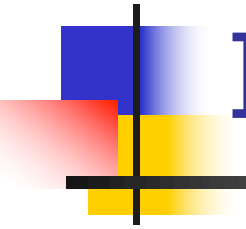
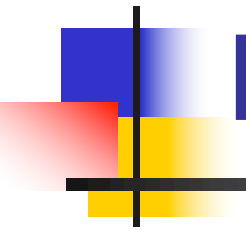


Investments

Lecture 8



Efficient Market

Random Walk

- Many investors and academics tried to find predictable patterns in stock prices
- The discovery of such recurring patterns would be a gold mine
- In reality, stock price movements are very close to random

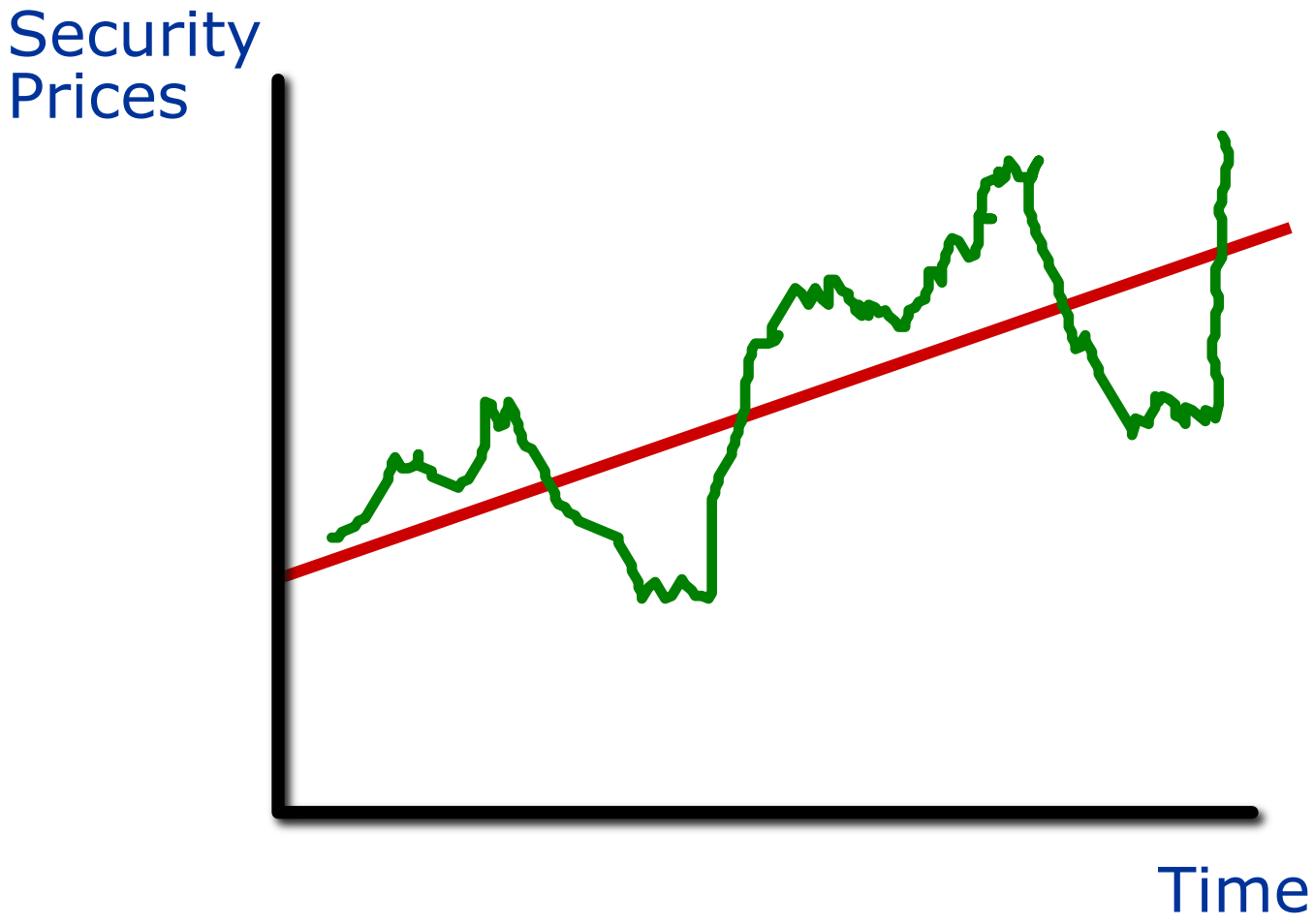
Random Walk

- Price changes are random and unpredictable

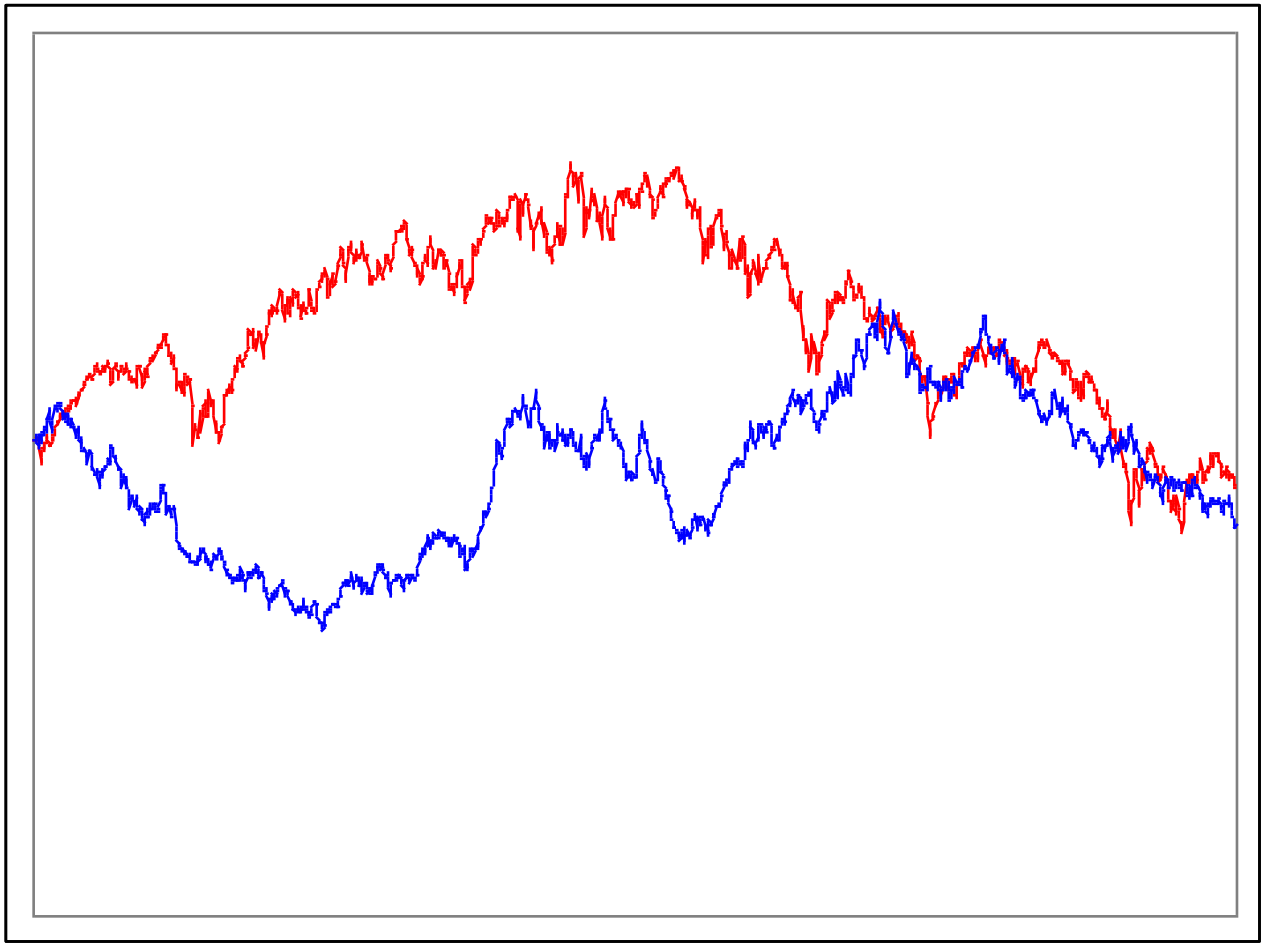
$$r_{t+1} = \ln P_{t+1} - \ln P_t = \mu + \sigma \times \varepsilon_{t+1}$$

  - r is the log-return of a stock (with continuous compounding)
  - μ and σ are the expected return and the standard deviation
  - ε is a random variable with a standard normal distribution

Random Walk with Positive Trend



Real and Simulated Stock Prices



Random Price Changes

Why are price changes random?

- Prices react to information
- Flow of information is random
- Therefore, price changes are random

