The Efficient Market Hypothesis

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Agenda

- Background and Definitions
- Tests of Efficiency
- Arguments against Efficiency
- Conclusions

Overview

- An ideal market is one in which prices provide accurate signals for resource allocation
- Extreme null hypothesis: a market is “efficient” if prices always “fully reflect” all available information
- Three forms of Efficiency:
  - Weak form
  - Semi-strong form
  - Strong form

Defining “Fully Reflect”

- Most work based on assumption that market equilibrium can be stated in terms of expected returns

$$E(\tilde{p}_{j,t+1}|\Phi_t)=[1+E(\tilde{r}_{j,t+1}|\Phi_t)p_{jt}$$

  - E = expected value operator, p_{jt} = price of security j at time t, $p_{j,t+1}$ = price at t+1, $r_{j,t+1}$ = one-period percentage return, Φ_t = information set assumed to be fully reflected
- Elevates concept of expected value
  - One possible measure of distribution of returns
  - Market efficiency does not per se instill it with any special importance

Expected return or “fair game” efficient market

- Market equilibrium can be stated in terms of expected returns
- Equilibrium returns are formed on basis of information set Φ_t
- Rules out possibility of trading systems based only on information Φ_t that have excess expected profits or returns

  Let $x_{j,t+1}=p_{j,t+1} - E(p_{j,t+1}|\Phi_t)$

  Then $E(x_{j,t+1}|\Phi_t)=0$

- So by definition the sequence $\{x_{jt}\}$ is “fair game” with respect to the information sequence $\{\Phi_t\}$

  Equivalently: $z_{j,t+1}=_{rj,t+1} - E(r_{j,t+1}|\Phi_t)$

The Submartingale Model

- Suppose we assume that for all t and Φ_t:

$$E(p_{j,t+1} \mid \Phi_t) \geq p_{jt} \text{ equivalently, } E(r_{j,t+1} \mid \Phi_t) \geq 0$$

- Expected value of next period's price is equal to or greater than the current price
- If submartingale, then trading rules based only on information Φ_t in cannot have greater expected profits than policy of always buying-and-holding the security during the future period

The Random Walk Model

- Successive price changes are independent and identically distributed

  Formally: $f(r_{j,t+1} | \Phi_t) = f(r_{j,t+1})$

- Entire distribution is independent of Φ_t
- More detailed statement and extension of “fair game” efficient markets model
  - Environment is such that return distributions repeat themselves

Market Conditions Consistent with Efficiency

- Sufficient but not necessary:
  - No transactions costs in trading securities
  - All available information is costlessly available to all market participants
  - All agree on implications of current information for current price and distributions for future prices
- All potential sources of inefficiency
- All most likely exist somewhat in the real world

Weak Form Tests

- Most results for weak form tests come from Random Walk literature
- Filter Tests (Fama-Blume and Alexander): for very small filters it is possible to devise trading schemes based on very short-term price swings that will on average outperform buy-and-hold
  - .5-1% filters
  - Miniscule average profits
  - Over long term outperform buy-and-hold
  - With minimum trading costs small filters advantage disappears
- Statistically significant, economically insignificant

Serial Covariance of a “fair game”

- Serial covariance of a “fair game” and a random walk are zero
- $E(x_{t+r}+x_t)=\int x_t E(x_{t+r}|x_t)f(x_t)dx_t$ and if x_t is fair game: $E(x_{t+r}|x_t)=0$
  - → all serial covariances between lagged value are zero
  - Observations are linearly independent
- Serial covariances of one-period returns aren’t necessarily zero
- Deviation of return for t+1 from its conditional expectation is a “fair game” variable but conditional expectation itself can depend on the return observed for t
- A large approximation in estimating covariances but seems not to greatly affect the results of covariance tests for common stocks

TABLE 1 (from [10])
First-order Serial Correlation Coefficients for One-, Four-, Nine-, and Sixteen-Day Changes in Log_e Price

Stock	Differencing Interval (Days)			
	One	Four	Nine	Sixteen
Allied Chemical	.017	.029	−.091	−.118
Alcoa	.118*	.095	−.112	−.044
American Can	−.087*	−.124*	−.060	.031
A. T. & T.	−.039	−.010	−.009	−.003
American Tobacco	.111*	−.175*	.033	.007
Anaconda	.067*	−.068	−.125	.202
Bethlehem Steel	.013	−.122	−.148	.112
Chrysler	.012	.060	−.026	.040
Du Pont	.013	.069	−.043	−.055
Eastman Kodak	.025	−.006	−.053	−.023
General Electric	.011	.020	−.004	.000
General Foods	.061*	−.005	−.140	−.098
General Motors	−.004	−.128*	.009	−.028
Goodyear	−.123*	.001	−.037	.033
International Harvester	−.017	−.068	−.244*	.116
International Nickel	.096*	.038	.124	.041
International Paper	.046	.060	−.004	−.010
Johns Manville	.006	−.068	−.002	.002
Owens Illinois	−.021	−.006	.003	−.022
Procter & Gamble	.099*	−.006	.098	.076
Sears	.097*	−.070	−.113	.041
Standard Oil (Calif.)	.025	−.143*	−.046	.040
Standard Oil (N.J.)	.008	−.109	−.082	−.121
Swift & Co.	−.004	−.072	.118	−.197
Texaco	.094*	−.053	−.047	−.178
Union Carbide	.107*	.049	−.101	.124
United Aircraft	.014	−.190*	−.192*	−.040
U.S. Steel	.040	−.006	−.056	.236*
Westinghouse	−.027	−.097	−.137	.067
Woolworth	.028	−.033	−.112	.040

