 41 Norwegian funds active Jan. 98-Oct. 03
- Every month, rank them according to return:
  - no. 41 has highest return
  - 1 has lowest return
- Connect the monthly dots
- If performance is persistent, lines will be horizontal

For a better view:

- repeat with the index plus
  - 2 best funds
  - 2 worst funds

Malkiel (2005) collected data on fund performance

% large cap. equity funds outperformed by index:

holding period (yrs.)	1	2	5	10	20
% outperformed	73	72	63	86	90

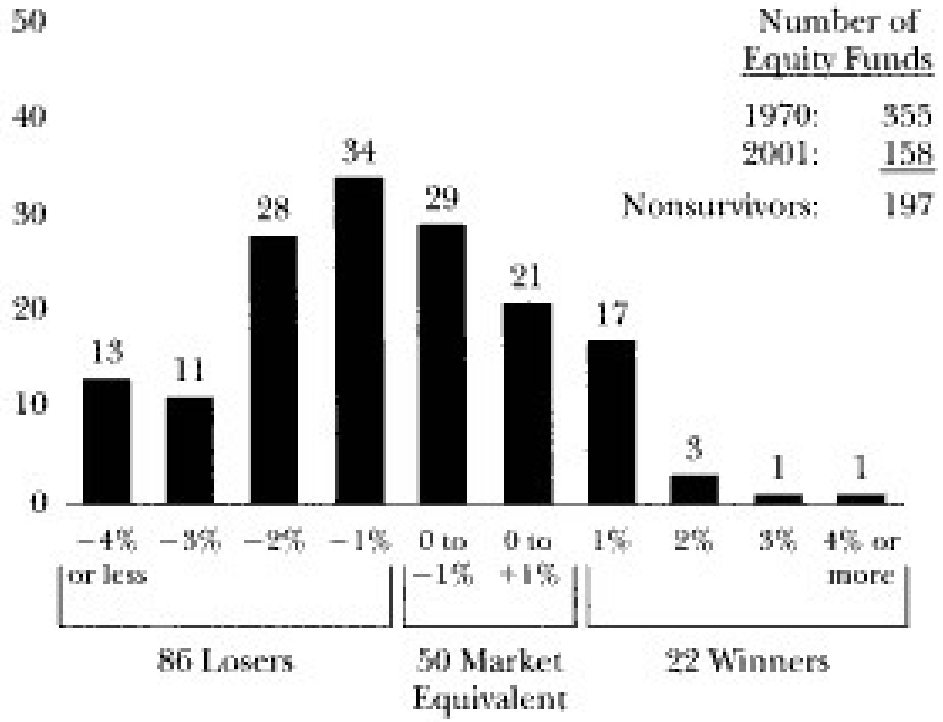
Index funds outperform actively managed funds by 2 points

Median total returns:

Yrs ending 12/31/2003	10 yrs	20 yrs
S&P 500 index	10.99%	12.78%
Av. equity fund	8.47%	10.54%
difference	2.52	2.24

Exhibit 9

The Odds of Success: Returns of Surviving Mutual Funds vs. S&P 500, 1970–2001



Source: Data from Lipper Analytic Services and The Vanguard Group.

Malkiel (2005) also analyses performance persistence:

How top 10 equity funds of 1970s performed during the 1980s:

Fund name	Rank '70-'80	Rank '80-'90
20^{th} Century growth	1	176
Templeton growth	2	126
Quasar ass.	3	186
44 Wall Street	4	309
Pioneer II	5	136
20^{th} Century select	6	20
Securita Ultra	7	296
Mutal Shares Corp.	8	35
Charter Fund	9	119
Magellan Fund	10	1

There are very many other studies, general results:

- funds show some investment expertise, part. stock picking
- hardly any timing expertise
- persistent large underperformance due to excessive trading (high transaction costs)
- excess returns, if any, more than absorbed by costs:
- *underperformance on average*

Remaining question is:
Can some (a few) funds systematically outperform the market

- popularly known as 'hot hands'
- note: regards only a few funds, and excess returns generally only marginally higher than costs

	Average underperfomance	Persistence ("hot hands")
Sharpe (1966)	Yes	some (10 yrs)
Jensen (1968)	Yes	-
Grinblatt and Titman (1992)	-	5 yrs
Hendricks et al. (1993)	Yes	1 yr
Malkiel (1995)	Yes	1 yr (1970's)
		No (1980's)
Brown and Goetzmann (1995)	Yes	1 yr
Elton et al. (1996)	Yes	1-3 yrs
Carhart (1997)	Yes	No (momentum)
Wermers (2000)	Yes	-
Droms and Walker (2001)	No (1970's)	1-3 yrs
	Yes (1980's)	No (5+ yrs)
Bollen and Busse (2005)	Yes	3 months
Kosowski et al. (2006)	-	1 yr
Cuthbertson et al. (2008)	-	only losers

Conclusions:

- Funds, on average, do not outperform the market
- Active management generates negative excess returns (costs money)
- The evidence on 'hot hands' is mixed:
  - existence is debated
  - excess returns usually not far above costs level
- for some (Malkiel) this is most direct and compelling evidence of market efficiency

Fund performance does not contradict the EMH

What should investors do?