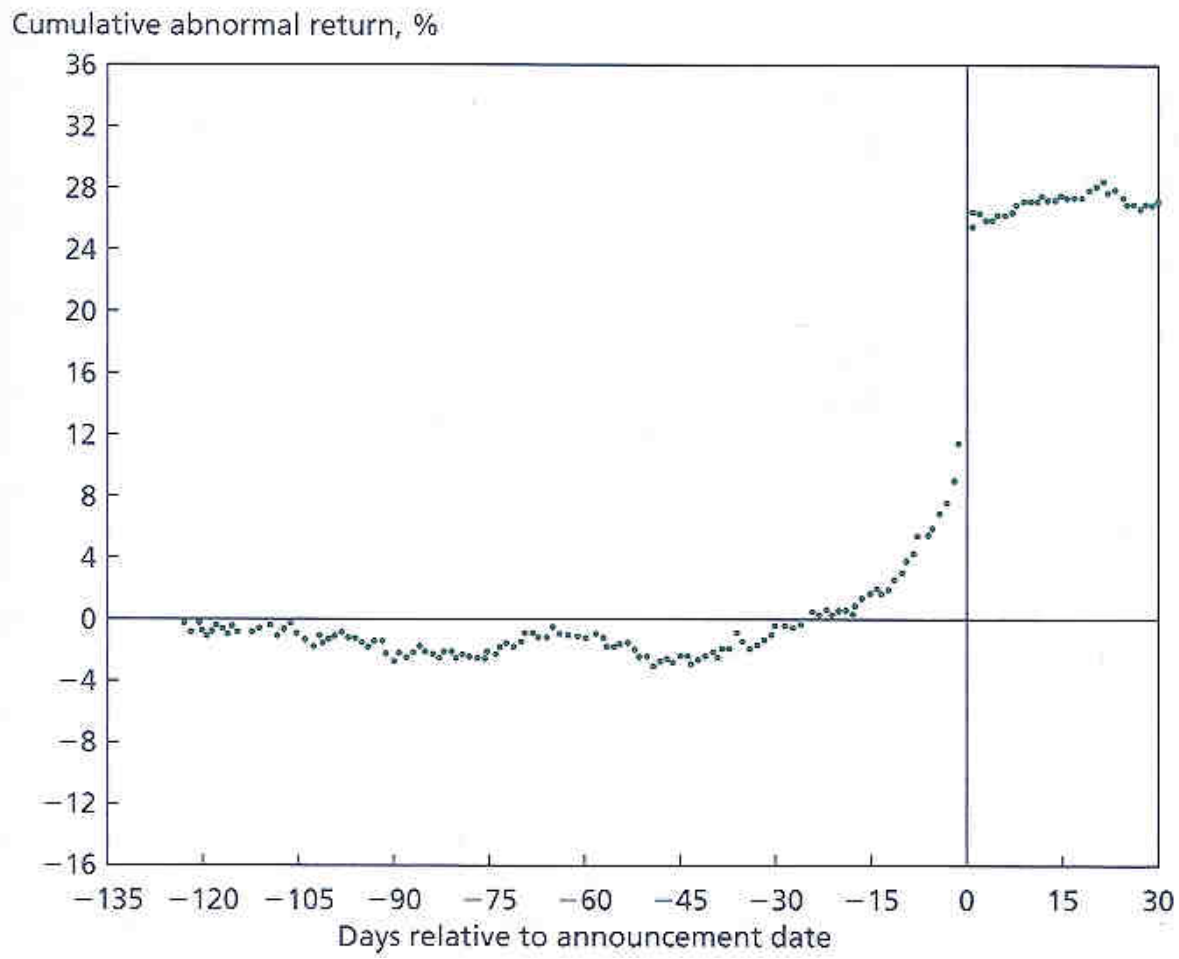
Random Walk

- Random stock movements are the necessary consequence of intelligent investors competing to discover relevant information
- Random stock movements are not proof of market irrationality

Random Walk

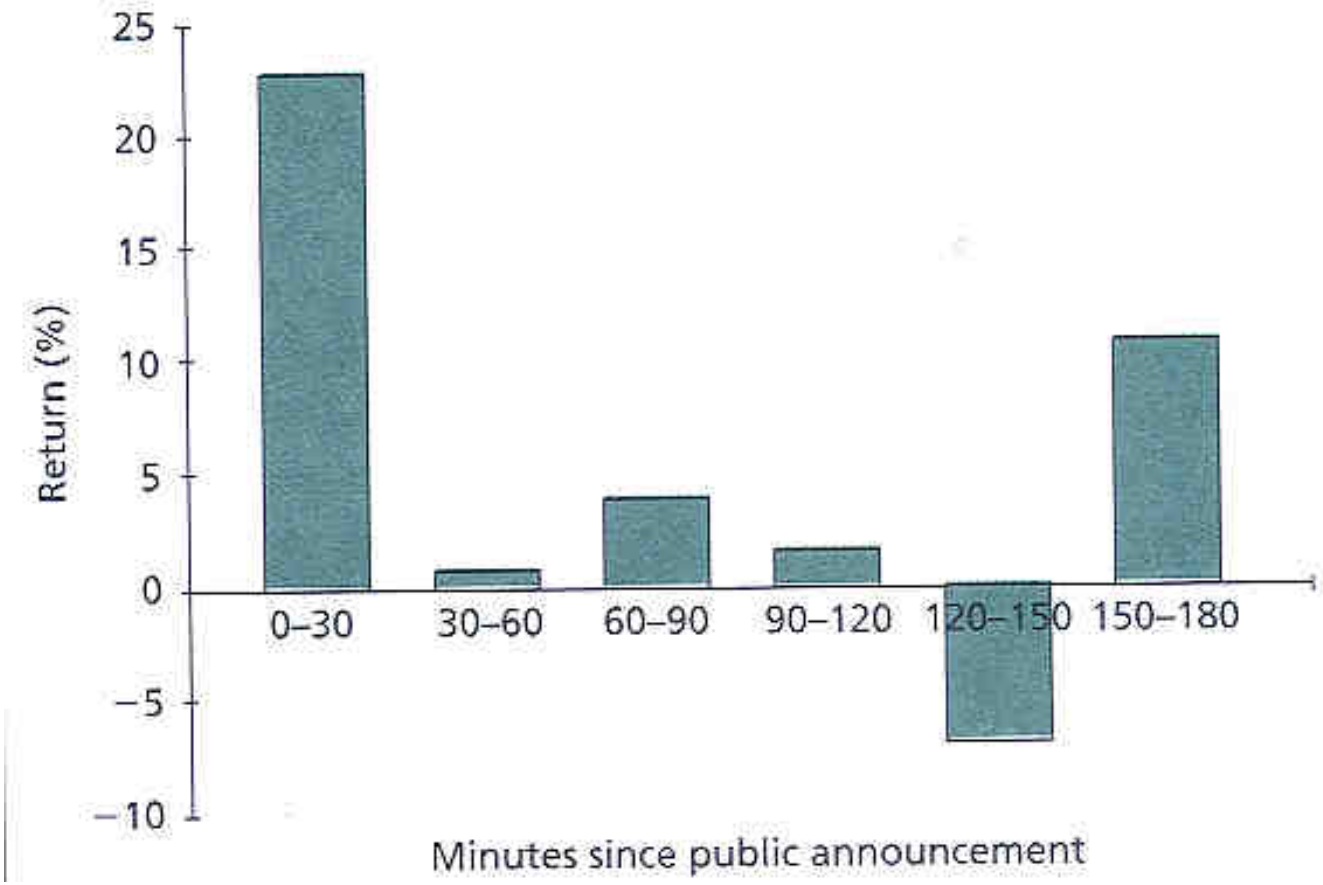
- You know that a stock will increase within a week by 10 percent
  - What should you do?
  - What happens if many other market participants have the same information?

Adjusted Cumulative Returns of Takeover Target Companies



Source: Keown and Pinkerton (1981)

Returns following Earnings Announcements



Source: Patell and Wolfson (1984)

Random Walk

- Prices react very fast to new information
- Competition in the financial markets assures that prices reflect all relevant information

Efficient Market Hypothesis

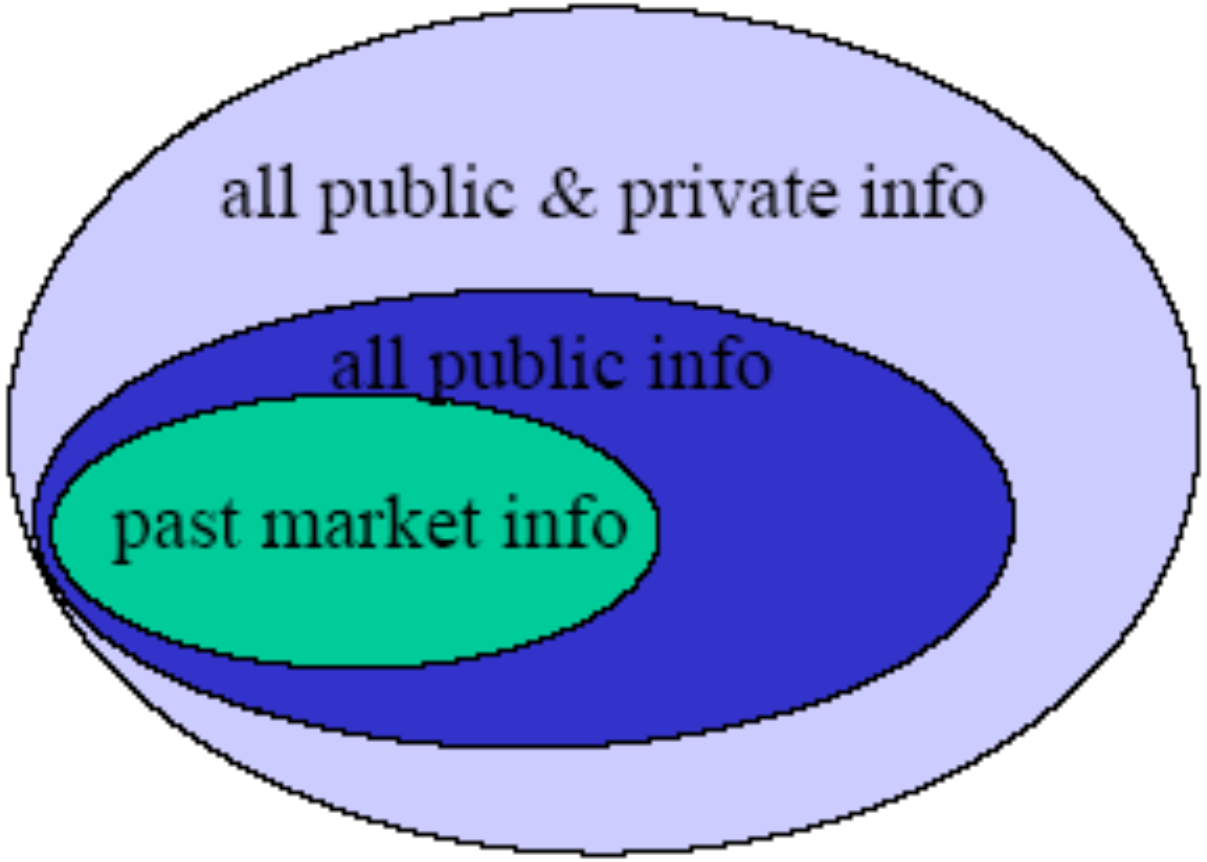
- The Efficient Market Hypothesis (EMH) states that prices of securities fully reflect available information
- Investors will spend resources to analyze new information as long as this generates higher investment returns

Market Efficiency also means:

- There is no free lunch:
  - the only way you can get higher returns is by taking on more risk
  - there is no information out there that can be used to construct strategies that earn returns higher than required for their risk

Three Version of the Efficient Market Hypothesis

- Weak-Form EMH
  - Stock prices already reflect all information contained in the history of stock trading
- Semistrong-Form EMH
  - Stock prices already reflect all publicly-available information
- Strong-Form EMH
  - Stock prices already reflect all relevant information including inside information


all public & private info
all public info
past market info

Blind Monkeys Throwing Darts

- Malkiel suggested that it does not matter how you choose stocks in efficient markets
- You can ask some blind monkeys to throw darts on the Wall Street Journal to select stocks
- “Random Walk Down Wall Street”

Adam Monk is the Chicago Sun-Times' stock-picking monkey.