* Coefficient is twice its computed standard error.

Behavior of Stock Market Prices, Eugene F. Fama, Journal of Business

Weak Form Tests: Behavior of Stock Market Prices

- 1957-1962
- N=1200-1700 observations per stock
- Statistically significant deviations from zero covariance
- Small absolute levels of serial correlation observed
    - EX: correlation as small as .06 almost double its standard error, but can also be used to explain about .36% of variation in the current price change
- Difficult to use as the basis of a substantially profitable trading system
    - Also difficult to determine what degree of serial correlation would imply the existence of trading rules with substantial expected profits

Random Walk Literature

- Violations of independence assumption of random walk model expected
  - “Fair game” expected return model as the basic model of market equilibrium
  - Random walk arises when additional conditions are such that distributions of one-period returns repeat themselves through time
- Osborne, Fama: large daily price changes tend to be followed by large daily changes
  - Signs of successor changes are random
  - Violates random walk model but not market efficiency hypothesis
  - Potential explanation: new information may not be evaluated precisely immediately

Niederhoffer and Osborne

- Reversals are 2-3x more likely than continuations
  - Bunching on unexecuted buy and sell limit orders
- Continuations are more frequent after a proceeding continuation than after a reversal
  - Tendency for limit orders “to be concentrated at integers, halves, quarters, and odd eighths in descending order of preference”
- Demonstrate statistically significant deviations from independence in price changes but Fama argues the types of dependence uncovered do not imply market inefficiency
- For specialist: unexecuted buy and sell limit orders
  - Monopoly power of information and market inefficiency with respect to strong form tests

Distributional Evidence

- Statistical tools relevant for testing
- Interpretation of any results
- Fama and Blume: non-normal stable distributions are a better description of distributions of daily returns on common stocks than normal distributions
- Economists are hesitant to accept these results

“Fair Game” Models in Treasury Bill Market

- Roll: first weak form empirical work in “fair game” tradition
- Used 3 theories of term structure:
  - Pure expectations hypothesis
  - Two market segmentation hypotheses (“liquidity preference” hypothesis)
  - Three theories differ only in value assigned to “liquidity premium”
- $r_{jt}=E(r_{o,t+j-1}|\Phi_t)+L_{jt}$
  - $L_{j,t}$: liquidity premium, r_{jt}: rate observed from term structure at period t for one week loans to commence at t+j-1 (“futures rate”), r_{j+1},t-1: rate on one week loans to commence at t+j-1, but observed at t-1
- Conditional expectation required in all three theories: $E(r_{j,t}|\Phi_{t-1})=r_{j+1,t-1}+E(L_{jt}|\Phi_{t-1})-L_{j+1,t-1}$

Roll: Treasury Bill Market

- The two market segmentation hypotheses fit the data better than the pure expectations hypothesis (slight advantage to liquidity preference hypothesis)
- The market for Treasury Bills is efficient
  - Z_{jt} seems to be serially independent
  - Non-normal distribution
  - If he had assumed normal distribution, support would not be so strong

Multiple Security Expected Return Model

- Single Securities Test
- Are securities “appropriately priced” vis-a-vis one another?
- Sharpe and Lintner’s Economic theory of equilibrium expected returns
- Expected one-period return on a security is the one-period riskless rate of interest plus a “risk premium” that is proportional to covariance
- Risk adjusted premium

Semi-Strong Form Tests

- Test whether current prices “fully reflect” all obviously available public information
- Each test is concerned with adjustment of prices to one kind of information generating event
- Fama, Fisher, Jensen, and Roll (FFJR): stock market able to respond efficiently to information implicit in a split

Splits and the Adjustment of Stock Prices (FFJR)

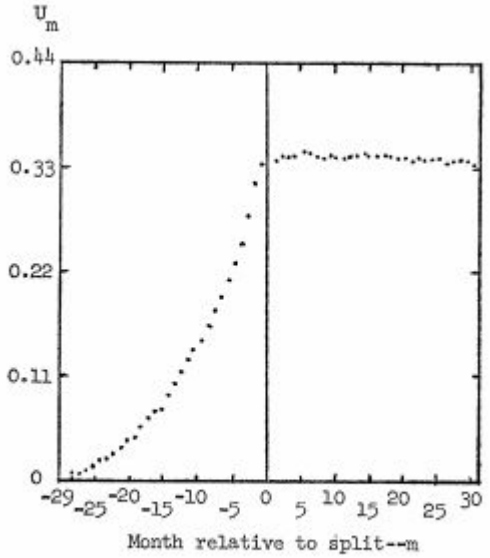


FIGURE 1a
Cumulative average residuals—all splits.