Take the advice of one of the very, very few people who have outperformed the market over an extended period of time, Warren Buffett:

> *"Most investors, both institutional and individual, will find that the best way to own common stocks (shares) is through an index fund that charges minimal fees. Those following this path are sure to beat the net results (after fees and expenses) of the great majority of investment professionals."*

Warren Buffett—Berkshire Hathaway Annual Report, 1996

Event studies

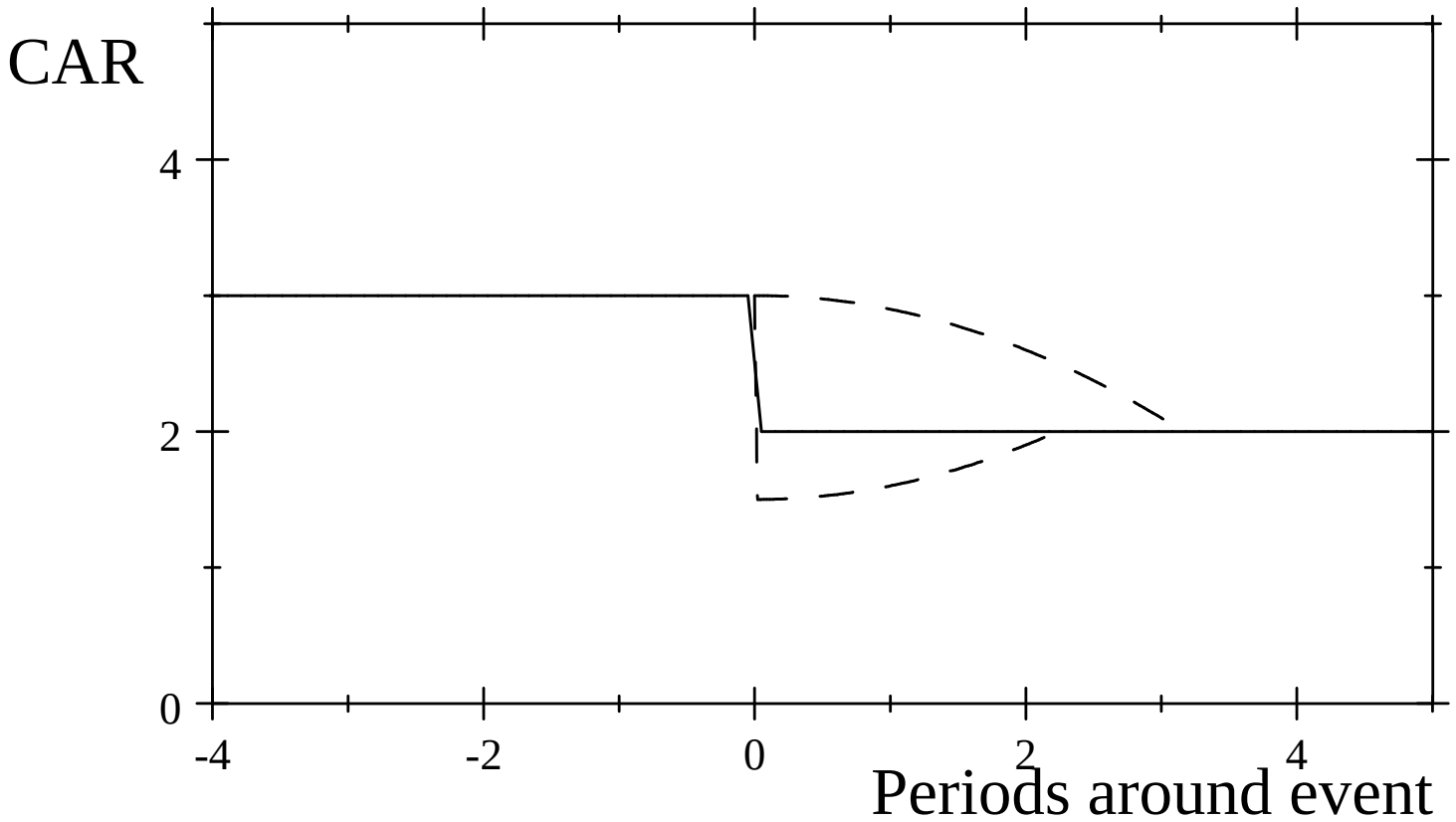
- Test the *speed* and *precision* of price reactions to news
- News can be anything:
  - announcements of dividends, merger, stock split
  - price jump on input, output market
  - sudden death of CEO, etc.
- Problem: news never comes alone
  - have to separate event from rest
  - need a technique for that
  - methodology known as 'event studies'

