Lecture 4: CAPM and empirical evidence

Investments
In the last 20 years or so, a large body of empirical evidence has surfaced that challenges some of the basic assumptions of finance theory.

Specifically, researchers have found evidence that challenges the capital asset pricing model.

This evidence has been interpreted as saying that modern finance theory is “wrong”, markets are not efficient or investors are not rational.

The goal of this lecture is to review some of this evidence and understand what it implies for modern portfolio theory.
The CAPM is the most often used model for figuring out the appropriate compensation for risk.

It is widely used in

a) Corporate Project Valuation
b) Portfolio Management
c) Evaluating Portfolio Managers
d) Cost-of-capital determination

Most of the evidence we will see challenges the CAPM.

- The failure of the CAPM implies that the market portfolio is not efficient.

- To understand what portfolio is efficient, you need to understand how it fails.

We will revisit the question of the appropriate discount rate in a couple of lectures.
Assumptions behind the CAPM

- The CAPM is an economic model that specifies what expected returns (and therefore prices) should be as a function of systematic risk.

- What is the argument that makes it hold? It is based on a proof by contradiction:
  1. Suppose that it didn’t hold.
  2. Investors would get rewarded for bearing non-systematic risk.
  3. Non-systematic risk can, by definition, be diversified away.
  4. Investors would be getting something for nothing.
  5. Everyone should follow these strategies.
  6. Prices will eventually adjust and the anomalies disappear.

- Notice that there is an additional set of hidden assumptions. What are they?
If the CAPM is true, then all securities should lie in the SML.

\[ E(\tilde{r}_i) = r_f + \beta_i \cdot [E(\tilde{r}_m) - r_f] \]

- The relation of expected return and \( \beta_i \) is linear
- *Only* \( \beta_i \) explains differences in returns among securities.
- \( E(R) \) of an asset with a \( \beta = 0 \) is \( r_f \).
- \( E(R) \) of an asset with a \( \beta = 1 \) is the expected return on the market.
How can we test the CAPM? 2 Approaches:

1. Test $\alpha_i = 0$ in

$$R_{i,t} - r_f = \alpha_i + \beta_i (R_{m,t} - r_f) + \varepsilon_{i,t}$$

2. Given, $E(R_{i,t} - r_f)$ and $\beta_i$, test $\gamma_0 = 0$, $\gamma_1 > 0$ and $u_i = 0$ in

$$E(R_{i,t} - r_f) = \gamma_0 + \gamma_1 \beta_i + u_i$$
1. Collect the data.
   ✅ We will use monthly data on 100 largest stocks

2. Estimate $\beta_i$ and $E(R_{i,t} - r_f)$.
   ✅ use a first-pass regression to estimate $\beta_i$
   ✅ use historical average for $E(R_{i,t} - r_f)$

3. Set up a second-pass regression in Excel.
   ✅ The dependent variable: $y_i = E(R_{i,t} - r_f)$
   ✅ The independent variable: $x_i = \beta_i$

4. Results:

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_0$</td>
<td>6.01%</td>
<td>1.8%</td>
<td>3.5</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.17%</td>
<td>1.7%</td>
<td>0.1</td>
</tr>
<tr>
<td>$R^2$</td>
<td>2%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. What do these numbers mean?
Average returns vs Betas for top 100 market-cap stocks.
To test the CAPM one needs to specify what the market portfolio is.

a) Only 1/3 non governmental tangible assets are owned by the corporate sector.
b) Among the corporate assets, only 1/3 is financed by equity
c) What about intangible assets, like human capital?
d) International markets?

Measurement error in $\beta$

$\rightarrow$ Can be avoided by grouping stocks into portfolios.

Measurement error in expected returns.
We can get around the measurement error problem by looking at diversified portfolios.

We can sort firms into portfolios based on characteristics that we think should explain risk premia.

Let’s try this with market beta:

1. For every year $t$, use past 5 years of data to estimate market beta.
2. At the beginning of the year sort firms into 10 portfolios based on their estimated beta.
3. Track the performance of these portfolios over the next year.
4. At year $t + 1$ repeat.

This test was done by Black, Jensen and Scholes.
BJS Portfolio selection technique

First Year:

Second Year:

Combine Sets of Returns:

Calculate Portfolio Beta (post-ranking beta)
Note first that the intercepts $\hat{\beta}$ are consistently negative for the high-risk portfolios $\hat{\beta} > 1$ and consistently positive for the low-risk portfolios $\hat{\beta} < 1$. Thus the high-risk securities earned less on average over this 35-year period than the amount predicted by the traditional form of the asset pricing model. At the same time, the low-risk securities earned more than the amount predicted by the model.