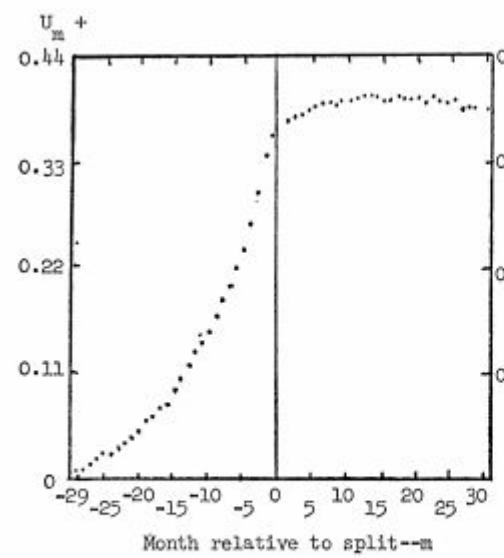


FIGURE 1b
Cumulative average residuals for dividend "increases."

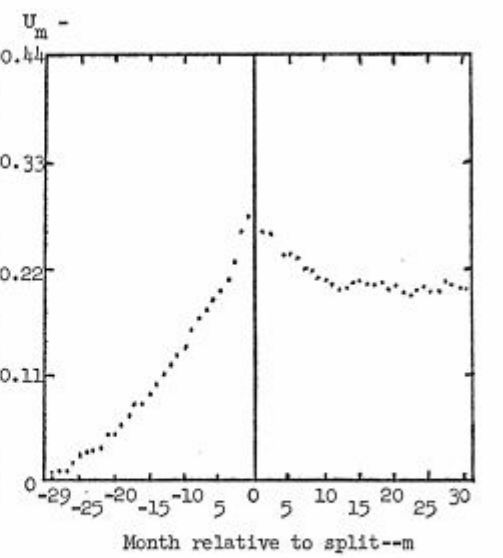


FIGURE 1c
Cumulative average residuals for dividend "decreases."

Public Announcements

- Annual Earnings Announcements (Ball and Brown):
  - 261 firms from 1946-1966
  - found no more than 10-15% of information in annual earnings announcement had not been anticipated by the month of the announcement
- Discount Rate changes by Federal Reserve Banks (Waud):
  - “Announcement effect” for first trading day after announcement
    - magnitude of adjustment <.5%
  - If anything, the market anticipates the announcement
    - Non-random patterns preceding announcement

Public Announcements

- Large Secondary Offerings of Common Stock and New issues of Stock
  - On average secondary issues are associated with decline of 1-2% in cumulative average residual returns
  - Magnitude of price adjustment unrelated to size of issue so not due to “selling pressure”
  - Evidence that largest negative cumulative average residuals occur where vendor is the corporation itself or one of its officers
  - Evidence that corporate insiders at least sometimes have important information about their firm not yet publicly known
  - Supports semi-strong form but also provides evidence against strong-form model

Strong Form Tests

- All available information is fully reflected in prices so that no individual has higher expected trading profits than others because he has monopolistic access to some information
  - Previous contradictory example: NYSE specialists
  - Officers of corporations
- Model not strictly valid but how far down through the investment community do deviations from the model permeate?

Theoretical Framework: Mutual Fund Performance

- Tests for special information and whether some funds are better at uncovering special information