Market model most frequently used in event studies

- calculates 'normal' return, given market developments
- difference with realized return is 'abnormal' return
- abnormal return attributed to event

Market efficiency tested by pattern of abnormal returns

- in efficient market, only occur in event period
- no predictable pattern afterwards
- gives familiar graph
- but with different Y-axis



Efficient (solid) and inefficient (dashed) price adjustments; CAR is Cumulative Abnormal Return

Market model uses simple, empirical regression relation:

$$r_{it} = \widehat{\gamma}_{0i} + \widehat{\gamma}_{1i} r_{mt} + \varepsilon_{it}$$

r_{it} = return of individual security i
r_{mt} = return on market portfolio (broad index)
$\gamma_{0,1}$ = estimated coefficients
ε_{it} = error term
t = subscript for time

Market model

- has no theoretical background as CAPM (char. line)
- no assumptions covar. structure (as single index model)
- is estimated in *estimation window*, before period in which event is studied (*event window*)

Estimated *normal* (or expected) return are market model's out-of-sample predictions, given the return on the market:

$$E(r_{it}) = \widehat{r}_{it} = \widehat{\gamma}_{0i} + \widehat{\gamma}_{1i} r_{mt}$$

$\widehat{\gamma}_0$ and $\widehat{\gamma}_1$ estimated over prior period
r_{mt} is observed is event window

Abnormal return, ar_{it}, is realised minus expected return:

$$ar_{it} = r_{it} - E(r_{it}) = \varepsilon_{it}$$

Conclusions based on sum ar_{it} over prediction period, the *cumulative abnormal return*, car_i:

$$car_i = \sum_t ar_{it}$$

Example event study: Google

April 17th 2008, Google announced results over first quarter

- profits 42% higher than same quarter last year
- much more than analysts expected
- next day Google's stock price opened 20% higher
- end of the month the price had crept up 6.5%

Was that due to market developments?

- NASDAQ Comp. Index was up 4.1% in same period
- if so, EMH not contradicted.

Or was it correction after initial underreaction to announcement?

- is so, EMH is contradicted

Announcement effects usually studied over long windows

- we use 10 days before and after
- estimation window 3 months before, Jan.-March
- has ± 60 trading days, enough for estimation
- download data from yahoo.com
  - daily closing prices Jan. 2 - May 1
  - of Google, ticker GOOG and
  - Nasdaq Composite Index (ticker IXIC)
- transform prices into returns