Table 2
(Sample Size for Each Regression =420)

<table>
<thead>
<tr>
<th>Item*</th>
<th>1</th>
<th>2</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>$\overline{R}_M$</th>
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</thead>
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<tr>
<td>$\hat{\beta}$</td>
<td>1.5614</td>
<td>1.3838</td>
<td>1.2483</td>
<td>1.1625</td>
<td>1.0572</td>
<td>0.9229</td>
<td>0.8531</td>
<td>0.7534</td>
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<tr>
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<td>-0.1938</td>
<td>-0.0649</td>
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<td>$r(\overline{R}, \overline{R}_M)$</td>
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<td>$\sigma(\tilde{e})$</td>
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<td>0.0152</td>
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<td>0.0586</td>
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* $\overline{R}_M$ = average monthly excess returns, $\sigma$ = standard deviation of the monthly excess returns, $r$ = correlation coefficient.
June 1931–September 1939
Average excess monthly returns (%)

- Intercept = 0.801%
- Std. err. = 0.180
- Slope = 3.041
- Std. err. = 0.171

October 1939–June 1948
Average excess monthly returns (%)

- Intercept = 0.439%
- Std. err. = 0.137
- Slope = 1.065
- Std. err. = 0.150

July 1948–March 1957
Average excess monthly returns (%)

- Intercept = 0.777%
- Std. err. = 0.105
- Slope = 0.333
- Std. err. = 0.099

April 1957–December 1965
Average excess monthly returns (%)

- Intercept = 1.020%
- Std. err. = 0.054
- Slope = 0.119
- Std. err. = 0.051
A number of researchers, starting with Keim (1981) and Banz (1981) found that differences in firm size explained differences in expected returns.

1. *firm size* was defined as total market capitalization.

2. Small stocks (i.e. small cap stocks) outperformed large stocks (i.e. large cap stocks).

In order to minimize measurement error, we will form portfolios of stocks based on their past market capitalizations.

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<td>Dec</td>
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<tr>
<td>1</td>
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The Small Firm Effect

Excess portfolio returns, historical average (1926-2007)
Is this evidence inconsistent with the CAPM?

Smaller firms tend to have higher $\beta$'s
To resolve this, Fama and French (1992) do a double sort, first on size, then on market $\beta$. 

1/Size ("Smallness")

Market Beta
The Small Firm Effect

- They find that the relation between average returns and market $\beta$ within size decile is generally negative.

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Low-\beta</th>
<th>β-2</th>
<th>β-3</th>
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<td>1.74</td>
<td>1.76</td>
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<td>1.92</td>
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<td>1.62</td>
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<td>1.26</td>
<td>1.25</td>
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<td>1.31</td>
<td>1.15</td>
<td>1.11</td>
<td>1.09</td>
<td>1.05</td>
</tr>
<tr>
<td>Large-ME</td>
<td>0.95</td>
<td>0.99</td>
<td>1.01</td>
<td>1.12</td>
<td>1.01</td>
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<td>0.95</td>
<td>0.95</td>
<td>1.00</td>
<td>0.90</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Other researchers have criticized these findings:

1. Other measures of firm size, such as book value of assets, or number of employees have no similar predictive power.

2. The size effect has more or less disappeared over the last 10-15 years.

Because the effect is mostly there for small stocks, it could be due to a liquidity premium: Small stocks are less liquid (i.e. they have higher transaction costs) so investors may require higher rates of return in order to hold them.
Some researchers, starting with Graham and Dodd in the late 1930s, noticed that value stocks outperformed growth stocks.

Definition: A value stock is a stock with a low market price relative to the book value of assets.

Some people believe these stocks are undervalued by the market and thus should present good investment opportunities.

Definition: A growth stock is a stock with a high market price relative to the book value of assets.

Some people believe that these stocks are “glamor” stocks that are overvalued by the market, and as such the expected returns form holding them will be poor.
The Value Effect

- Sort all stocks into 10 portfolios based on the *ratio of book value of equity to the market value of equity*.
- Re-balance portfolios every year.