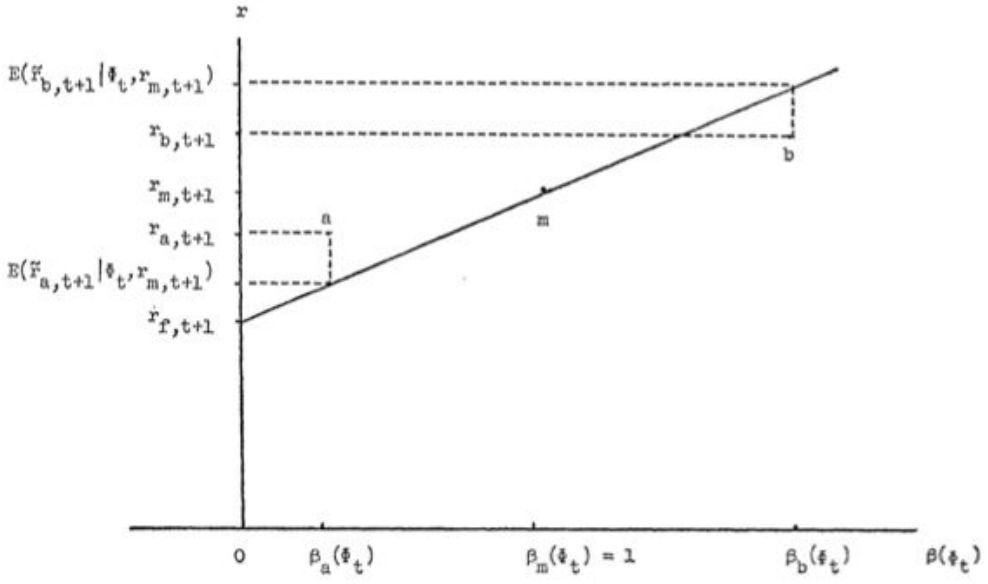


FIGURE 2
Performance Evaluation Graph

Empirical Results: Mutual Fund Performance

- Jensen: 115 mutual funds from 1955-1964
- 89 out of 115 cases, fund's risk-return combination for 10 year period is below market line for the period
  - Average deviation of ten year returns from market is -14.6%
  - Ignoring loading charge, the average deviation of ten year returns from market line is -8.9%
- Adding back published expenses to their returns, risk return combinations for 58 funds were below market line, with average deviation of -2.5% (-2.5%-.9% estimating for commissions)
- Individual funds: returns above the norm in one subperiod do not seem to be associated with performance above the norm in other subperiods
  - Number of funds with large positive deviations is less than by chance

Burton G. Malkiel (a non random walk)

Short-term Momentum

- Claim: Markets exhibit short term positive serial correlations
- Transactions Costs
- Odean (1990): Survey suggests momentum traders did worse in a period of time with positive momentum then buy-and-hold traders
- Positive in 90s, highly negative in 2000s
- Event Studies Fama (1998): Stock splits, surprise earnings, Dividends, IPOs
  - Underreaction as common as overreaction
  - Post event continuation as common as reversals
- January Effect

Long-run Return Reversals

- Claim: Negative serial correlation
  - 25-40% of long period returns can be predicted Fama and French (1988)
  - Behavioral Decision Theory
    - Investors are overconfident in their ability to predict price and earnings
- Mean reversion weaker in some periods
  - Empirical data based in periods like the depression
- If it exists, it signal efficiency
  - Interest rates are volatility correcting and mean reverting
- Fluck, Malkiel, Quandt (1997)
  - 13 year study