Blind Monkeys Throwing Darts

- However, rational security analysis is still useful:
  - Monkeys will probably not pick a well-diversified portfolio with a desired level of risk
  - Monkeys do not know the tax considerations of stock choice
  - Monkeys do not take your specific circumstances into account (job, age, location)

A Paradox

- If markets are efficient, then there are no gains from doing research
- If there are no gains from doing research, then nobody does research
- If nobody does research, then asset prices are inefficient
- If markets are inefficient, then it is profitable to do research
- …

Evidence for EMH

- Stock prices appear to move randomly
- New information appears to be quickly incorporated into prices
  - E.g. announcement effect of takeover
  - Event study
- Professional money managers do not clearly beat the market on average

Predictability of Stock Returns

- Returns over the short-term (3-12-month holding periods) are slightly positively correlated
  - Momentum Effect: Portfolios of winner stocks outperform portfolios of loser stocks

Predictability of Stock Returns

- Returns over the long-term (3-5 years) are negatively correlated
  - Reversal Effect: Losers rebound and winners fade back

Predictability of Stock Returns

- Broad Market Measures
  - Aggregate stock market will be higher if the dividend yield (d/p) is high
  - Aggregate stock market will be higher if the earnings yield (e/p) is high
  - Aggregate stock market will be higher if the spread between high- and low-grade bonds is higher

D/P and following 1-year (5-year) return

Table I

Return-Forecasting Regressions

The regression equation is $R^e_{t\to t+k} = a + b \times D_t/P_t + \varepsilon_{t+k}$. The dependent variable $R^e_{t\to t+k}$ is the CRSP value-weighted return less the 3-month Treasury bill return. Data are annual, 1947–2009. The 5-year regression t-statistic uses the Hansen–Hodrick (1980) correction. $\sigma[E_t(R^e)]$ represents the standard deviation of the fitted value, $\sigma(\hat{b} \times D_t/P_t)$.

Horizon k	b	$t(b)$	R^2	$\sigma[E_t(R^e)]$	$\frac{\sigma[E_t(R^e)]}{E(R^e)}$
1 year	3.8	(2.6)	0.09	5.46	0.76
5 years	20.6	(3.4)	0.28	29.3	0.62

Source: Cochrane (2011)

D/P and following 7-year return

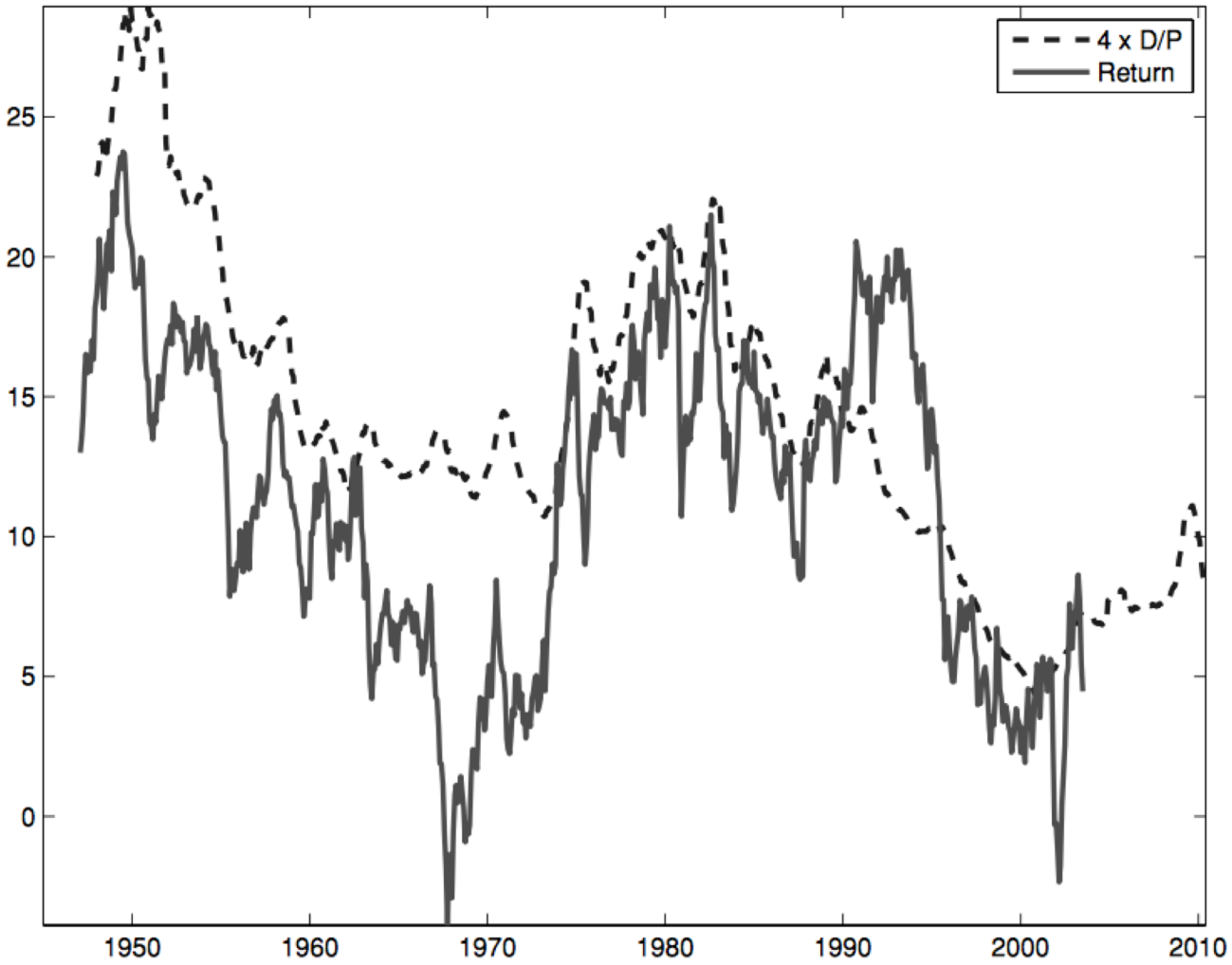
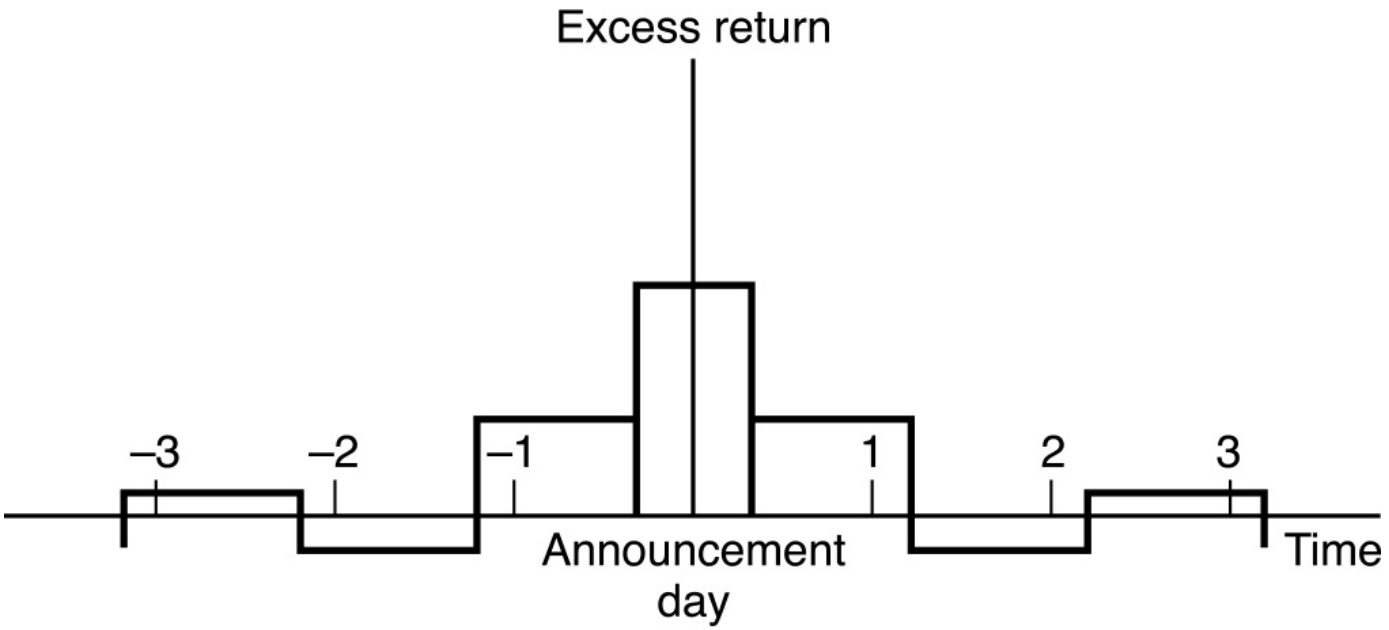


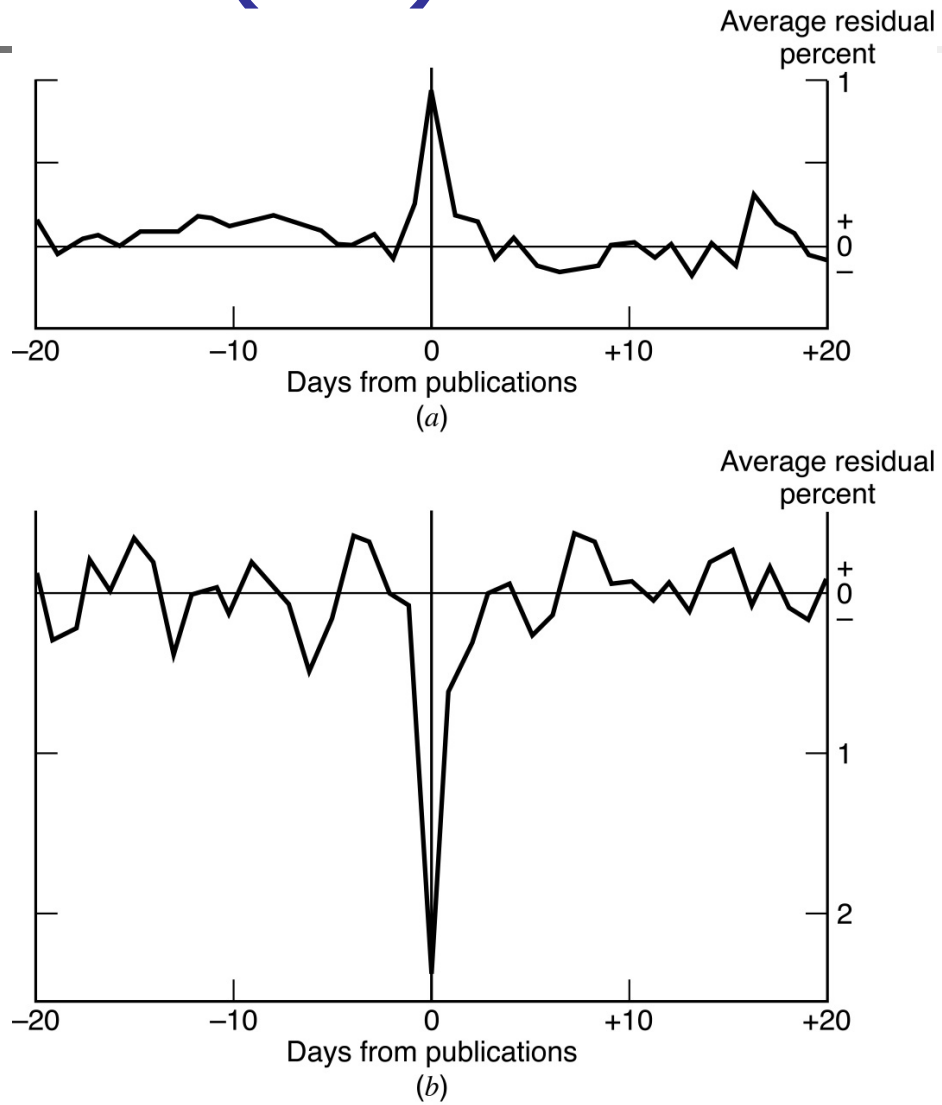
Figure 1. Dividend yield and following 7-year return. The dividend yield is multiplied by four. Both series use the CRSP value-weighted market index.