<table>
<thead>
<tr>
<th>Sort</th>
<th>Lo</th>
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<th>7</th>
<th>8</th>
<th>9</th>
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<th>Hi-Lo</th>
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<td>(t)</td>
<td>(2.22)</td>
<td>(2.13)</td>
<td>(2.07)</td>
<td>(2.34)</td>
<td>(2.18)</td>
<td>(2.39)</td>
<td>(2.59)</td>
<td>(2.70)</td>
<td>(2.95)</td>
<td>(3.62)</td>
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<td>21.06</td>
<td>19.60</td>
<td>21.46</td>
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<td>24.22</td>
<td>26.48</td>
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<td>(1.34)</td>
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<tr>
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<td>0.98</td>
<td>1.06</td>
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<td>(0.02)</td>
<td>(0.04)</td>
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<td>(0.04)</td>
<td>(0.06)</td>
<td>(0.07)</td>
<td>(0.05)</td>
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<td>$R^2(%)$</td>
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</table>
The Value Effect

Puzzle is more pronounced in the post-war period

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<td>$E(R_i) - r_f$</td>
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<td>15.01</td>
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25 portfolios sorted on Size and Book to Market

Average excess portfolio returns vs market beta (1962-2007)
Some potential explanations:

**distress risk**  Value stocks tend to be stocks that have underperformed in the past. A lot of them are in the verge of bankruptcy and may be particularly risky. Investors may require an additional risk premium in order to hold them.

**liquidity risk**  Small stocks are more illiquid and may thus command a higher premium.

Are these plausible?
Related patterns

- Value and size effects are only the tip of the iceberg.

- The literature has documented a number of other patterns:
  - Firms with high investment rates under-perform firms with low investment rates. 
    Titman, Wei and Xie (2003)
  - Firms that issue new shares under-perform that do not. 
    Loughran and Ritter (1995)
  - Firms that repurchase their shares over-perform that do not. 
    Ikenberry, Lakonishok and Vermaelen (1995)
  - Firms with high idiosyncratic volatility under-perform firms with low idiosyncratic volatility. 
    Ang, Hodrick, Xing, and Zhang (2009)

- Are these separate phenomena?
In a 1993 *Journal of Finance* article, Jagadeesh and Titman show that firms with high (low) returns in the previous year tend to have higher (lower) returns in the following few months.

The momentum effect seems short-lived in the data, lasting for only a few months.
Form portfolios of stocks selected on their past return over the last 12 months.

We will rebalance these portfolios every month.

<table>
<thead>
<tr>
<th>Sort</th>
<th>Lo</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Wi</th>
<th>Wi-Lo</th>
</tr>
</thead>
<tbody>
<tr>
<td>E(Ri) - rf</td>
<td>0.31</td>
<td>5.18</td>
<td>5.12</td>
<td>6.72</td>
<td>6.80</td>
<td>7.58</td>
<td>8.68</td>
<td>10.30</td>
<td>11.47</td>
<td>15.37</td>
<td>15.07</td>
</tr>
<tr>
<td></td>
<td>(3.70)</td>
<td>(3.13)</td>
<td>(2.70)</td>
<td>(2.50)</td>
<td>(2.31)</td>
<td>(2.26)</td>
<td>(2.17)</td>
<td>(2.09)</td>
<td>(2.20)</td>
<td>(2.52)</td>
<td>(2.94)</td>
</tr>
<tr>
<td>σ</td>
<td>33.24</td>
<td>28.15</td>
<td>24.24</td>
<td>22.41</td>
<td>20.77</td>
<td>20.33</td>
<td>19.51</td>
<td>18.78</td>
<td>19.78</td>
<td>22.64</td>
<td>26.44</td>
</tr>
</tbody>
</table>

| α     | -11.52 | -5.08 | -3.91 | -1.77 | -1.18 | -0.39 | 1.09 | 3.05 | 3.97 | 7.48 | 19.01 |
|       | (1.65) | (1.31) | (1.12) | (0.94) | (0.79) | (0.66) | (0.70) | (0.70) | (0.81) | (1.33) | (2.44) |
| βMKT  | 1.53   | 1.33  | 1.17  | 1.10  | 1.03  | 1.03  | 0.98  | 0.94  | 0.97  | 1.02  | -0.51 |
|       | (0.08) | (0.07) | (0.06) | (0.04) | (0.04) | (0.02) | (0.02) | (0.02) | (0.03) | (0.06) | (0.13) |
| R² (%) | 74.95  | 78.61 | 82.24 | 85.01 | 87.30 | 90.93 | 89.64 | 88.34 | 85.09 | 71.90 | 13.05 |
At the moment, the momentum effect is one of the most studied anomalies in Finance.