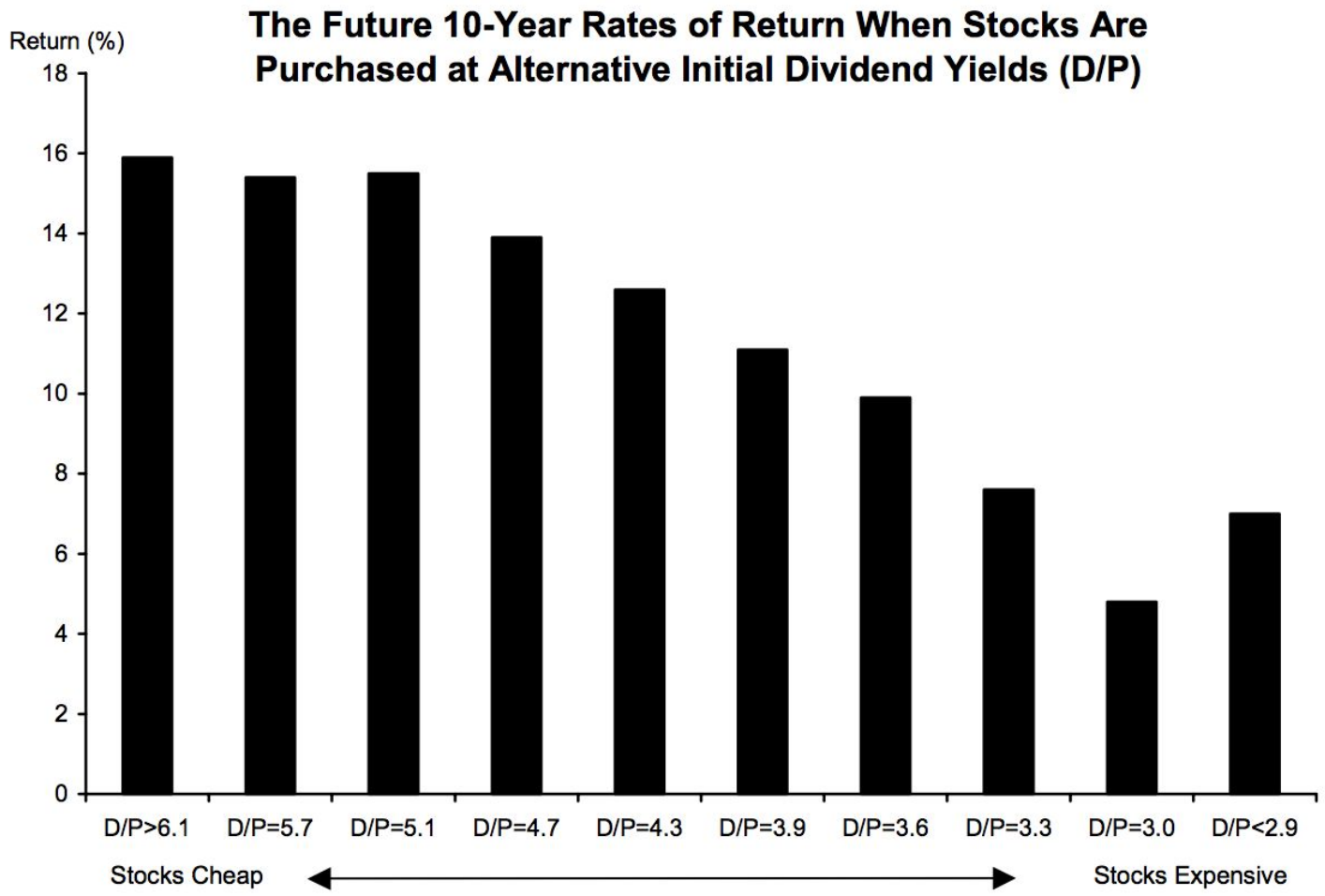
Valuation Parameters

- Trading strategies that involve analysis of initial valuation parameters
- Dividend Yield
- Price to Earnings
- Other factors

Dividend Yield

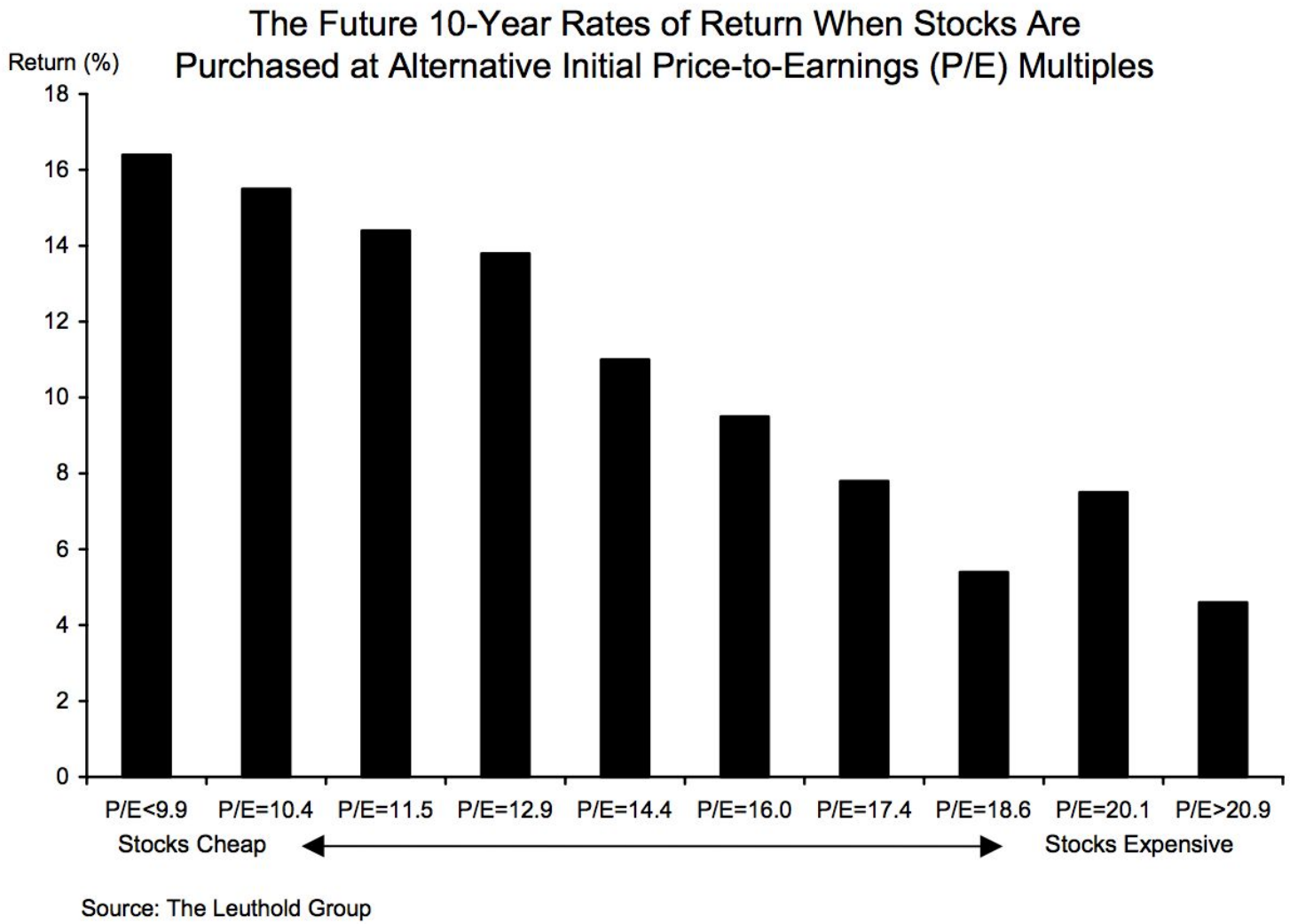
- Claim: up to 40% of the future returns from stocks can be predicted by initial dividend price ratios
  - Higher rate of return when holding stocks with high initial Dividend Yields
  - Lower rate of return when holding stocks with lower initial dividend yields
- Not inconsistent with efficiency
  - High when interest rates are high, low when rates of low
    - Prediction shows adjustments of economic conditions
- Strategy ineffective since 1980s
  - 3% dividend yields with 15% returns
- Does not work with individual stocks
- “Dogs of the Dow”