Source: Cochrane (2011)

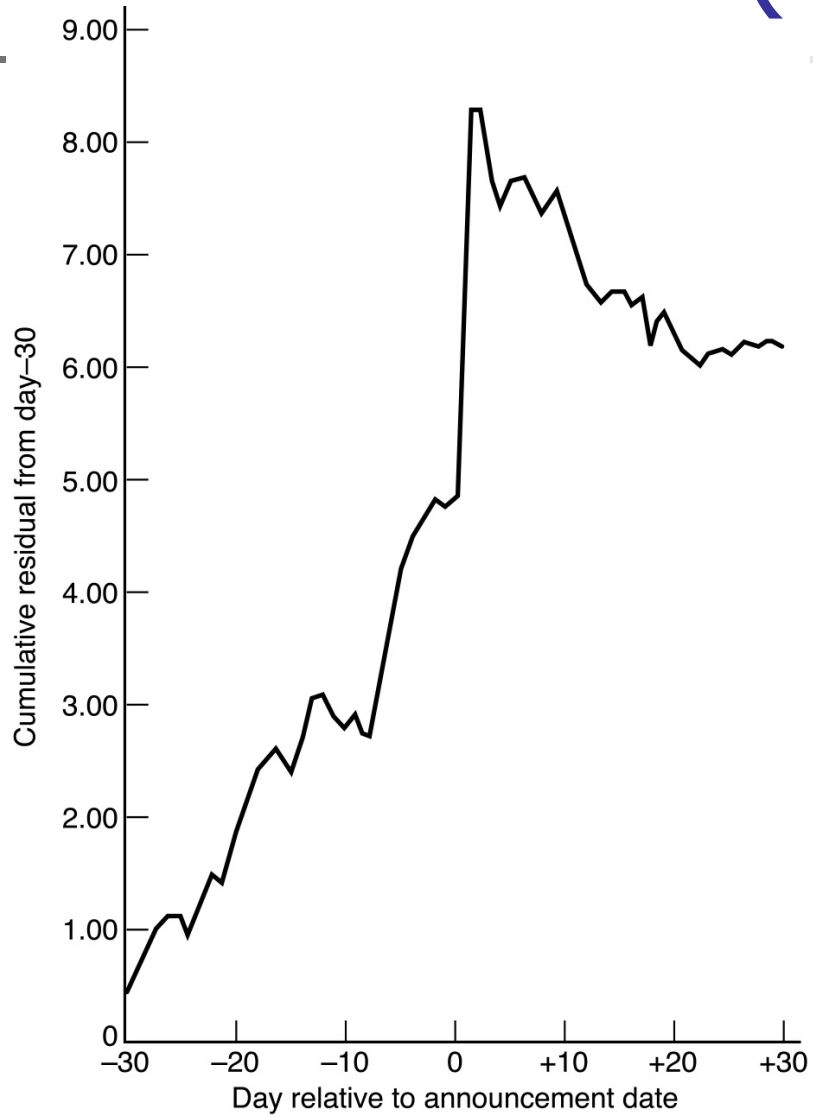
Event Studies



Event Studies: Abnormal Returns (AR)



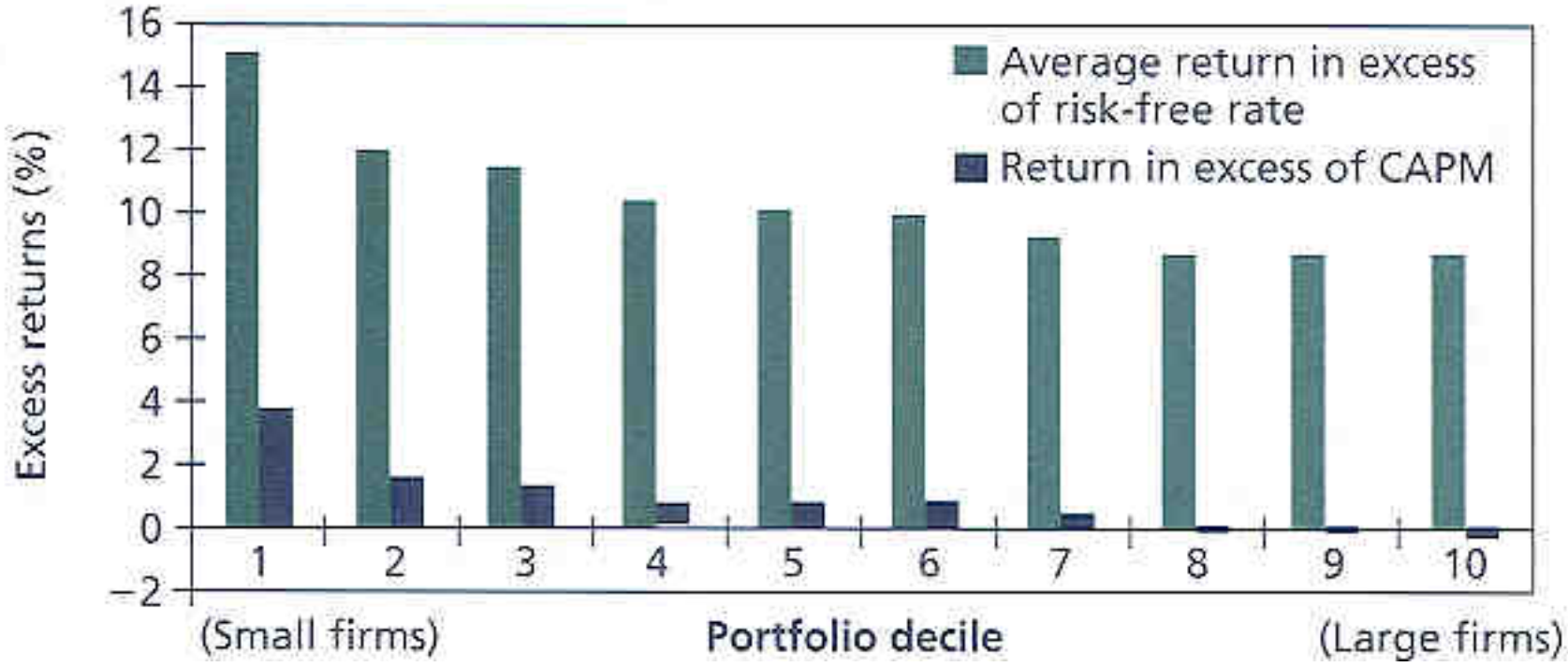
Event Studies: Cumulated Abnormal Returns (CAR)



Market Anomalies

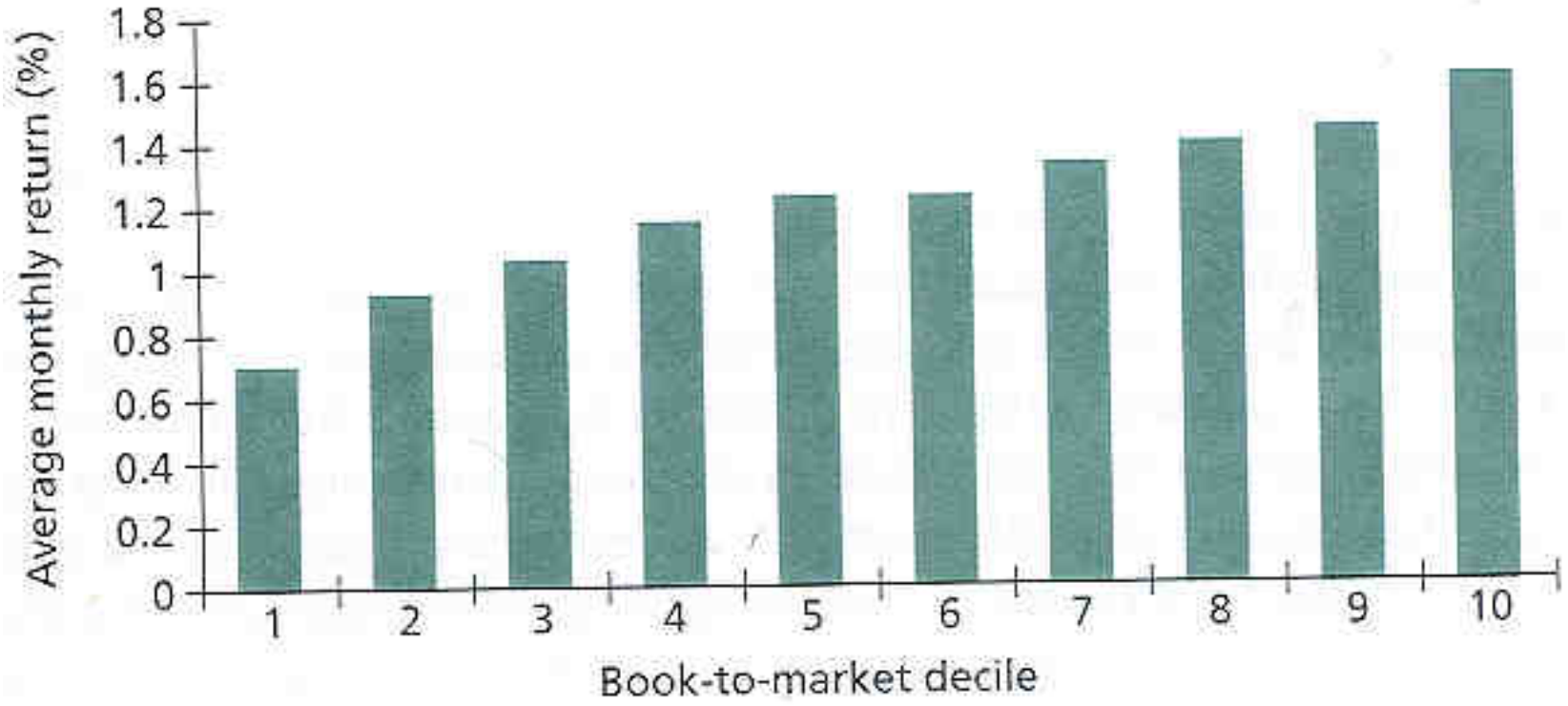
- Small-Firm Effect
  - Stocks of small firms have earned abnormal returns (particularly in January)
- Book-to-Market Effect
  - Stocks with high book-to-market ratios (value stocks) tend to outperform stocks with low book-to-market ratios (growth stocks)
- P/E Effect
  - Stocks with low price-earnings ratio (value stocks) tend to outperform stocks with high price-earnings ratio (growth stocks)