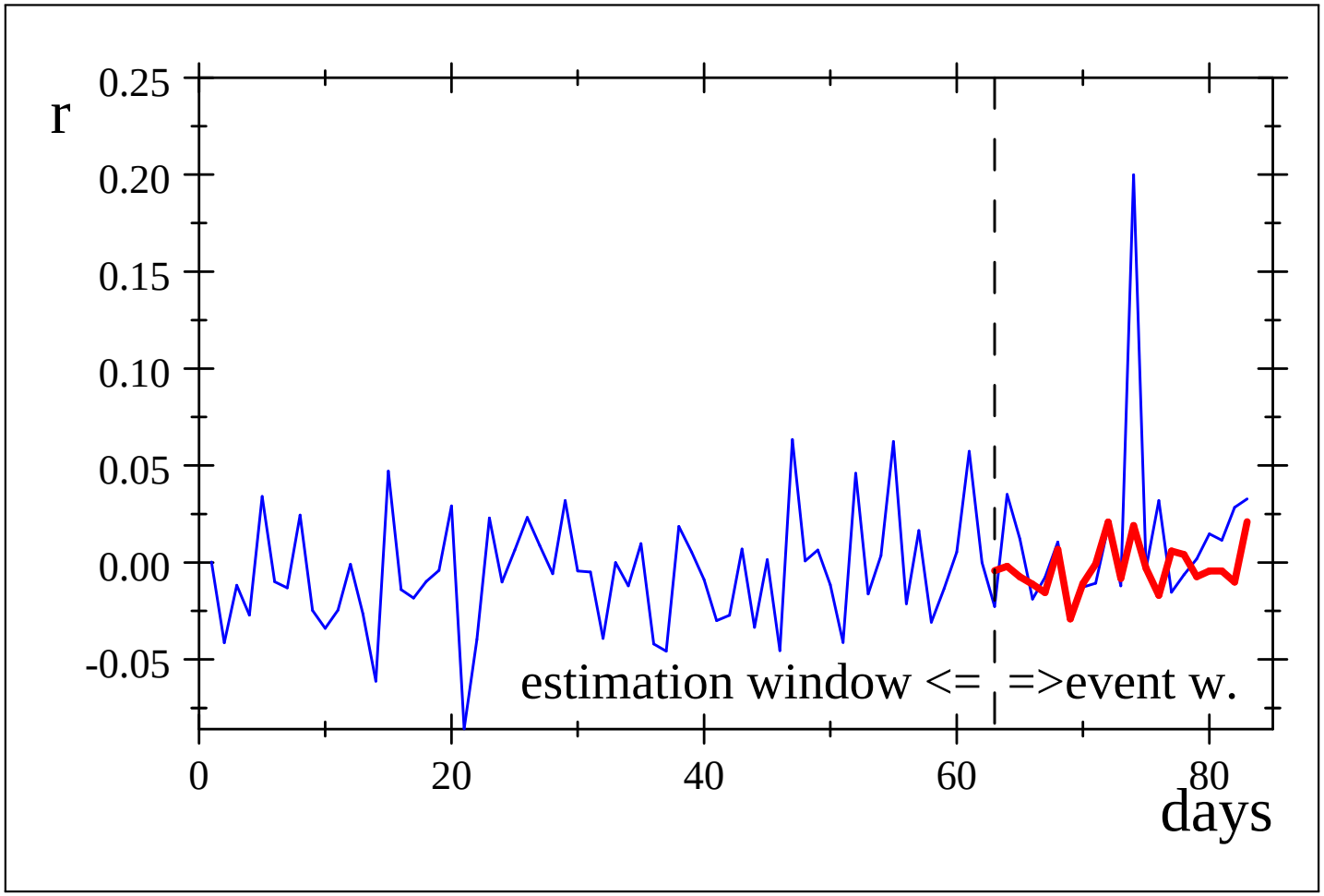
Select data of estimation window,
estimate market model for Google with regression analysis:

$$r_{goog} = -.005 + .922 r_{ixic} \quad R^2 = .278$$

- coefficients' standard errors are .003 and .189
- sensitivity coefficient significantly $\neq 0$, intercept is not

Calculate Google's expected returns:

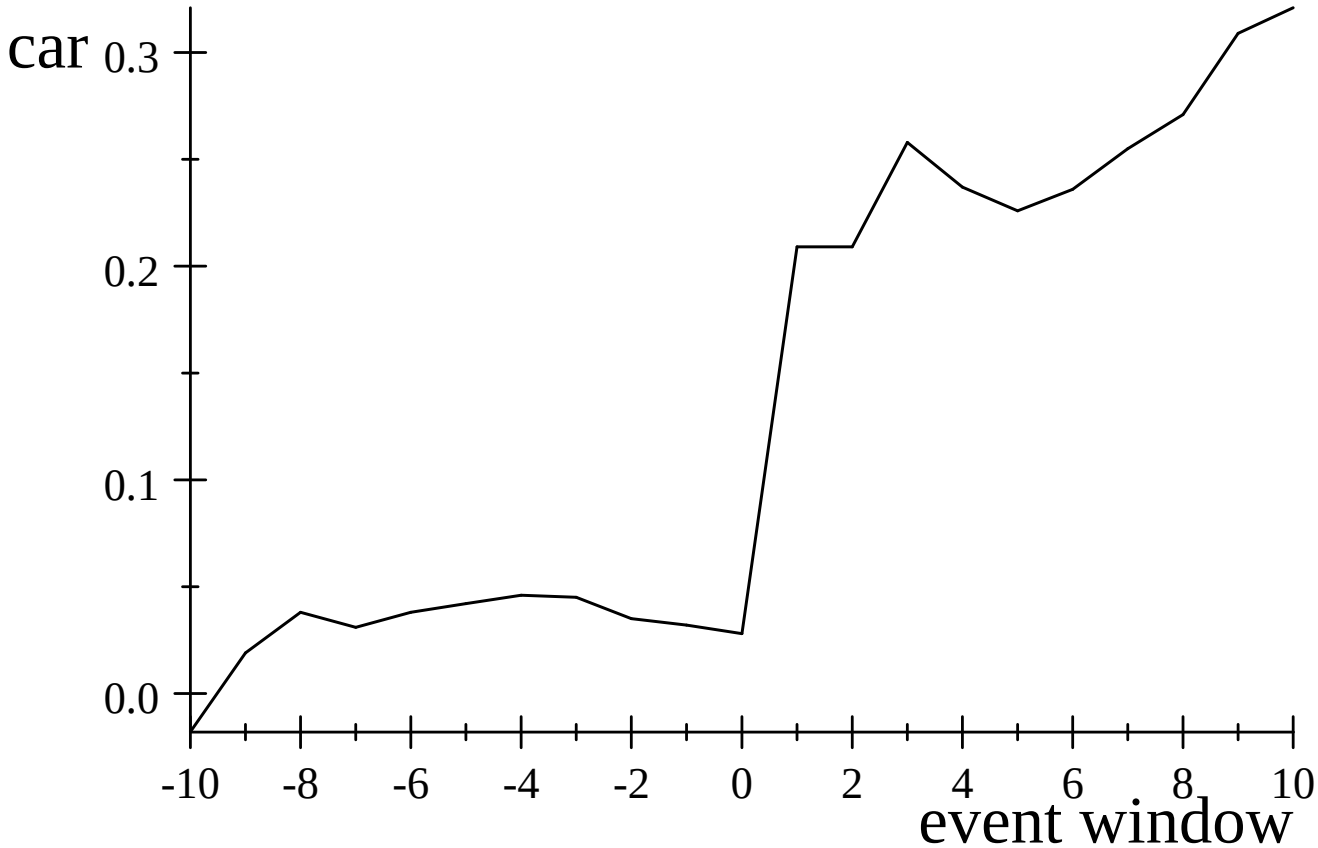
- e.g. first trading day after announcement (day 1)
  - index return is .026
  - expected return Google is $-.005 + .922 \times .026 = .019$
  - Google's actual return is .2
  - abnormal return is $.2 - .019 = 0.181$