Exhibit 1


The Future 10-Year Rates of Return When Stocks Are Purchased at Alternative Initial Dividend Yields (D/P)
Return (%)
18
16
14
12
10
8
6
4
2
0
D/P>6.1
D/P=5.7
D/P=5.1
D/P=4.7
D/P=4.3
D/P=3.9
D/P=3.6
D/P=3.3
D/P=3.0
D/P<2.9
Stocks Cheap
Stocks Expensive

Price-Earnings Multiples

- Claim: Investors earn larger long-horizon returns when purchasing stocks at low P/E multiples
  - Explanation of up to 40% of variance
- P/E of S&P 500 in low 20s in late 80s
  - Rate of return 16.7%
- P/E of S&P 500 in mid 20s in early 2000s
  - Rate of return around 11.2%
- Other assertions: term structure of i spreads, risk spreads, short term rates
  - May exist, but may just point to required rates of return and different risk premiums



Source: The Leuthold Group

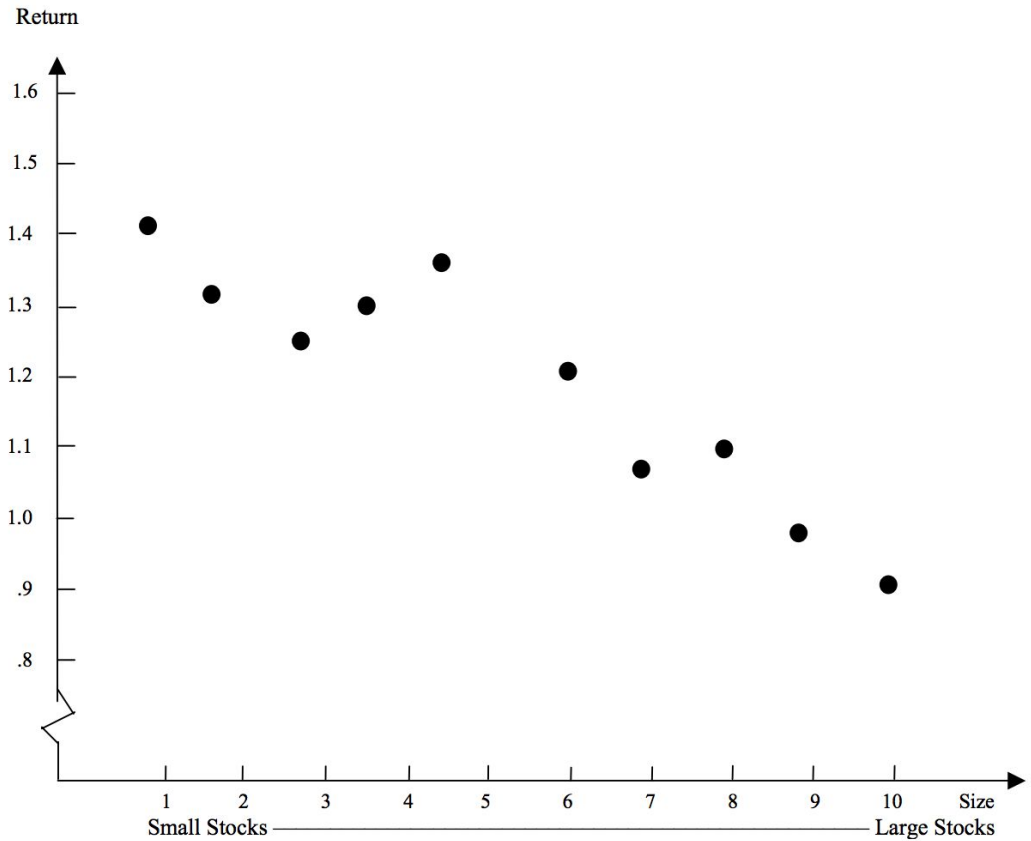
Long Term Firm Characteristics

- Size
- Value Stocks
- Equity Risk Premium Puzzle

The Size Effect

- Claim: Over long periods of time, smaller companies produce larger returns than larger companies:
- Exhibit 2
- Predictable pattern to generate excess risk adjusted returns?
  - Association with Beta
- Survivorship Bias
  - Some companies fail

