CAPM

Measuring Market Risk

Total risk can be decomposed into two components: systematic and unsystematic risk. Unsystematic risk can be eliminated by diversification while systematic risk is present in an asset.

A) Market Portfolio: In principle these are not just stocks.
B) Only “macro” events affect the value of market portfolio, or a portfolio of all assets in the economy. A broad market base, such as the S&P 500 is often used as a proxy for the market portfolio.
C) Firm specific or unique risk are averaged out or diversified away when considering the market portfolio. Hence, risk depends on exposure to macroeconomic events.
D) A stock’s systematic risk can be measured as the sensitivity of a stock’s returns relative to the fluctuation in return of market portfolio. This sensitivity is called stock’s beta (β).
E) The reward for bearing risk depends only on the systematic risk of an investment. An investor with a diversified portfolio will be interested in the effect each stock has on the risk of the entire portfolio.

Beta

Beta is the slope of the regression line of individual stock return relatives to the market portfolio returns. In other words, beta tells us how much systematic risk a particular asset has in relative to market portfolio.

\[ \beta = \frac{\Delta \text{in return of a particular security}}{\Delta \text{in return of a market portfolio}} \]

Beta measures the volatility of returns on individual stock relative to the stock market index of returns, such as the Standard & Poor’s 500 Stock Index.

| \( \beta = 0 \) | U.S. Treasury Bill or called risk-free T-bill. |
| \( \beta = 1 \) | If the return in the market goes up (down) by 1%, return of a stock will go up (down) by 1% Market portfolio or if you owned all the S&P 500 index stocks A common stock with a beta of 1.0 is said to be of equal risk with the market. |
| \( \beta < 1 \) | If the return in the market goes up (down) by 1%, return of a stock will go up (down) by less than 1%. Defensive stock since it varies less than the market portfolio. Stocks with betas of less than 1.0 are less riskier than the market. |
| \( \beta > 1 \) | If the return in the market goes up (down) by 1%, return of a stock will go up (down) by more than 1%. Aggressive stock since it varies more than the market portfolio. Stocks with betas greater than 1.0 are riskier than the market. |

**Key:** Assets with larger beta have greater systematic risks, they will have greater expected return and risk premium.
Portfolio Beta: **is just an average of the betas of all securities weighted by fraction of investment.**

\[
\beta_p = (W_1 \beta_1) + (W_2 \beta_2) + (W_3 \beta_3) + (W_4 \beta_4) + \ldots
\]

where \( W_i \) represents the percentage of money invested in stock \( i \)
\( \beta_i \) represents the beta of stock \( i \)
\( \beta_p \) represents the beta of a portfolio.

\[
W_i = \frac{\text{Amount of money invested in stock } i}{\text{Total Investment}}
\]

**Example 1:** Given the information in the following table do parts A to G

<table>
<thead>
<tr>
<th></th>
<th>Standard Deviation</th>
<th>Beta</th>
<th>Amount Invested</th>
<th>Expected Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM</td>
<td>40%</td>
<td>0.95</td>
<td>2,000</td>
<td>6%</td>
</tr>
<tr>
<td>AT&amp;T</td>
<td>20%</td>
<td>1.10</td>
<td>4,000</td>
<td>10%</td>
</tr>
</tbody>
</table>

A) What is the beta of market portfolio?
   Ans: \( \beta_m = 1 \).

B) \( \beta_{IBM} = 0.95 \) indicates that?
   Ans: IBM is a defensive stock.

C) Which stock has a greater total risk? Greater systematic risk? Which one has a higher risk premium?
   i) IBM has higher standard deviation, hence higher total risk.
   ii) AT&T has higher beta, hence higher systematic risk.
   iii) AT&T has higher returns hence higher risk premium.

D) Which stock is a defensive stock and which is an aggressive stock? In what sense?
   \( \beta < 1 \) is defensive stock, hence IBM with \( \beta = 0.95 \) is defensive stock.
   \( \beta > 1 \) is aggressive stock, hence AT&T with \( \beta = 1.1 \) is aggressive stock.

E) In a boom economy, which stock would you consider to include in the portfolio?
   Ans: AT&T.

