

15.407 Recitation

December 4, 2003

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CAPM, APT and Capital Budgeting:

Things to cover today:

1. Theory of CAPM
2. Theory of APT
3. Notes regarding Capital Budgeting

CAPM:

CAPM states that:

$$E(R_i) - R_f = \beta_i(E(R_m) - R_f)$$

where $\beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)}$

Compare to portfolio choice:

$$E(R_i) - R_f = \beta_{iT}(E(R_T) - R_f)$$

What are the similarities and differences?

- Both equations price all assets
- Both equations use beta as a measure of risk
- CAPM uses the market portfolio, PT uses the tangent portfolio
- The key argument of CAPM is that the market portfolio is the same as the tangent portfolio, therefore everyone only holds the market portfolio and the risk-free asset.

Application of CAPM:

- Estimating risk:

Market beta could be a more useful measure of risk than standard deviation of returns.

- Estimating expected return of a assets:

For example, it is hard to estimate the return of a stock using historical return, but beta could be estimated more precisely. Therefore it could be sensible to measure the beta of a stock and estimate its return using CAPM. You can also use CAPM to measure the cost of capital of a project

- Evaluating fund performance:

Estimate the beta of a fund. then calculate $\alpha_i = R_i - R_f - \beta_i(R_m - R_f)$. If $\alpha_i > 0$, then the fund is outperforming the market. Average over time will yield sharper results.

Sharpe ratio:

The Sharpe ratio is defined by $\theta_i = \frac{\mu_i - r_f}{\sigma_i}$. This is a measure of the "risk-to-return" ratio. If one stock has a higher Sharpe ratio than another, is that stock a better investment?

Example: Stock 1 has average return of 10%, stdev = 25%, beta = 1. Stock 2 has average return of 12%, stdev = 35%, beta = 1.

According to CAPM, both stocks should have the same return, therefore stock 2 is better, although it has a lower Sharpe ratio.

This is because stock 2 has more idiosyncratic risk, so if you diversify, it is actually less risky than stock 1.

However, under CAPM, the market portfolio has the highest Sharpe Ratio possible. So you can compare performances by Sharpe ratio only if you use the market portfolio as a benchmark.

Testing CAPM:

- Testing CAPM is harder than it seems
- It is not easy to find the market portfolio. You will have to use all assets in the market, including stocks, bonds, real estates, human capital, etc. Using the stock market as a proxy could be misleading
- Still, it seems that there are strong evidence against the CAPM, even though it is always possible to look at historical data and find deviations to CAPM
- The Fama-French factors (SMB, HML) and momentum are strong indications that the CAPM doesn't work.
- Industry usually use a 3- or 4-factor model to estimate stock returns. However, these models do not have a theoretical background supporting them, so you need to be very careful about data mining problems.

APT:

APT says that there are factors determining the risk premium for each stock.

Suppose a stock has loadings of b_k on factor k , then:

$$E(r) - r_f = b_1(E(r_1) - r_f) + b_2(E(r_2) - r_f) + \dots$$

where r_i is the risk premium on factor i .

Implementing APT:

To estimate r_i , you need a portfolio that has loadings on only that specific factor. This will give you the risk premium for that factor.

Then, for each other asset, you only need to determine the factor loadings, then you can estimate the expected return on the asset.

However, the APT does not tell you what factors you need to use.

Capital Budgeting:

Basic idea: take project with positive NPV using the discounted cashflow (DCF) model.

$$NPV = \sum_{t=1}^T \frac{CF_t}{(1+r)^t}$$

The two questions we need to answer are:

- (1) How to calculate cashflow
- (2) How to find the appropriate discount rate for the project

(2) can be dealt with using CAPM/APT or similar models, how about (1)?

Similar to the DDM model, you want the actual cash inflow/outflow of the company to be discounted. Otherwise you may be discounting them from a wrong date.

A simple example:

(I) A client promises to pay you \$1000 today, you deliver the goods to them one year later.

(II) You deliver the same good to the client in one year, but the client pays you \$1000 at the time of delivery.

Both entries will be booked as a revenue of \$1000 today in earnings, but it is apparent that they have different values. Therefore you need to adjust for accounting identities that does not reflect actual cash changing hands.

Cashflow calculations:

$$\begin{aligned} \text{CF} &= \text{Cash inflow} - \text{Cash outflow} \\ &= \text{Operating Revenues} - \text{Operating Expenses} \\ &\quad \text{without depreciation} - \text{Capital Expenditures} - \\ &\quad \text{Income Taxes} \end{aligned}$$

Let's examine each item in more details:

- Revenue - Calculate the sales for that period (include account receivables)
- Expenses - Calculate how much expenditure is planned (include accounts payable). Depreciation is removed because you do not pay someone when your machine gets old.
- Capital expenditure - Include the expenses you paid to acquire new assets. Here is where you adjust for changes in accounts receivable and payable. You also need to adjust for change in the level of dividend. These three are grouped into the term "working capital"
- Income tax - the amount of tax you paid is not calculated above, so you have to subtract them.

Remember to ignore sunk costs!