Average Monthly Returns for Portfolios
Formed on the Basis of Size: 1963-1990



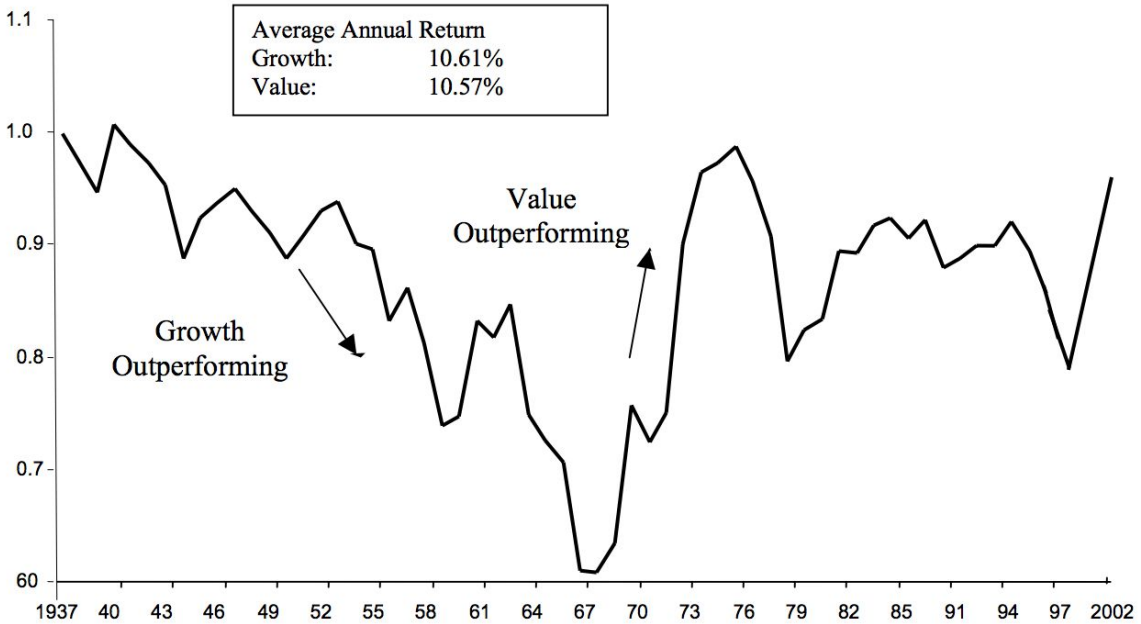
Source: Fama and French, "The Cross-Section of Expected Stock Returns," Journal of Finance, June 1992.

“Value” Stocks

- Claim: “Value” Stocks tend to outperform “growth” stocks
- Stock price to book value ratio
  - Stock price / ((assets - liabilities)/shares outstanding)
- Low price to book shows “value”
  - Fama and French suggest this idea is more prevalent in other world markets
- Seem to be at odds with efficiency or CAPM
  - P/BV may imply a premium of risk not captured by model
  - Rise of 3-factor model
- Bar the period of 1960-1990 value strategy is negative with “actively managed fund”

Exhibit 3

Reversion to the Mean: Relative Performance of "Value" vs. "Growth" Mutual Funds, 1937-June 2002



Source: Lipper Analytic Services and Bogle Research Institute Valley Forge, Pennsylvania.
Note: The exhibit shows the cumulative value of one dollar invested in the average "value" fund divided by the same statistic calculated for the average "growth" fund.

Equity Risk Premium Puzzle

- Claim: Risk Premium inconsistant with risk of common stocks in general
  - 1926-2001
  - 10.5% on stocks but 5.5% on bonds
- Equity Risk higher during Great Depression
- Survivorship bias
- Data misconstrued by World War II
  - US market was one of the few that stayed in continuous operation during whole period
- *Ex ante* vs *Ex post* risk premiums

Predictable Patterns

- For their to be true inefficiencies, patterns must be robust and proliferate through the period, not just be viable for short-term strategies
  - January Effect
- More profitable a strategy is, the less likely it will survive
- Result of Data Mining
  - Bias in academics towards disproving the consensus
  - A statistician can massage any result out of data

Robert Shiller and Richard Role

“I have personally tried to invest money, my client’s money and my own, in every single anomaly and predictive device that academics have dreamed up. … I have attempted to exploit the so-called year-end anomalies and a whole variety of strategies supposedly documented by 23 academic research. And I have yet to make a nickel on any of these supposed market inefficiencies … a true market inefficiency ought to be an exploitable opportunity. If there’s nothing investors can exploit in a systematic way, time in and time out, then it’s very hard to say that information is not being properly incorporated into stock prices.”