F) What is the portfolio expected return consisted of IBM and AT&T stock?
   Solution:
   \[
   W_{IBM} = (2000/6000) = 1/3 \quad W_{AT&T} = (4000/6000) = 2/3
   \]
   \[
   R_p = W_{IBM} R_{IBM} + W_{AT&T} R_{AT&T} = (1/3) (6\%) + (2/3) (10\%) = 8.67\%
   \]

G) What is the portfolio beta?
   Solution:
   \[
   \beta_p = W_{IBM} \beta_{IBM} + W_{AT&T} \beta_{AT&T}
   \]
   \[
   \beta_p = (1/3) (.95) + (2/3) (1.10) = 1.05
   \]
**Capital Asset Pricing Model (CAPM) & Expected Return**

U.S. T-bills have very low risk and have a beta of zero, while a market portfolio of common stock is the most risky investment and have a beta of one.

**Market Risk Premium** = Return on the market (R_m) – Return on T-bill (R_f)

In other words, it is the risk premium demanded by investors to hold the market portfolio rather than T-bills.

Over the past 73 years, the market risk premium has averaged 8%; the R_m = 12%, R_f = 4.0%.

**Risk Premium on any asset (R-R_f) = β(R_m - R_f)**

**Expected Return** = Risk-free rate + market risk premium

\[
\begin{align*}
R & = R_f + \beta(R_m - R_f) \\
E(R) & = R_f + \beta(E(R_m) - R_f)
\end{align*}
\]

**CAPM**: relationship between risk and return which states that expected risk premium on any asset equals its beta times the market risk premium. CAPM shows that the expected return for a particular asset depends on three things.

- The pure time value of money. As measured by risk-free rate which is a reward for merely waiting for your money without taking any risk.
- The reward for bearing systematic risk. As measured by the market risk premium (R_m-R_f), the reward the market offers for bearing an average amount of systematic risk in addition to waiting.
- The amount of systematic risk. As measured by β, and this is amount of systematic risk.

Example 2: Suppose the risk free rate is 4 percent, the market risk premium is 8.6% and a particular stock has a beta of 1.3, based on CAPM, what is the expected return on the stock? What would the expected return be if the beta were to double?

**The Security Market Line**: relationship between expected rate of return and the beta.

A plot of expected rates of return of varied risk (beta) portfolios is called the security market line. SML is the risk-return trade-off of investors.

According to the CAPM, expected rates of return for all securities and all portfolios lie on this line.

**Expected Return E(R_i)**          **SML**

\[
E(R_i) = R_f + \beta E(R_m) - R_f
\]

In a well-functioning market, all asset return and beta should be plotted on the same line (SML).
A stock with a given beta that is expected to earn a return higher than that on the security market line will be purchased by investors, bidding up the price and lowering the expected rate of return to the SML.

Example 2: If the risk free rate is 8% and the expected return on the market is 12%

<table>
<thead>
<tr>
<th>Security</th>
<th>Beta</th>
<th>Expected Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft</td>
<td>1.6</td>
<td>16%</td>
</tr>
<tr>
<td>McGraw-Hill</td>
<td>1.2</td>
<td>11%</td>
</tr>
</tbody>
</table>

A. What is the market risk premium?
Market Risk Premium = \( R_m - R_f = 12 - 8 = 4\% \)

B. What is the risk premium on Microsoft and McGraw-Hill’ stocks?
Risk Premium for Microsoft = 16 - 8 = 8%
Risk Premium for McGraw-Hill = 11 - 8 = 3%

C. According to CAPM, what are the expected returns on Microsoft and McGraw-Hill’s stock?
\[
R_{MSFT} = R_f + (R_m - R_f) \beta_{MSFT} = 8 + (12 - 8) (1.6) = 14.4\% \\
R_{McGraw} = R_f + (R_m - R_f) \beta_{McGraw} = 8 + (12 - 8) (1.2) = 12.8\% \\
\]

D. Draw the security market line for the above security?

E. Are these securities correctly priced? If not, are they over or under-valued?

\[
R_{MSFT} = 16\% \text{ (Under priced)} \\
R_{Mcgraw} = 11\% \text{ (Over priced)} \\
\]