Small-Firm Effect



Source: Ibbotson Associates (2000)

Value versus Growth Stocks



Source: Fama and French (1992)

Additional Anomalies

- Monday Effect
- January Effect
- Sunshine Effect
- Full-moon Effect

TABLE 1

Average Percent Daily Returns by Day of the Week for 1980-1984 (%)

	U.S.	U.K.	Canada	Korea	Japan	Australia
Monday	–.116	–.042	–.218	–.072	.063	.021
Tuesday	.070	.071	.039	–.087	–.110	–.162
Wednesday	.128	.129	.117	.087	.165	.021
Thursday	.034	.041	.085	.014	–.001	.116
Friday	.080	.164	.090	.120	.082	.144
Saturday				.230	.107	
Overall[a]	.041	.074	.027	.043	.049	.021
F-statistic[b]	2.62	1.24	5.07	4.54	7.53	3.85
Significance	.03	.29	.00	.00	.00	.00

a Overall returns are computed without regard to the day of the week

b The F-statistics test equality of means across days of the week for each index

TABLE 2

After-Holiday Returns and Before-Holiday Returns for 1980-1984

	After-Holiday	Before-Holiday	Non-Holiday
U.S.	.028	.164	.038
U.K.	–.184	.177	.078
Canada	–.171	.186	.029
Korea	–.188	–.020	.055
Japan	.014	.131	.044
Australia	.037	.258	.020

TABLE 3

Daily Returns on The Spring/Fall Daylight Saving Weekend vs. All Other Weekends

	Spring	Fall	Other Weekend
NYSE (1967-1997)	–.181	–.627	–.070
AMEX (1967-1997)	–.210	–.662	–.085
NASDAQ (1967-97)	–.159	–.742	–.100
S&P500 (1928-1997)	–.143	–.548	–.041
TSE300 (1969-1998)	–.248	–.370	–.082
UK Total (1969-1998)	–.423	–.430	–.097
DAX100 (1973-1998)	–.148	–.018	–.026

Interpretation of Market Anomalies

- Market Anomalies might be due to:
  - Risk Premia
    - Small and value stocks tend to be more risky than large and growth stocks
  - Irrational Behavior
    - Investors prefer to purchase large and growth stocks and neglect small and value stocks
  - Data Mining
    - By chance, some criteria will appear to predict returns

Are Markets Efficient?

- Magnitude Issue
  - Some price anomalies are relatively minor, because transactions costs exceed the profits
- Lucky Event Issue
  - If you have enough people doing something, then some people will always be lucky
- Selection Bias Issue
  - Investors will not report the successful strategies

Types of Stock Analysis

- Technical Analysis
  - Research using historical price and volume information to predict future prices
- Fundamental Analysis
  - Research using economic and accounting information to predict future prices

Types of Portfolio Management

- Passive Investment Strategy
  - Buying a well-diversified portfolio without searching for mispriced securities
- Active Investment Strategy
  - Research companies and buy mispriced securities which are expected to outperform the market

Active and Passive

- Passive management: indexing
- Active management
  - Market Timing
  - Stock selection

Passive Management: Indexing

Index Management

- Motivation: You want to follow a passive portfolio strategy, but, you do not want to hold the market portfolio because of transaction costs. So, what should you do?

- Construct a portfolio that mimics as closely as possible the market portfolio.

Tracking Errors

- We find this portfolio by minimizing the tracking error

- Defined as

$$TE = \sigma(\tilde{r}_p - \tilde{r}_m)$$

Choosing Portfolio

- Mathematically, the index managers are solving this problem:

$$\min \sigma\left(\sum_{i=1 \, to \, N} w_i \tilde{r}_i - \tilde{r}_m \right)$$

- Choose weights of a portfolio to minimize the tracking error

$$\tilde{r}_p = \alpha_p + \beta_p \tilde{r}_m + \tilde{\varepsilon}_p$$

$$\tilde{r}_p - \tilde{r}_m = \alpha_p + (\beta_p - 1)\tilde{r}_m + \tilde{\varepsilon}_p$$

Thus

$$TE = \sqrt{\sigma_\varepsilon^2 + (\beta_p - 1)^2 \sigma_m^2}$$

- If you have a portfolio with a beta of one, then the only difference in risk between the market and your proxy is the proxy's residual risk.

Security Selection in Indexing

- The issues involved in equity indexing are:
  - Which securities should you include in your tracking portfolio?
  - How many securities should you include?
- The best securities to include are a set of securities that are:
  - are individually well diversified (i.e., low residual risk).
  - Have low bid-ask spreads
  - Have high liquidity.

How Many

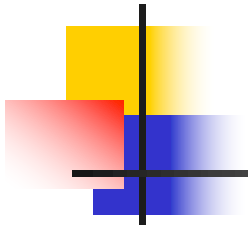
- The decision of how many securities is predominately determined by transaction costs.
- The more securities you include the lower the tracking error, but the larger the transaction costs.

Performance Enhancement

- Most index-fund managers claim that they do some performance enhancement simply because, if they did not, they would under-perform the index (as a result of transaction costs).
- We have presented considerable evidence that traditional indices are inefficient.
  - Fama and French (and other) evidence on size, book-to-market, and momentum.

Performance Enhancement

- A manager can reliably beat the market index (with some high probability): i.e. higher loading on other factors
- To maximize the probability of beating the index, the manager wants to solve the problem of maximizing his portfolio return relative to the benchmark.
- Subject to the constraint that the variance not be above some level.



$$\max E\left(\sum_{i=1}^{N} w_i \tilde{r}_i - \tilde{r}_m\right)$$

$$s.t$$

$$\sigma(\tilde{r}_p - \tilde{r}_m) \le \bar{\sigma}$$

$$\min \sigma\left(\sum_{i=1}^{N} w_i \tilde{r}_i - \tilde{r}_m\right)$$

$$s.t$$

$$E(\tilde{r}_p - \tilde{r}_m) \ge \bar{R}$$

Performance Enhancement

- Equivalent to mean-variance theory
- The only difference is that now, instead of solving the minimum-variance problem for the asset returns themselves, we are solving the problem for asset returns relative to a benchmark
- We can also consider the transaction costs in the constraints.

Active management:
Market timing
Stock selection

Market timing

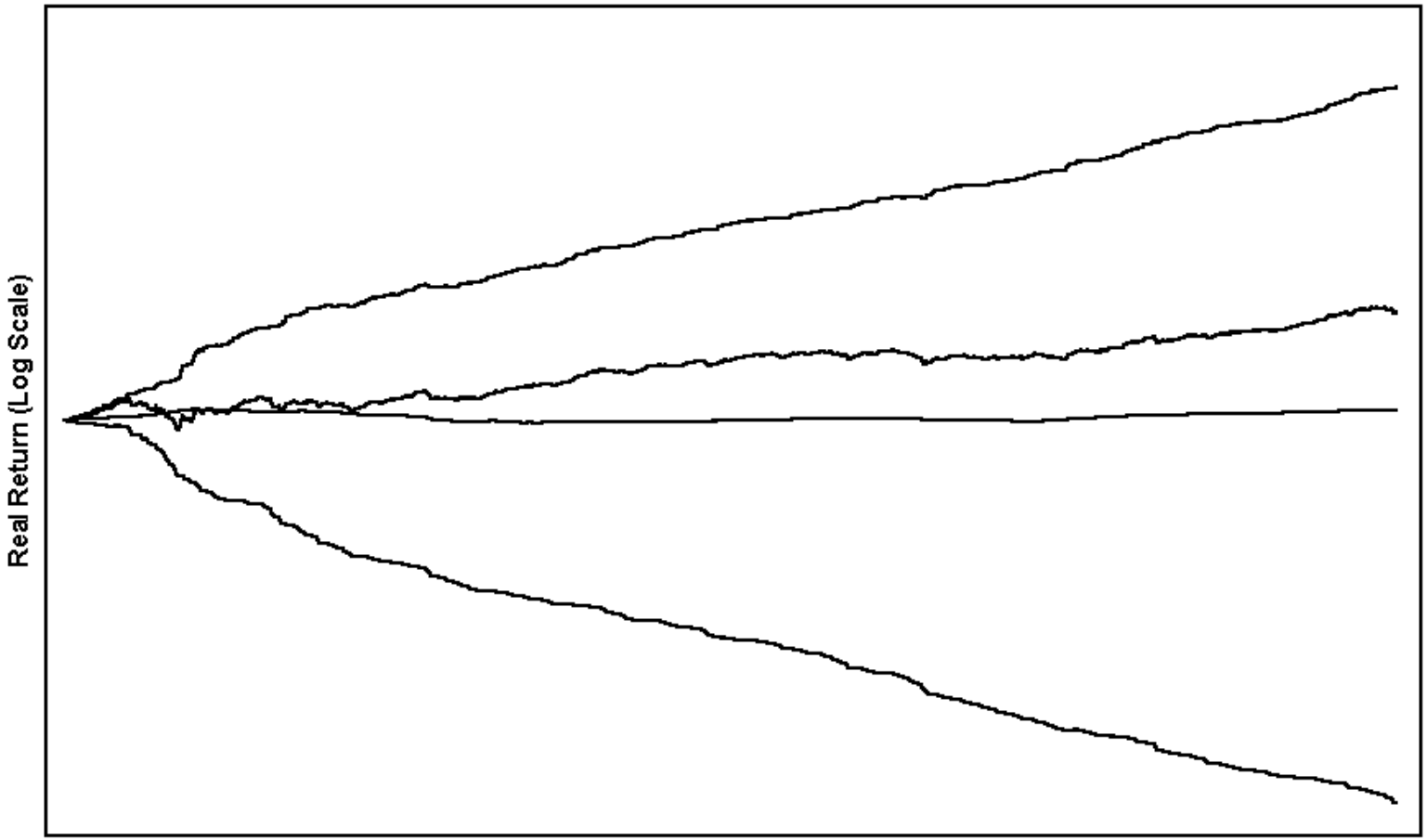
- The definition of market timing is: You believe you can forecast the market (and probably that other people are not forecasting correctly)
  - You may be using variables like the dividend yield, business cycle indicators or macroeconomic analysis to forecast returns.
  - You shift funds between a market index portfolio and a safe asset based on your forecasts

