Today's Class

- Talk some more about the CAPM
- Today's new topic: the Efficient Markets Hypothesis (EMH) and performance evaluation
- Midterm review and homework review

A Review of the CAPM

- A model that links expected returns to risk
  - What risk? "Beta risk".

$$E[R_i] = R_f + \beta_i \cdot (E[R_M] - R_f)$$

- Tells us what the optimal portfolio to invest in is
  - What is it?
  - How do we get that result?

Three lines

- CML : Capital Market Line
- SML : Security Market Line
- SCL : Security Characteristic Line

CML

- What is the setting for CALs? What do CALs tell you?
- The CML is just the CAL with the market portfolio in place of the risky asset
  - Market portfolio is a black box
- If I tell you the expected return on a portfolio of a risky asset and the riskfree asset, how will you find the standard deviation of that portfolio?
- How?
  - Painfully

- Given the numbers below, find the standard deviation of a portfolio of the risky asset and the riskless asset which has a mean return of 6%

$$\sigma_{risky} = 10\%, E(r_{risky}) = 12\%, r_f = 5\%$$
$$E(r_p) = 6\%$$

$$E(r_p) = wE(r_{risky}) + (1-w)r_f$$
$$6 = w(12-5) + 5$$
$$w = \frac{1}{7}$$

$$\sigma_{risky} = 10\%, E(r_{risky}) = 12\%, r_f = 5\%$$
$$E(r_p) = 6\%$$

$$w = \frac{1}{7}$$

Then

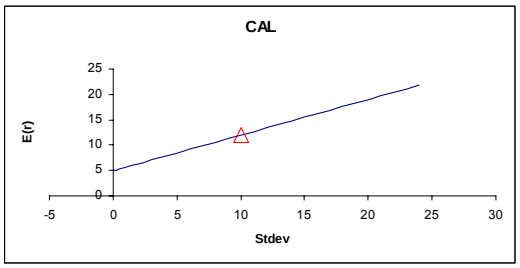
$$\sigma_p^2 = \omega_1^2\sigma_1^2 + \omega_2^2\sigma_2^2 + 2\omega_1\omega_2\rho_{12}\sigma_1\sigma_2$$
$$\sigma_p^2 = \omega_{risky}^2\sigma_{risky}^2 = (\frac{1}{7})^2 * 100 = \frac{100}{49}$$
$$\sigma_p = \sqrt{\sigma_p^2} = \frac{10}{7}$$

The CAL allows us to do this easily

- Use the equation, or

$$E(R_p) = R_f + \left(\frac{[E(R_{\text{risky}}) - R_f]}{\sigma_{\text{risky}}} \right) \sigma_p$$

- Just read it off the graph



CML

- The CML is just the CAL with the market in place of the risky asset
- The CML is for portfolios of the market and the riskless asset *only*
  - "Efficient portfolios"
- The slope of the CML is the Sharpe ratio of the market portfolio, also called the Market Price of Risk

The Security Market Line (SML)

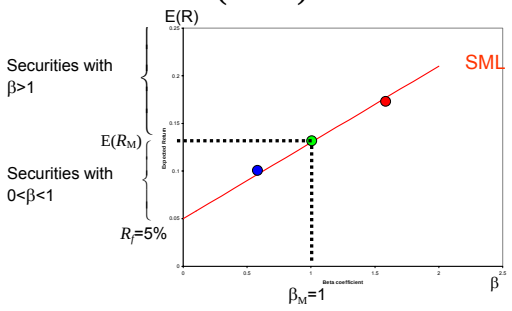
- Is the principal equation of the CAPM
- Makes a prediction about what the expected return on a stock/asset/portfolio *should be, if the CAPM were literally true*

$$E[R_i] = R_f + \beta_i \cdot (E[R_M] - R_f)$$

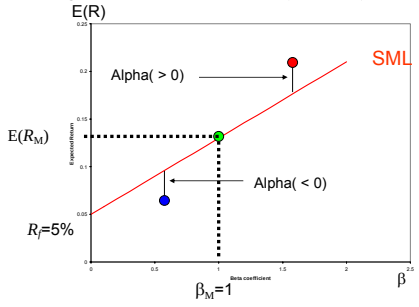
$$E[R_i] - R_f = \beta_i \cdot (E[R_M] - R_f)$$

- We can measure both sides
  - The two sides may not, in practice, be equal
- Alpha: difference between what *your expectation of Ri* and *what the CAPM predicts Ri should be*

Predicted Security Market Line (SML)



What-might-actually-happen Security Market Line (SML)



Applications of the CAPM

- Portfolio choice
  - Market portfolio is the efficient portfolio of risky assets, so you should only hold the market portfolio in combination with riskless assets (e.g. T-bills)
- Tells you what return you might expect from the security - gives benchmark for security analysis
  - So if you form your own estimates of expected returns, you can ask the question, is the return I expect in line with what the CAPM expects?
  - Positive/negative alphas
- Required return used in capital budgeting

SCL

- We just regress the excess return of the stock on the excess return of the market:

