TIØ4146 Finance for Science and Technology Students

Chapter 4 - Market Efficiency

Carlos Miguel Dos Santos Oliveira
Ståle Størdal
Felipe Van de Sande Araujo
September 20, 2023

Norwegian University of Science and Technology

The efficiency concept

Empirical evidence

Conclusions

The efficiency concept

Empirical evidence

Conclusions

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

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)

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:

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

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, deviations from expected values are zero in the long run

- fair coin: each side 50% probability
- fair die: each side 1/6 probability
- games can also be fair if loss is expected, as in lottery or roulette

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 a project:

- 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:

$$\varepsilon_t > 0$$
$$E(\varepsilon_{t+1} | \Phi_t) = 0$$

and next period's price is:

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

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

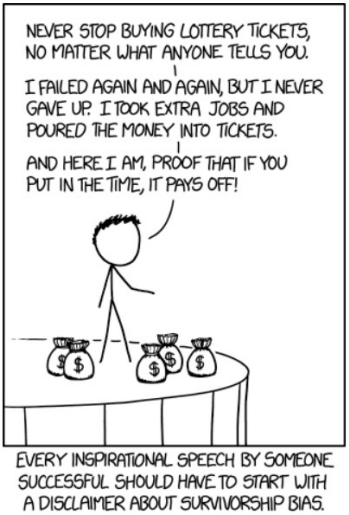
Means: cannot systematically earn positive excess returns

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



Source https://xkcd.com/1827/

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:

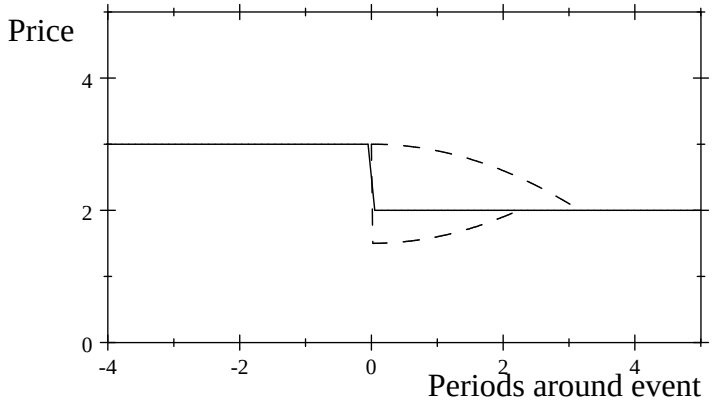
- no fund can systematically earn positive excess returns
- differences in risk adjusted performance are random
- hence: differences are not persistent

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

Value of foresight

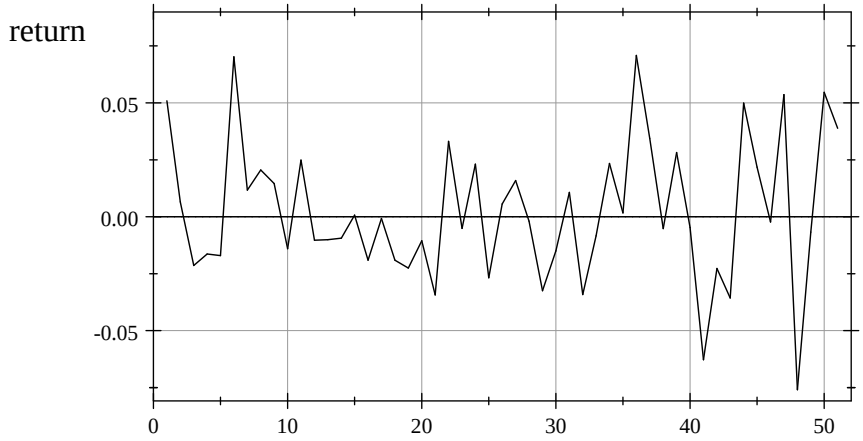
Market efficiency usually received with disbelief

- 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...

The efficiency concept

Empirical evidence

Conclusions

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!