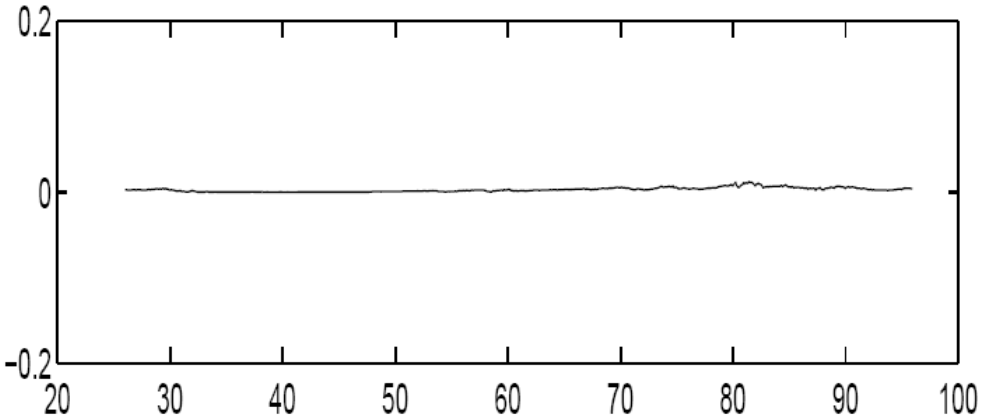
$$\tilde{r}_p = w_t \tilde{r}_m + (1 - w_t) r_f$$

Benefit of Market Timing

- If you had put $1 into T-Bills in January 1926, and rolled over the proceeds every month, you would have had $1.71 on January 1, 2003.
- If you had put $1 into S&P500, you would have had $282
- If you are a perfect market timer, you would have had $25,616,693

Figure 1: The maximum impact of market timing the S&P500

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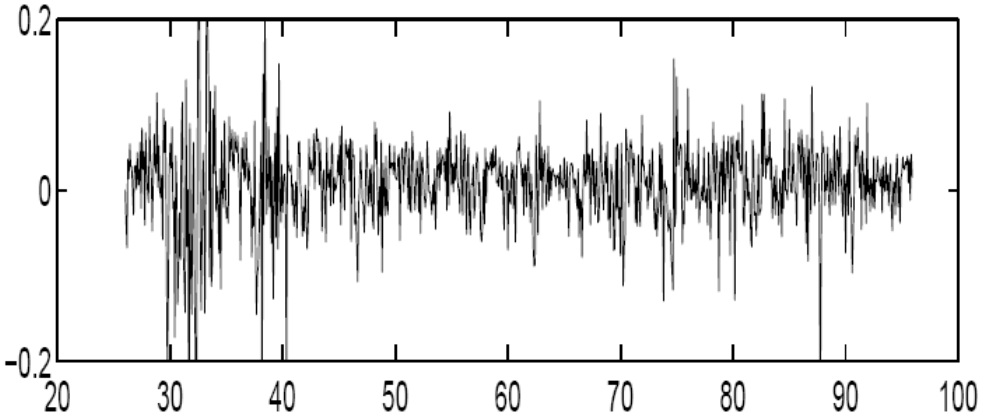
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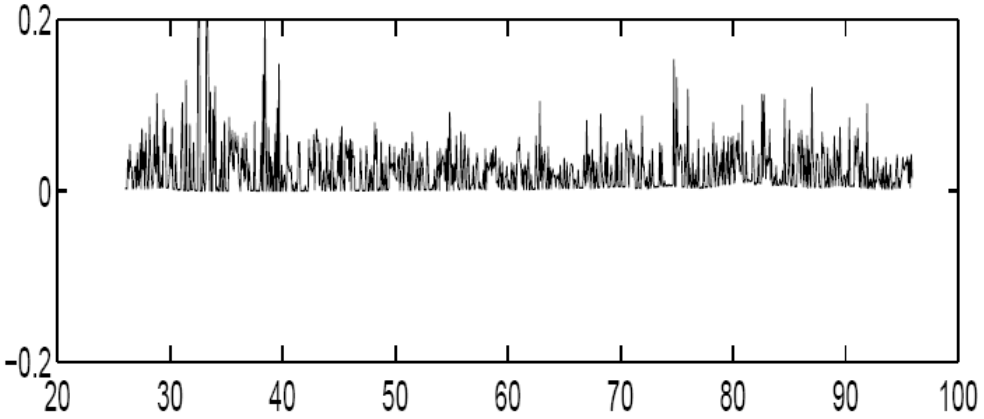
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Case of China

- If you had put ￥1 into bank in January 1993, and rolled over the proceeds every month, you would have had ￥1.25 on Dec 1, 2007.
- If you had put ￥100 into stock market, you would have had ￥14.1
- If you are a perfect market timer, you would have had ￥11919

Market Timing and CAPM

- If you take the CAPM as your benchmark then market timing presumes you can forecast the return on the market portfolio better than can the market itself.
- The return on the market in any month is equal to $\tilde{r}_{m,t} = E[r_{m,t}] + \tilde{e}_{m,t}$

Varying Beta

- You can vary the β of your portfolio by shifting in and out of the risk-free asset over time. If the beta of your portfolio is $\beta_{p,t-1}$, and the return on your portfolio will be:

$$\tilde{r}_{p,t} - r_{f,t} = \beta_{p,t-1}([E(\tilde{r}_{m,t}) + \tilde{e}_{m,t}] - r_{f,t}) + \tilde{e}_{p,t}$$

Superior Return

- If, on average $\beta_{p,t-1}$ is high when $\tilde{e}_{m,t}$ turns out to be high, you will earn superior returns. Specifically:

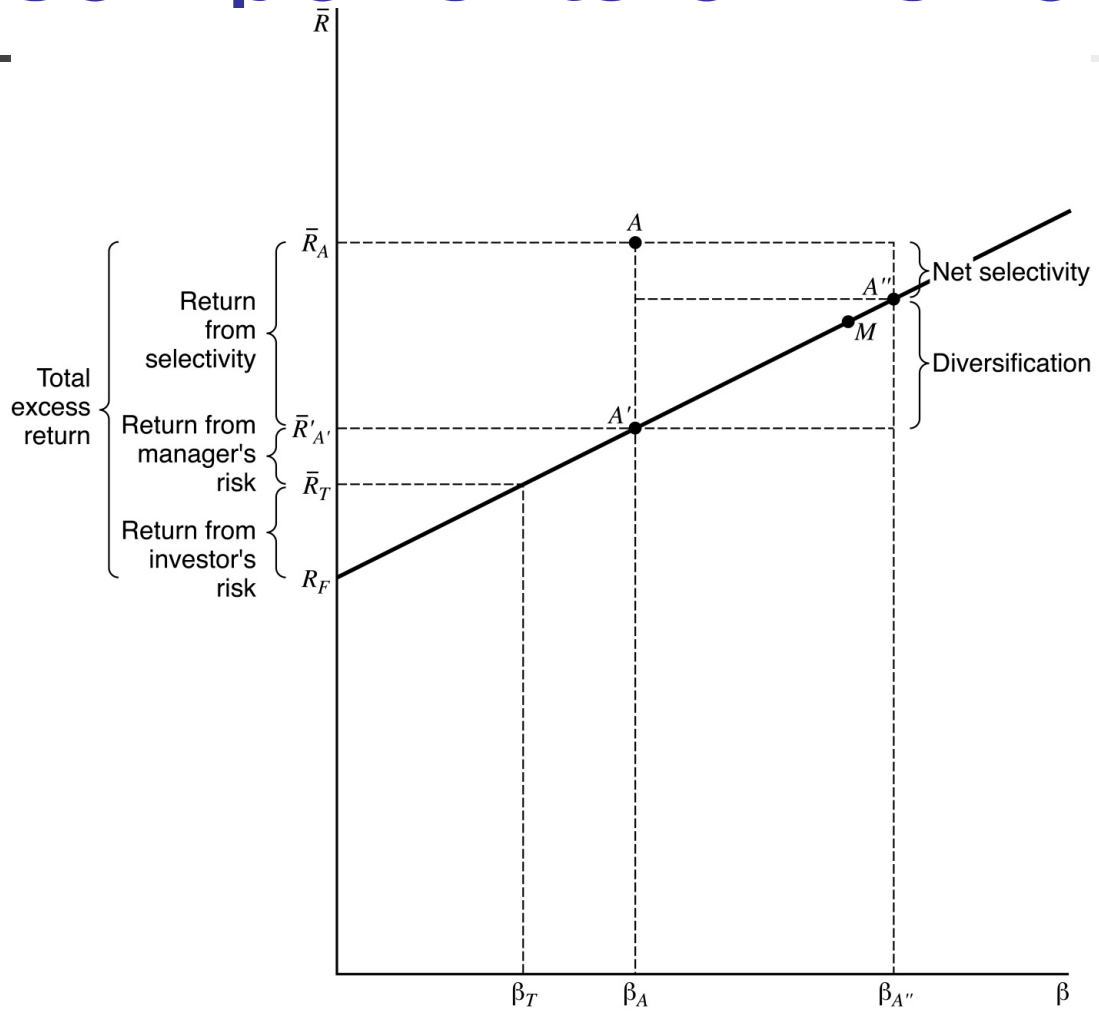
$$E(\tilde{r}_{p,t} - r_{f,t}) = \bar{\beta}_{p,t-1}(E(\tilde{r}_m) - r_f) + \mathrm{cov}(\tilde{e}_{m,t}, \beta_{p,t-1})$$

- Market Timing ability is as the ability to take high market sensitivity (β) positions before the market goes up and low beta positions before the market goes down

Stock Selection

- Stock picking is a portfolio management technique that presumes superior knowledge about expected returns.
  - For the most part we observe portfolio managers spending a lot of money on information and then selecting stocks they think are underpriced, i.e. stocks with positive alphas.
  - It appears that these portfolio managers attempt to construct a well diversified portfolio of positive alpha stocks.