Google's return (blue) and normal return (red)

Returns around event day

Day	r_{ixic}	$E(r_{goog})$	r_{goog}	ar_{goog}	car_{goog}
10	0.028	0.021	0.033	0.012	0.321
5	0.010	0.004	-0.006	-0.010	0.226
1	0.026	0.019	0.200	0.181	0.209
-5	0.013	0.007	0.011	0.004	0.042
-10	0.001	-0.004	-0.023	-0.018	-0.018



Cumulative abnormal returns of Google

Real event study requires many announcing firms:

- perform calculations for each firm
- synchronize results on event day
- calculate cumulative average abnormal returns, *caar*
- test their significance (is bit complex)
- significant post event drift contradicts EMH
- significant pre event drift more difficult to interpret
  - could be information leaking out
  - could be sample selection bias, e.g. only dividend increases after period of extra good results

Many hundreds of event studies are performed
We will look at 2 well known examples:

1. Fama's (1969) classic study of stock splits
2. Rendleman's (1982) study of earnings announcements

Stock splits are what name suggests:

- 1 old share is replaced by 2 (or more) new ones
- keeps price per share 'affordable'
- creates no value
- no dilution of value or voting rights either
- should have no price effect in efficient market

Fama (1989) among first event studies

- used methodology with market model variant
- collected 940 splits, 1926-1960
- event windows 20 months before - 30 months after split
- split is usually announced beforehand
- results:
  - caar rise steadily before split
  - is stable after split
  - no contradiction EMH