Look at tests of implications 1 by 1

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

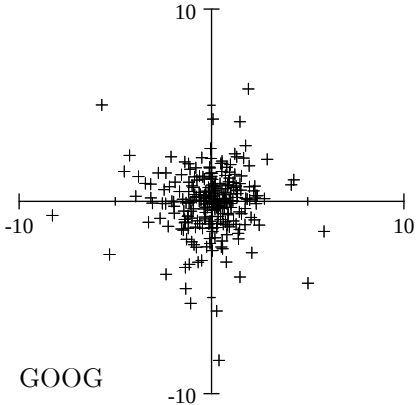
Over short periods of time:

- 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 $\varepsilon_{i,t+1} \approx r_{i,t+1}$

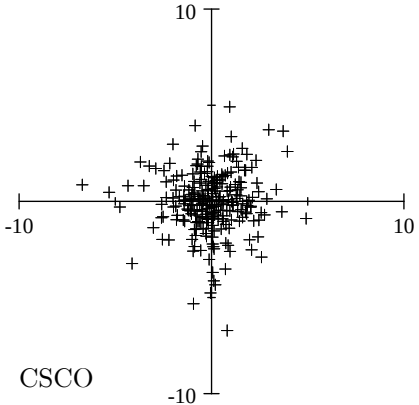
Procedure to visualize autocorrelation:
plot this period's returns against next period's

- 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

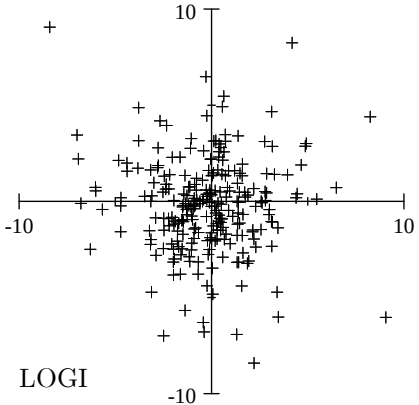
Make such plots for a few stocks + indices



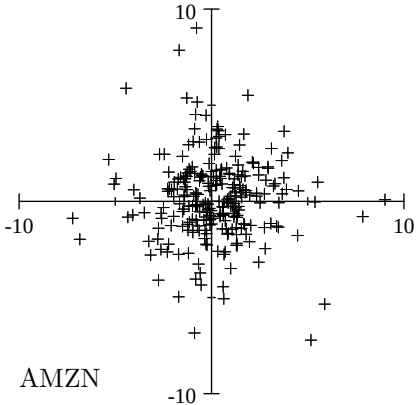
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Google



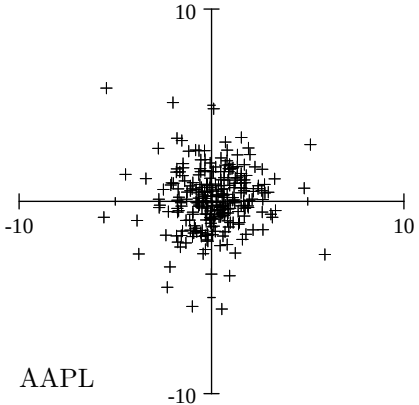
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Cisco



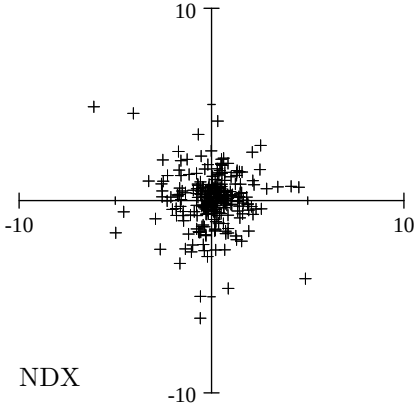
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, LogiTech



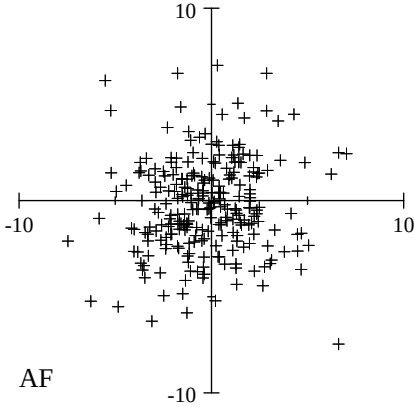
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Amazon