Components of Performance



Fund Managers

- More money than ever is under the control of indirect managers, who make decisions about where money should be invested.
  - Though more money than ever is in passive funds, there is still over $1 trillion in active funds.
  - Active funds have considerably higher fees than passive funds.

Active Fund Fees

- For example, the Vanguard S&P 500 Index fund has expenses of 0.20% per year, while the Fidelity Magellan Fund has an initial load of 3%, expenses of 0.95% per year.
- The average expense ratio of active funds was 130 basis points.
- In the case of US, investors spend over $10 billion/year on active management.

Pay for the Managers

- In deciding where to invest money, and how much to pay the fund, it is crucial to be able to determine how much fund managers add.
- If fund managers are generating high returns by taking on more risk, they should not be paid for it.
- We should only pay a manager for getting high returns if we could not have gotten those returns with an implementable ex ante strategy.

For Example

- If we could have levered up an index fund and gotten those returns, we should not pay the manager
- If we could have used other ex-ante rules and gotten the same returns, we should not pay the manager.
  - Buying small stocks
  - Buying high book-to-market stocks
  - Buying high momentum stocks.

What should we pay for?

- We should only be willing to pay the manager what the extra returns that she can generate in excess of what we could have generated. The manager can do this in two ways:
  - Market timing, factor timing, or characteristic timing.
  - Stock selectivity.

Active Managers Performance

- Early studies found, and later studies continue to find that the average active manager adds very little/no value.
- This does mean that you are better off buying a passive fund than investing in an average active fund. However, there is also the question of whether there are some exceptional managers who do add value.

Stars

- Marcus (1990), in "The Magellan Fund and Market Efficiency," shows that the Peter Lynch exhibited statistically significant abnormal performance, even after we correct for the fact that he was the best performing manager of this period.
  - Lynch beat the S&P 500 in 11 of the 13 years in the 1977-1989 period.
  - Marcus shows that this in itself is not evidence of value enhancement. If we look at a set of 500 "coin-flippers," let each of them flip 13 coins, the winner will, on average, have 11.63 heads.

Stars

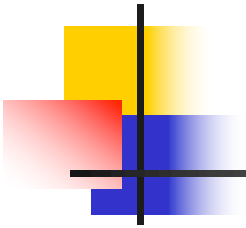
- However, Lynch also beat the S&P by large amounts and consistently (from 79-89, Magellan returned 28%/year, vs.17.5% for the S&P).
- Marcus shows that this level of performance is statistically significant, even after accounting for the fact that we have chosen the best manager.

Good Managers

- One way that you could potentially identify good active managers is by past performance.
- The evidence on the persistence of active managers is mixed, but there is some limited evidence consistent with persistence.
  - Chevalier and Ellison (1999) find that there is manager persistence, not fund persistence.

Period Jan 1 – Dec 31	Number of Funds	Top 30 Funds Each Period Number of Funds > S&P500	Subsequent Period Jan 1 – Dec 31	Performance of Same Funds Number of Funds > S&P500
1971 – 1975	172	30	1976 – 2002	17
1976 – 1980	249	30	1981 – 2002	4
1981 – 1985	275	30	1986 – 2002	6
1986 – 1990	391	30	1991 – 2002	12
1991 - 1995	628	30	1996 – 2002	5
1996 - 2000	1729	30	2001 - 2002	10

Source: Micropal (excludes international, balanced and specialty funds), Dimensional Fund Advisors Inc.
US study



- Also, Chevalier and Ellison (1999) find that other manager characteristics predict future performance:
  - Younger managers do better
  - Managers with an MBA do better
  - Undergraduate institution matters.
  - Higher composite SAT score managers do better.

Direct Comparisons

- The most popular performance measure is still the past return of a fund:
  - These measures fail to properly account for risk, and we could easily have taken on more risk without paying a manager.
- Often, comparisons are made of funds with "the same investment objectives." (Growth Funds, Value Funds, Income Funds, etc.)
  - However, these categorizations are not accurate, and are not usually a proper reflection of their risk.

CAPM Based Measures

- This set of measures uses the CAPM as the benchmark model.
- However, the ideas behind these measures are the basis for more general adjusted portfolio measures.
- All measures actual returns on a portfolio to the return achievable using the market and the risk-free asset.

Sharpe Measure

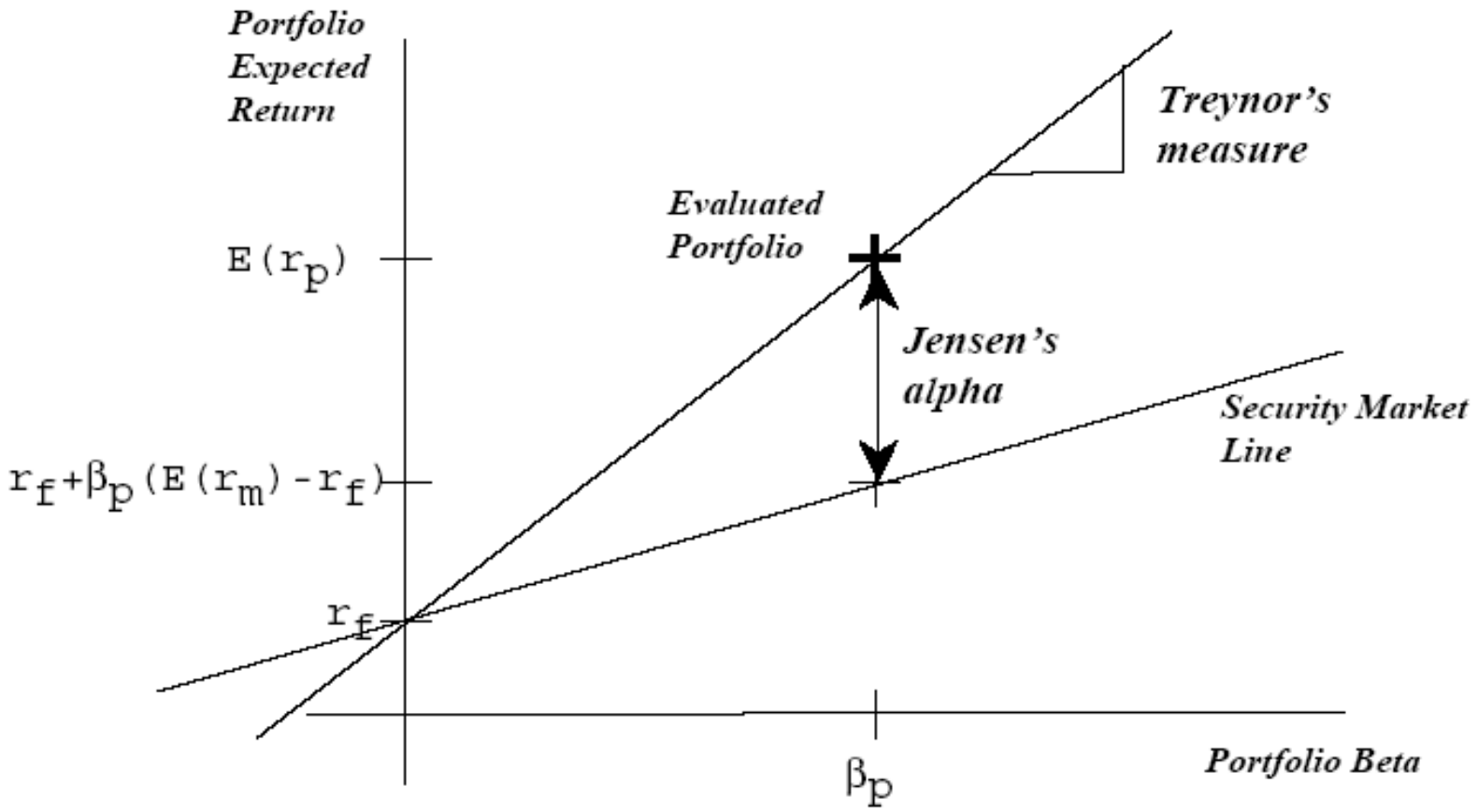
- For well diversified portfolios we should use the Sharpe Measure, or estimated Sharpe Ratio of a portfolio is appropriate.
- The Sharpe Measure is the reward to variability ratio for the portfolio ”p” (i.e., the slope of the CAL for security p)

Measures for Undiversified Portfolios

- The Sharpe measure is not appropriate for funds that you are considering as part of a larger portfolio, or when you are deciding how much to compensate managers.
- Want to use a measure which looks at the return relative to the systematic risk of the portfolio
  - Jensen Measure (alpha)
  - Treynor Measure ((Rp-Rf)/beta)
  - Appraisal Ratio (alpha / unsystematic risk std. dev.)

Three Measures

- These are three measures are based on the SML (Security Market Line), as opposed to the CML (Capital Market Line).
- Each of these measures is asking the question of how well the fund would have done relative to a portfolio of the market and risk-free asset with the same systematic risk.


Portfolio
Expected
Return
Treynor's
measure
Evaluated
Portfolio
E(rp)
Jensen's
alpha
Security Market
Line
rf+βp(E(rm)-rf)
rf
βp
Portfolio Beta

Jensen Index

- The Jensen measure is the most popular of these three measures, perhaps because it is so easy to calculate.
- Jensen's alpha is also the maximum you should be willing to compensate a portfolio manager.
  - Remember that α is in units of return
  - So if, for example, a fund has a pre-expense α of 0.0015 when calculated with a monthly regression, this means that we should be willing to pay up to 0.15%/month (or approximately 1.8%/year) in expenses.
  - Alternatively, were you to compensate the manager this much, your after-expense α would be zero.

Jensen Index

- However, the Jensen measure does not take into account the amount of systematic (β) risk that the fund took on in beating the market.

Treynor Index

- The Treynor measure makes this adjustment for the amount of systematic risk taken on in earning alpha
- The Treynor measure is used when the portfolio you are evaluating is one actively managed portfolio out of many that you will be adding to a passive portfolio.

Treynor Index

- The Treynor measure is the slope of the SML for the actively managed portfolio under consideration:

$$T_p = \frac{E(r_p) - r_f}{\beta_p}$$

- it is similar to the Sharpe ratio — except that there is a β rather than σ in the denominator.
- It is a reward / variability measure when β (systematic risk), rather than total risk, is under consideration.