On the surface, momentum appears to challenge the efficient market hypothesis.

This has led behavioral finance advocates to declare victory. They propose several behavioral explanations:

1. under-reaction: bad news travels slowly.
2. over-reaction: positive feedback.
3. disposition effect: investors are reluctant to sell loser stocks.
Momentum also exists among different asset classes, not just individual stocks.

It also exists among:

- Commodities
- Currencies
- Sovereign bonds
- Industry indices
Bernard and Thomas in the 1989 article in *Journal of Accounting Research* found evidence that stock prices were predictable based on past earnings announcements.

1. They found that firms that had better than expected earnings had higher returns over the next few months.
2. Firms that had worse than expected earnings in the past had lower returns going forward.

They interpret this as evidence of market inefficiency due to investor *under-reaction* to earnings announcements.

They formed portfolios of stocks based on past earnings surprises and tracked their performance.
Post-Earnings Announcement Drift

FIG. 2.-Cumulative abnormal returns (CARs) for SUE portfolios: all announcements.

Earnings announcements are assigned to deciles based on standing of standardized unexpected earnings (SUE) relative to prior-quarter SUE distribution. Based on 84,792 announcements from 1974 to 1986. CARs are the sums over pre- and postannouncement holding periods (beginning day -59 and day 1, respectively) of the difference between daily returns and returns for NYSE/AMEX firms of the same size decile. SUE represents forecast errors from a first-order autoregressive earnings expectation model (in seasonal differences) scaled by its estimation-period standard deviation (see section 3.2 for details).

The pre- and postannouncement periods, to make the postannouncement abnormal returns easier to gauge. Our results for 1974-86 are similar to those obtained by FOS for 1974-81. That is, there is a pronounced post-earnings-announcement drift, increasing monotonically in unexpected earnings. A long position in the highest unexpected earnings decile and a short position in the lowest decile would have yielded an estimated abnormal return of approximately 4.2% over the 60 days subsequent to...
A closely related pattern to the post-earnings announcement drift is the so-called profitability effect.

Form portfolios of firms sorted on the past ratio of earnings before income and tax (EBIT) to book assets.

Rebalance portfolios every year.

<table>
<thead>
<tr>
<th>Sort</th>
<th>10 portfolios sorted on return on assets, 1962-2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lo</td>
</tr>
<tr>
<td>$E(R) - r_f$ (%)</td>
<td>-0.19</td>
</tr>
<tr>
<td>$\sigma$ (%)</td>
<td>36.38</td>
</tr>
<tr>
<td>$\alpha$ (%)</td>
<td>-7.81</td>
</tr>
<tr>
<td>($t$)</td>
<td>(-2.17)</td>
</tr>
<tr>
<td>$\beta_{MKT}$</td>
<td>1.52</td>
</tr>
<tr>
<td>($t$)</td>
<td>(7.31)</td>
</tr>
<tr>
<td>$R^2$ (%)</td>
<td>56.79</td>
</tr>
</tbody>
</table>
The only test of the CAPM is whether the market portfolio is mean-variance efficient.

- CAPM will always hold if the market proxy that is used is MVE.
- If proxy is not MVE, relationship between $E(R)$ and $\beta$ will not hold.
Roll points out that, since the market portfolio is not identifiable, we cannot really test the CAPM. The market proxies that we use do not include:

- a) Real Estate
- b) Human Capital

Roll concludes the CAPM is useless because it is not testable. Roll instead advocates the use of the APT, which we will see next.

However, perhaps the usefulness of the Roll critique is in reminding us that if we find that the CAPM tests do not hold, then the so-called “market” (or really market proxy) is not MVE and, unless you have very special reasons for doing so, you should not hold the market proxy!
Implications for portfolio choice

- If we believe these anomalies we should feed this information into the Black-Litterman model.

- Violation of the CAPM means that the market portfolio is not MVE.

- We can beat the market!

- Hedge funds have been doing exactly that for the last 15 years.

- We will do this in the next lecture.
Is modern finance theory useless?

Not really. Maybe just the CAPM...

...or the version that we can test.

We can use the same principles about the risk-return tradeoff to guide us into better models.

These models will help us understand better these patterns in expected returns.

1. If these are indeed anomalies, there is no reason why they should persist in the future.

2. If there is a rational explanation, then these patterns may persist, but are not necessarily “free money”.
Infinite monkey theorem: Given enough time, a hypothetical chimpanzee typing at random would, as part of its output, almost surely produce one of Shakespeare’s plays (or any other text).