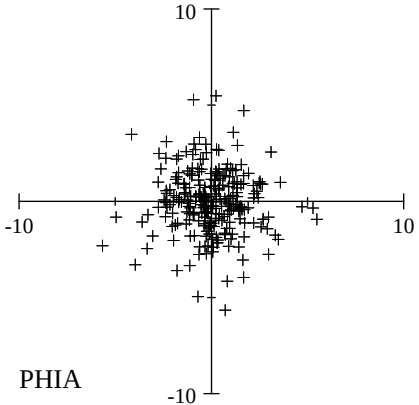
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Apple



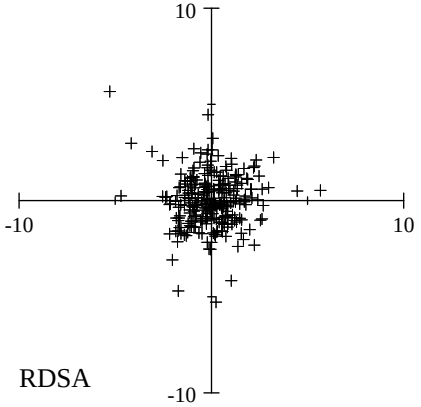
Return day t (x-axis) vs. day t+1 (y-axis), 21-10-2010 to 19-10-2011, Nasdaq-100 index



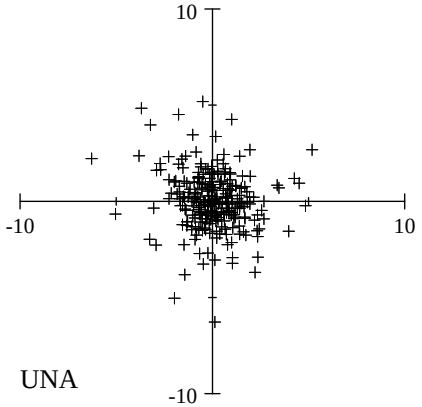
Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, Air France-KLM



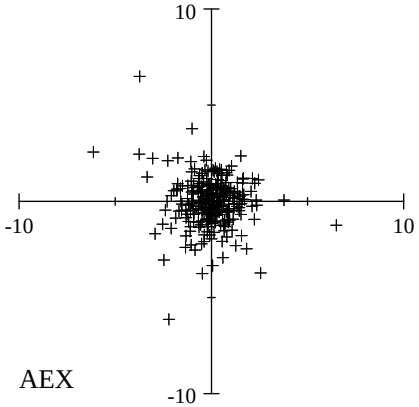
Return day t (x-axis) vs. day t+1 (y-axis), 02-03-2007 to 29-02-2008, Philips



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 $< 0.5\%$

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}	R^2
Google	-0.062	-0.018	0.082	-0.091	0.071	-0.089	0.037
Cisco Systems	-0.145	0.026	0.009	-0.074	-0.015	-0.20*	0.049
Logitech Int.	-0.290	-0.001	0.096	-0.090	0.011	0.032	0.018
Amazon.com	0.167	-0.013	0.064	-0.055	0.022	-0.075	0.015
Apple	0.101	0.032	0.100	-0.119	0.039	-0.100	0.043
NDX index	0.035	0.016	0.075	-0.20*	0.082	-0.118	0.084

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

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

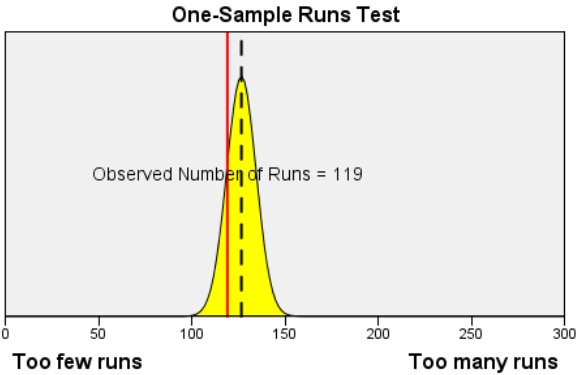
Another alternative test procedure is 'runs test'

- 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, Lakonishok and Ritter (1992)	5 years	
Jegadeesh and Titman (1993)		3-12 months
Rouwenhorst (1998)		3-12 months
Chan, Hameed and Tong (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