“Seemingly Irrefutable Cases”

- Recent Evidence could not possibly have been set by rational investors
- Market Crash of 1987
  - Can prices be efficient at the beginning and end of a crash?
- Internet Bubble of 1990s
  - Pricing of internet stocks could not possibly have been rational

Market Crash of 1987

- Claim: Rapid market changes prove that pricing is based on psychology and not logic
  - ⅓ market drop in October of 1987
- Can be broken down into a logic based argument
  - Yields on Long term treasuries increased from 9% to 10 ½% prior to crash
  - Threats of a “merger” tax
  - James Baker says he will encourage further fall in exchange value of USD
    - Scared foreign and domestic investors
- Impossible to say that psychology had nothing to to with price changes, but many innocuous problems can coalesce to create a perfect storm

Market Crash of 1987

- R=D/P + G
  - R is Rate of Return of a stock
  - D is dividend paid by company
  - P is price of Stock
  - G is growth rate
- Look at R as the required rate of return
- Government Yield increase scares investors
  - Investors now require a higher rate of return
  - Price falls as a result

1990s Internet Bubble

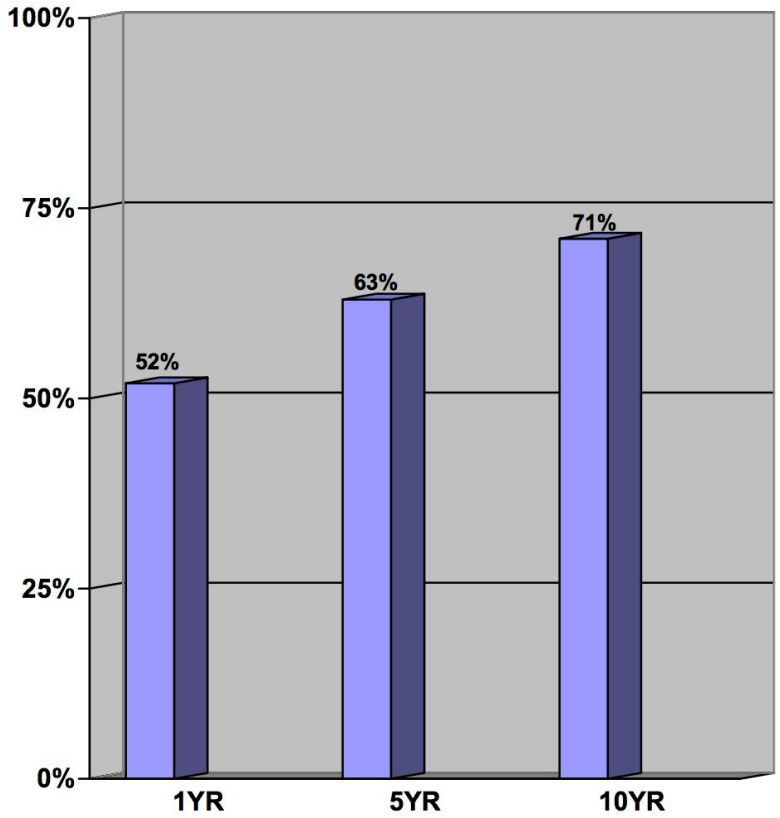
- Claim: Over pricing of internet companies can not be based in rational expectations
- Easy to see *ex post*
  - No arbitrage opportunities existed before the bubble popped
- Hindsight is 20/20
  - Internet use double every several months
  - Alan Greenspan fell in line
- Arbitrage and the Greater Fool
  - Stock may be at 2x value, but someone may be willing to pay 3x value
- Markets may have temporarily failed
- Bubbles are exception, not the rule

Professional Investor Performance

- Professional investors should be able to beat a market that is inefficient
- Jensen (1969) and Malkiel (1995) show managers underperform broad market ETFs
- More Survivorship Bias
- Top 20 mutual funds in the 70s doubled the performance of ETFs
  - The next decade, those Funds underperformed
- Top 20 funds in 1998 and 1999 tripled ETF
  - In 2000 and 2001, they did 3x worse

Exhibit 5

Percent of General Equity Funds Outperformed by the S&P 500 Index Ending 12/31/2001



Conclusions

- Most of the debate about efficient markets is based upon definitions
  - Prices fully reflect information
  - Professional consensus
- Long-term efficiency
  - Highly exploitable trends live short lives
  - Prices are not always correct in the short-term
- Markets more efficient than ever
  - Internet
  - 24 hour news cycle

Questions?

Bibliography

- *Efficient Capital Markets: A Review of Theory and Empirical Work, Eugene F. Fama, The Journal of Finance, 1970*
- *The Efficient Market Hypothesis and Its Critics, Burton G. Malkiel, Journal of Economic Perspectives, 2003*