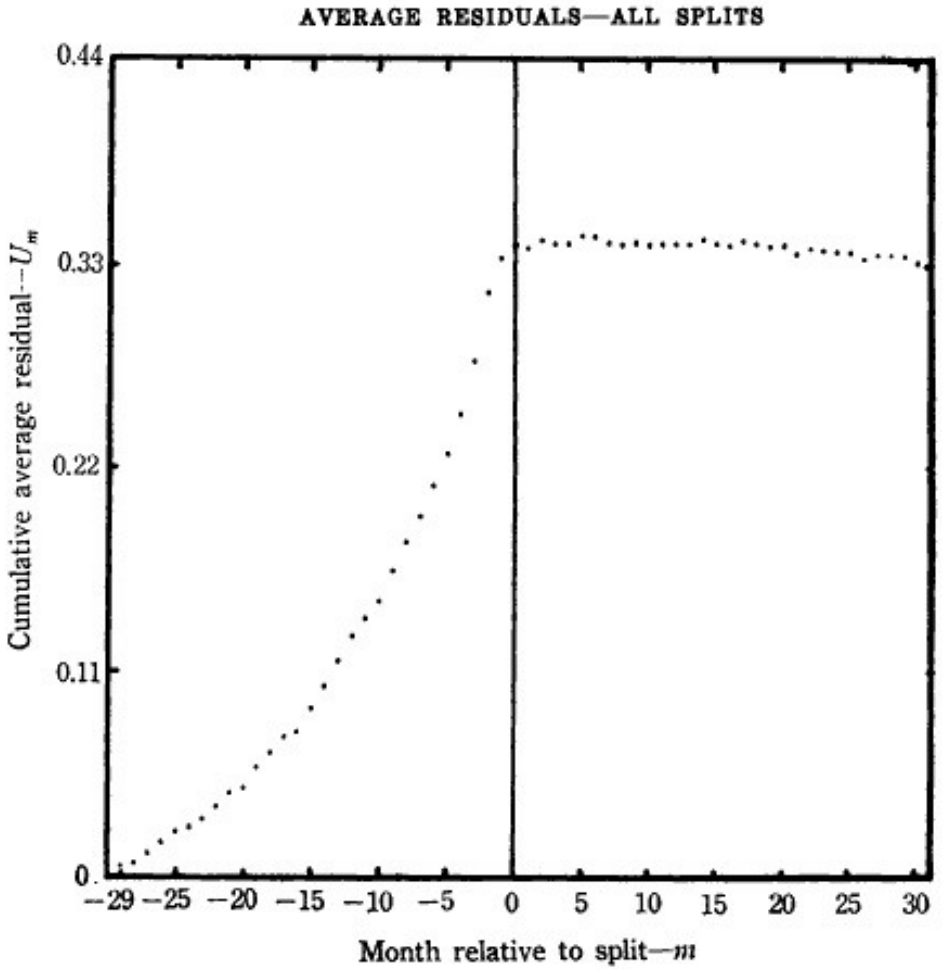
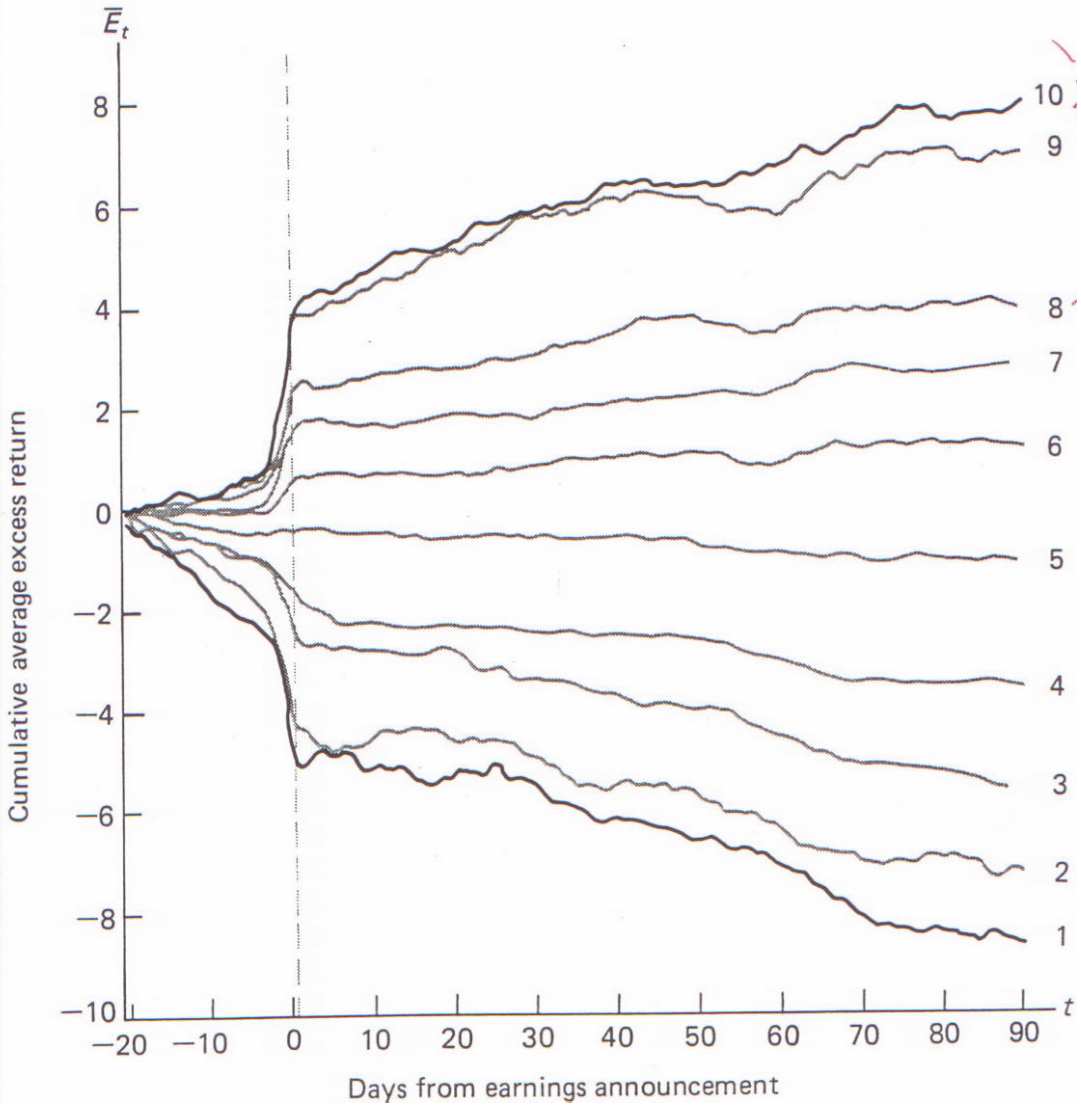