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

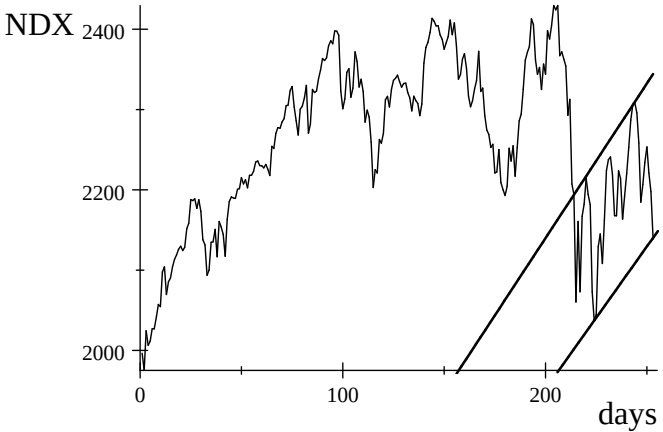
Conclusion:
Contradictory evidence makes it difficult to reject market efficiency
the many reported momentum and/or contrarian effects, remain puzzling

Technical analysis (charting)

- Based on perceived regularities (patterns) 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)

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
exotica can be found at http://www.investopedia.com/

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

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

- 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

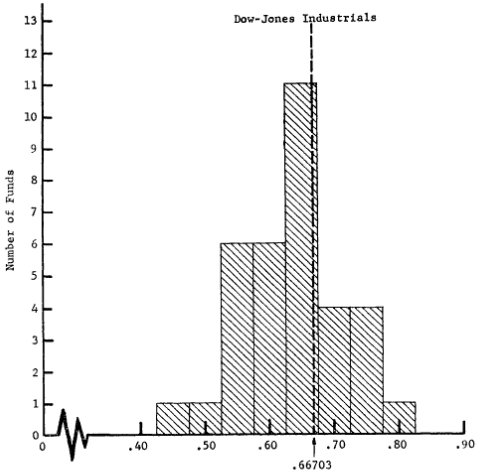


FIG. 9.—Mutual fund performance versus Dow-Jones Industrials, 1954-63

Sharpe's (1966) results

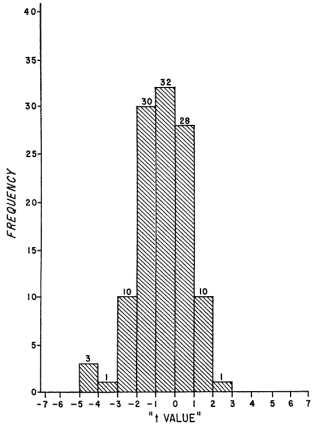


FIGURE 1

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

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 underperform.	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, Gruber and Blake (1996)	Yes	1-3 yrs
Carhart (1997)	Yes	No (momentum)
Wermers (2000)	Yes	-
Droms and Walker (2001)	No (1970's) Yes (1980's)	1-3 yrs 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

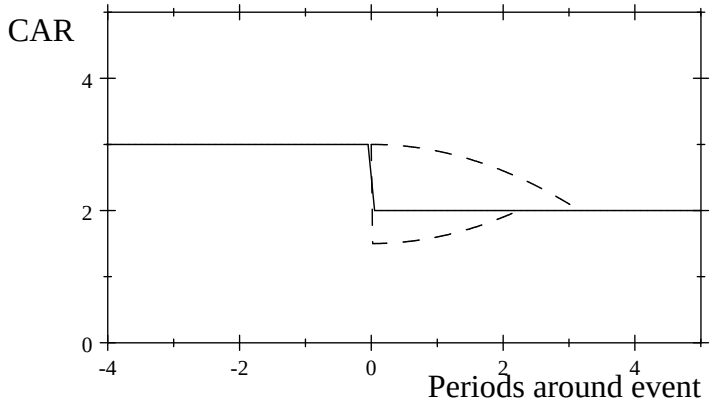
- Test the *speed* and *precision* of price reactions to news
- News can be anything:
  - announcements of dividends, merger, stock split
  - price jump on input, output market
  - sudden death of CEO, etc.
- Problem: news never comes alone
  - have to separate event from rest
  - need a technique for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

Recap: market efficiency 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.

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 some countries conviction for insider trading is very difficult

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 $-£ 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

The efficiency concept

Empirical evidence

Conclusions

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
- excessive trading is punished

There is no way around it:

Markets are efficient

To end, one quote on financial markets:

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