Adjusted Treynor Measure

- The adjusted Treynor measure is defined relative to the slope of the SML

$$T_p^* = \frac{E(r_p) - r_f}{\beta_p} - \frac{E(r_m) - r_f}{\beta_m} = \frac{\alpha_p}{\beta_p}$$

- Example

Appraisal Ratio

- The problem with both the Jensen and Treynor measures is that they do not adjust for the amount of idiosyncratic risk in the portfolio.
- The more idiosyncratic risk, the more of the fund we can add to a diversified portfolio without driving up the variance too much.

Appraisal Ratio

- The Appraisal Ratio is like a benefit/cost ratio for a mispriced fund.

$$AR_A = \frac{\alpha_A}{\sigma_{e_A}}$$

Appropriate Measure: Compensation

- Compensation: Jensen Index
- Jensen's alpha is the maximum amount you should be willing to pay a manager
  - The payment should be in terms of the fraction of the portfolio value per period.
  - If you are using a past alpha, this assumes that the manager's future performance will be the same as their past performance

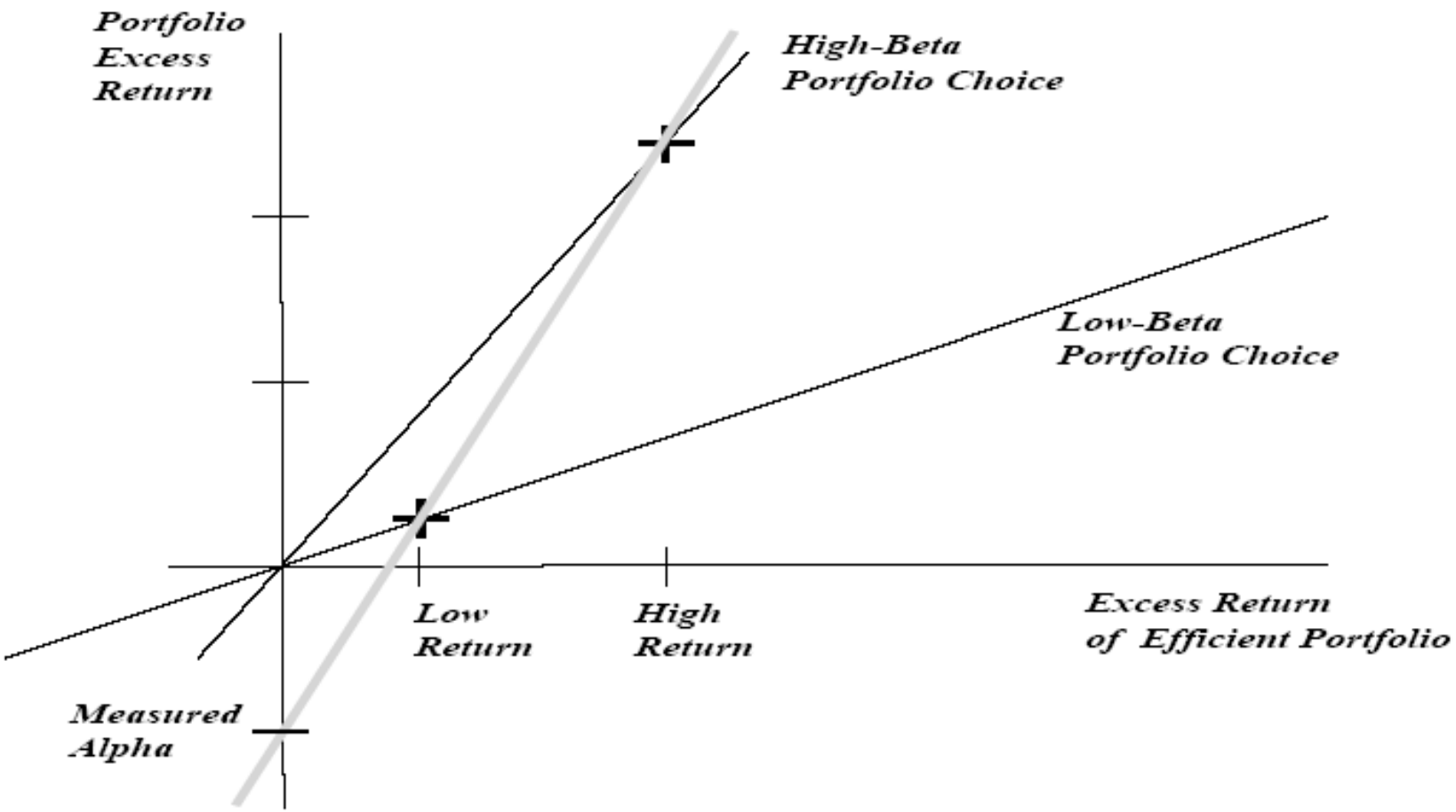
Optimal Portfolio Choices

- Use the Sharpe Ratio when the portfolio represents the entire investment fund
- Use the Appraisal Ratio when the portfolio represents the single actively managed portfolio to be optimally mixed with the passive portfolio
- Use the Treynor Measure: when the portfolio represents one of many actively managed portfolios out that you are adding to a passive portfolio.

Name	ROR	STD	SR	beta	alpha	Treynor	Treynor*	Res Std	AR
Avg. Risk Free Rate	0.34%								
S&P 500	1.20%	4.40%	0.20	1	0.00%	0.86%	0.00%	0.00%	
Dean Witter Div Grth Sec	1.14%	3.79%	0.21	0.81	0.17%	0.99%	0.13%	1.29%	13.2%
Dreyfus Fund	0.87%	3.69%	0.14	0.74	-0.02%	0.72%	-0.14%	1.74%	-1.2%
Fidelity Magellan Fund	1.48%	5.12%	0.22	1.09	0.17%	1.05%	0.19%	1.79%	9.5%
Janus Fund	1.22%	3.99%	0.22	0.8	0.26%	1.10%	0.24%	1.88%	13.8%
Pioneer II	1.05%	4.59%	0.15	0.96	-0.11%	0.74%	-0.12%	1.80%	-6.1%
Putnam Growth and Income	1.18%	3.61%	0.23	0.77	0.03%	1.09%	0.23%	1.25%	2.1%
Templeton World Fund	1.16%	4.26%	0.19	0.85	0.14%	0.96%	0.10%	2.04%	6.9%
Twentieth Century Select	1.09%	5.17%	0.15	1.09	-0.22%	0.69%	-0.17%	1.93%	-11.4%
Vanguard Index TR 500	1.18%	4.56%	0.18	1	-0.03%	0.84%	-0.02%	1.20%	
Windsor Fund	1.23%	4.40%	0.20	0.87	0.19%	1.02%	0.16%	2.17%	8.8%

Market Timing

- A manager who has market timing ability may appear to have poor performance using the standard measures
- It can therefore be useful to decompose the timing and selectivity abilities of a manager


Portfolio
Excess
Return
High-Beta
Portfolio Choice
Low-Beta
Portfolio Choice
Low
Return
High
Return
Excess Return
of Efficient Portfolio
Measured
Alpha

Market Timing Ability

- Henriksson and Merton:

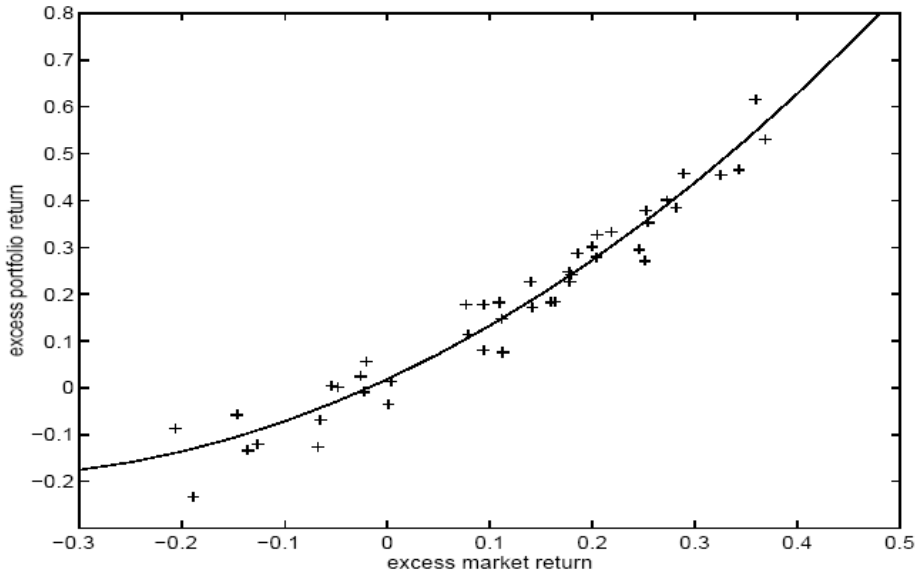
$$\tilde{r}_{p,t} - r_{f,t} = \alpha + b_p(\tilde{r}_{m,t} - r_{f,t}) + c_p D_t(\tilde{r}_{m,t} - r_{f,t}) + \tilde{\varepsilon}_{p,t}$$

$$D_t = 1 \quad if \quad r_{m,t} > r_{f,t}; 0 \quad otherwise$$

Market Timing Ability

- Treynor and Mazuy:

$$\tilde{r}_{p,t} - r_{f,t} = \alpha + b_p(\tilde{r}_{m,t} - r_{f,t}) + c_p(\tilde{r}_{m,t} - r_{f,t})^2 + \tilde{e}_{p,t}$$



- This shows the fitted Treynor Mazuy regression for simulated data, with $b = 1$ and $c = 1.5$.

Findings

- The Treynor and Mazuy study finds no evidence of market timing ability
- Henriksson finds that 62% of funds have negative market timing ability.
- However, studies such as that by Grinblatt and Titman (1989) suggest that some funds have selectivity ability (positive alphas w.r.t. 3-factor model).

APT-based Measures

- All of the measure discussed above (with the exception of Grindblatt and Titman) are based on the CAPM as a benchmark. In most situations, the CAPM will be more appropriate. Luckily, we can use the same basic measures
- Since our definition of total risk has not changed, we calculated the Sharpe measure just as we did with the CAPM.
- The intuition for the Jensen measure is still the same as with the CAPM, but now need to calculate it based on the APT. The same is the Appraisal ratio

APT-based Measure

- Treynor Measure:
  - With the APT the Treynor Measure is not well-defined because there are multiple sources of risk.
  - Use Jensen's Measure or the Appraisal ratio
- Factor Timing Ability
  - the test can be modified to look for factor timing ability by including the square of each factor-portfolios return as a right-hand side variable.
  - A significant positive coefficient on this variable is evidence of successful "tilting" (factor timing ability.)