FIGURE 2b
CUMULATIVE AVERAGE RESIDUALS—ALL SPLITS

Rendleman looks at effect earnings announcements

- uses simple time series model to forecast Earnings per Share (EPS)
- difference between forecasted EPS and EPS in announcement is Unexpected Earnings UE
- UE is standardized with stand. dev. of regression (SUE)
- divide sample in 10 groups:
  - groups 10 has highest SUE
  - group 1 has lowest SUE
- event study for each group
- for all but 1 group, post event drift is significantly $\neq 0$
- clearly contradicts EMH
- excess returns small: 4.3% post-event drift for top SUE group


$\overline{E}_t$
8
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t
−20
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0
10
20
30
40
50
60
70
80
90
Cumulative average excess return
Days from earnings announcement

Overview of event studies

Study	Event	Efficient?
Fama et al. (1969)	Stock splits	Yes
Ikenberry and Ramnath (2002)	Stock splits	No
Byun and Rozeff (2003)	Stock splits	Yes
Boehme and Danielsen (2007)	Stock splits	Yes
Ball and Brown (1968)	Earnings ann.	Yes
Reinganum (1981)	Earnings ann.	Yes
Rendleman et al. (1982)	Earnings ann.	No
Chordia and Shivakumar (2005)	Earnings ann.	No
Battalio and Mendenhall (2005)	Earnings ann.	No
Mendenhall (2004)	Earnings ann.	No

Overview of event studies (cont.'ed)

Study	Event	Efficient?
Keown and Pinkerton (1981)	Merger ann.	Yes
Travlos (1987)	Merger ann.	Yes
Loughran and Vijh (1997)	Merger ann.	Yes/No
Pontiff and Woodgate (2008)	Stock issue	No
Fama and French (2008)	Stock issue	No
Brav et al. (2000)	Stock issue	Yes
Eckbo et al. (2000)	Stock issue	Yes
Liu et al. (2008)	Dividend ann.	Yes

Conclusions:

- Most information efficiently absorbed in prices
- but many event studies contradict EMH
- Effect of inefficiencies probably limited:
  - again: overreaction about as common as underreaction
  - excess returns are generally small
- Results event studies sensitive to small changes in specification:
  - excess returns found in equally weighted portfolios
  - but not in value weighted portfolios
  - suggests inefficiencies limited to small stocks

Event studies provide mixed evidence on EMH

Strong form tests

Refers to private and inside information

- Difficult to test:
  - trading on such information is illegal
    makes test criminal investigation
- Some tests reported on in literature
  - fund performance considered strong form test:
    models and strategies are private information
  - some other tests as well

1. Investment columns in Wall Street Journal
   - leaked prior to publication (person involved convicted)
   - info can give 6.25% return over 2 days
   - rejects strong form EMH
2. Investment columns in Wall Street Journal
   - also analysed apart from illegal trading
   - $>$1000 buy or sell recommendations analysed
   - prices react 2 days before publication (!)
   - 3 day caar is 3%
   - rejects EMH

Most tests refer to legal insider trades

- company directors, boardmembers, large shareholders can trade in 'own' stock
- trades must be reported to financial authorities
  - sanctions (fine) if not reported
- made public soon after filing
- actions if trades based on inside info
  - fine
  - trade can be reversed
  - criminal charges can be made
- in many countries insider trading formulated such that conviction is almost impossible

General result of insider trade tests:

- Insiders can earn excess returns
- some disagreement about details:
  - excess return may increase with place in organisation
  - may increase with size of transaction
  - purchases more profitable than sales
- all reject strong form market efficiency
- exception: Eckbo's study Oslo Børs
  - insiders earn no or negative excess returns

Conclusion: strong form tests reject EMH

Empirical problems in EMH tests

1. Joint hypothesis problem
   - EMH defined in excess, or abnormal, returns
   - requires a model of normal returns
   - empirical analyses joint test of EMH and model
     cannot test one without the other