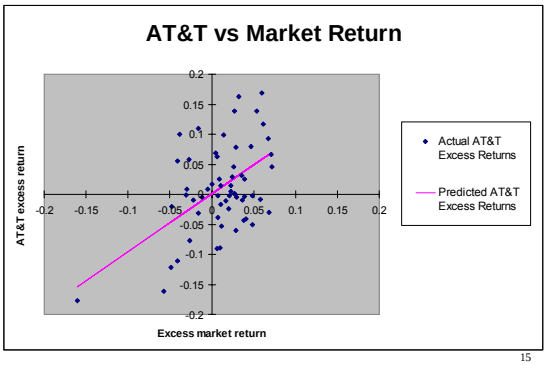
$$R_i - Rf = \alpha_i + \beta_i(R_M - Rf) + e_i$$

- Now take expectations, and notice that E(e)=0

$$E[R_i - Rf] = \alpha_i + \beta_i E[R_M - Rf]$$

- Suppose I find beta=2, alpha=1% and I expect Rm-Rf to be 10% next period
- What is my (regression's) prediction for Ri-Rf?
- What is the CAPM's expectation of Ri-Rf?

SCL



Market Efficiency and Performance Evaluation

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Outline

- Efficient Market Hypothesis
- Three versions: Weak Form / Semi-strong/Strong Form Efficiency
- Performance evaluation

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Efficient Market Hypothesis (EMH)

- [Informational] Efficiency = Prices fully reflect all available information.
- The EMH implies that:
  - a stock price is always at the "fair" level
  - a stock price reacts to news immediately
  - a stock price changes only when the fair level changes

➔ Stock price changes are unpredictable because no one knows tomorrow's news.

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EMH: What makes the market efficient?

- If markets were not efficient, investors would trade to take advantage of the inefficiencies.
- Supply and demand and **competition** make it so.
- Efficiency does **not** mean that:
  - Stock prices must go up when a company announces 20% growth.
  - No one can ever outperform the market.
    - Trick is consistently, after transactions costs, and on a risk-adjusted basis

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Efficient Market Hypothesis (EMH)

Three Forms of Efficiency:

- Weak form efficiency
  - prices reflect all information contained in past trading
- Semi-strong form efficiency
  - prices reflect all publicly available information
- Strong form efficiency
  - prices reflect all relevant information, including inside information

These three forms differ in the information set.

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Weak Form Efficiency

- Price reflect all information contained in ***history of past prices***
- For example, previous price patterns are part of this information set.
- Technical analysis tries to find the pattern in the history of the price and predict the future price movement. Weak form efficiency means technical analysis should not be useful.

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Semi-Strong Form Efficiency

- Prices reflect all publicly available information (not just the information from past price, but also other information publicly available, e.g. earnings announcements, changes in dividend policy, merger news, etc.)
- Studies suggest that abnormal returns to trading on publicly available information are *zero on average* and *disappear quickly*.

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Strong Form Efficiency

- Prices reflect all available information, not only public but also private information.
- Empirical findings: corporate insiders earn abnormal returns. Markets are **not** strong form efficient.
- Strong form efficiency ➔ Semi-strong form efficiency ➔ Weak form efficiency

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EMH and Performance

- EMH suggests that it is very difficult to beat the market, especially when transaction costs are taken into consideration
- A good test of EMH is to look at the performance of market professionals and see if their performance is superior to that of a passive index fund or market portfolio

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Performance Evaluation

Measuring Performance

Suppose we want to measure performance of a strategy (or a portfolio or a mutual fund)

Is it fair to just compare returns?

➔No, we need to adjust for the risk.

➔Why?

Three traditional methods used

- Sharpe Ratio
- Treynor Measure
- Jensen's Alpha Measure

Risk Adjusted Performance: Sharpe

1) Sharpe Ratio

$$\frac{\bar{r}_p - \bar{r}_f}{\sigma_p}$$

$\bar{r}_p$ = average return of the portfolio (or fund)

$\bar{r}_f$ = risk free rate

σ_p = standard deviation of portfolio return

Hard to interpret

Risk Adjusted Performance: Treynor

2) Treynor Measure $\dfrac{\bar{r}_p - \bar{r}_f}{ß_p}$

$\bar{r}_p$ = average return of the portfolio

$\bar{r}_f$ = risk free rate

$ß_p$ = β for the portfolio

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Risk Adjusted Performance: Jensen

3) Jensen's Alpha Measure

$$\alpha_p = \bar{r}_p - [\bar{r}_f + ß_p (\bar{r}_m - \bar{r}_f)]$$

α_p = alpha for the portfolio

$\bar{r}_p$ = average return of the portfolio

$ß_p$ = β for the portfolio

$\bar{r}_f$ = risk free rate

$\bar{r}_m$ = average return on market portfolio

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Risk Adjusted Performance: an example

- Fund A: average return=0.35, vol=0.42, beta=1.2
- Fund B: average return=0.26, vol=0.30, beta=0.8
- Average return of market portfolio=0.28
- Risk free rate=0.05

Which fund to pick?
- Sharpe measure
- Treynor Measure
- Jensen's Alpha Measure

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