2. Biasses can be (almost) unavoidable
   - survivorship bias
   - selection bias:
     - only well performing firms announce dividend increase
     - selecting well performing firms means selecting smaller firms

3. Data snooping

- formerly known as data mining
- repeatedly using same dataset for selecting and testing models
- reduces value of results
- increases probability that results are data specific
  - in sample almost perfect fit
  - out of sample performance very bad
- obvious solution: re-testing on other data
- may not be possible:
  - most countries have only 1 stock exchange
  - there is only 1 time series of $-NOK exchange rates

Puzzles or 'anomalies'

Refers to inefficiencies with a certain persistence

Small firm effect is one of the oldest

- often reported in tests of CAPM
- included in Fama-French 3 factor model
- seems to have disappeared in most recent research
- several small-cap funds became available in 1980s
  can have increased demand, extra return priced away

Calendar effects also attracted much attention

- January effect: prices higher in Jan.
  - seems to persist
  - several economic explanations, none satisfactory
- weekend effect: prices higher on Monday
  - seems to have disappeared

Value - growth effect

- large, mature firms (value) give high return
- small, growing firms give low returns
- seems to have disappeared

Momentum effect

- seems to persist

Some common misconceptions

1. EMH means market is always right
   - EMH requires all information reflected in prices
   - not that information is complete
     or, with hindsight, correct
   - market can be wrong
     - but not systematically

Suppose info can take 2 values (war-peace, dry well-oil found)

- stock price becomes 50 or 100
- 50-50 probability $\Rightarrow$ price now=75 $\Rightarrow$ price never right
- suppose price becomes 50 (war, dry well)
- was price of 75 'irrational exuberance'?

2. People who made fortunes on stocks disprove EMH

   - People can get (repeatedly) lucky
     but with a low probability
   - If investing is betting on year-end stock prices,
     what is probability of betting right 10 yrs. in row?

Often illustrated with coin tossing analogy:

Take 100.000 investors, make them flip coin

   - 50.000 heads, they stay, tails leave
   - after 10 tosses, $\pm$ 100 left ($0.5^{10} = 0.000977$)
     Of 100.000 investors, 100 will bet right 10 yrs. in row
   - those 100 will claim investment skills, not luck

Now suppose you want to invest some money

- Look at track record of 250 mutual funds over 10 years
- Find that fund X has beaten market in all 10 years
- Probability is $0.5^{10} = 0.000977$, must be hot hands, right?

Wrong, 0.000977 is probability fund X beats the market

- You looked at all funds, to see if *any fund* beats the market
- that has a different probability under EMH:

Prob. that a part. fund does not beat market is $(1 - 0.000977)$
Prob. that *no* fund beats the market: $(1 - 0.000977)^{250} = 0.783$
Hence, prob. that at least 1 fund beats market $1 - 0.783 = 0.217$

Probability even higher if more 10 yr periods could be used

3. Large price fluctuations mean inefficiency
   - enormous amount of info available each day
   - combined impact on individual stocks hard assess
   - may give false impression price changes are without reason
   - Opposite is true: no/small price fluctuations mean inefficiency

4. If markets are efficient, one stock is as good as another
   - all stocks differ in risk, growth, dividends, etc.
     - no 2 stocks are alike
     - investor has to match portfolio to his preferences
   - but all these aspects are fairly priced
     - cannot be used to earn excess profits
     - in that respect, all stocks are alike

Conclusion: are markets efficient?

Reconsider the evidence:

1. Autocorrelations and runs tests do not reject EMH
2. Vast majority of investment strategies earn no excess returns, we cannot reliably predict whether next period:
   - has momentum or contrarian returns
   - shows over- or under-reaction
   - return pattern will continue or reverse
   - small firm effect will stay away or return (opposite sign?)
   - excess returns, if any,:
     - are real or premium for omitted risk factor
     - substantially above transaction costs level

3. Actively managed funds do not outperform market
   - on average, they underperform
   - evidence on performance persistence is mixed, but
   - limited to few funds, short periods and low excess returns

4. Some, not all, event studies reject EMH
   - e.g. January effect, post earnings announcement drift
   - repeatedly found, seem to persist
   - but: over-reaction as common as under-reaction
   - excess returns sensitive to measurement method

For corporate managers with inside information:

- markets not strong form efficient
- can earn excess returns
- often find ways to do so

For large majority of investors:

- Financial markets function well
- transactions at fair prices, investments give fair return
- stupidity (excessive trading) is punished

There is no way around it:

Markets are efficient

To end, two quotes on financial markets:

> *Market can stay irrational longer than you can stay solvent (J.M. Keynes)*

> *Those who say don't know and those who know don't say*