Estimating Beta

Beta measures the sensitivity of the return on the stock to variations in the market return. It is usually *estimated* by an analysis of the past relationship between the return of the stock and that of the market. This involves collecting a sample of past returns on both the stock and the market and estimating the line of best fit between the two sets of returns. The beta (or more strictly, the estimated beta) is the slope of this *regression* line.

The slope of the line is equal to the covariance between the stock returns and the market returns divided by the variance of the market returns. You can also think of it as the correlation between the two sets of returns multiplied by the ratio of the standard deviation of the stock returns to the standard deviation of the market returns. Other things equal, the more highly the stock and market are correlated, the higher the beta, and the more variable the stock is relative to the market, the higher the beta.

A simple way to estimate beta is to enter the returns into an Excel spreadsheet and use the SLOPE function to estimate beta. In the following simple example you should get an estimated beta of .786:

Stock Market Return Return

May 4.0 6.1

June 5.3 5.7

July -2.4 -3.0

=SLOPE(B3:B5,C3:C5)

Remember that the *y* variable in the regression is the set of stock returns, and the *x* variable is the set of market returns. You will get different and wrong estimates if you reverse the two series.

A Warning

You sometimes come across people who try to estimate beta by regressing the stock *prices* on levels of the market index. This gives nonsense results. You need to regress stock *returns* on market *returns.*

Returns, Price Changes, or Risk Premia

Often dividends are not readily available and it is simpler to measure percentage price changes than returns. In practice dividends vary so little compared with prices that this makes very little difference to your estimate of beta (though it may affect the estimated alpha or intercept).

Another common practice is to work with the difference between the returns and the risk-free interest rate (i.e., the risk premium). Again the risk-free interest rate varies so little compared with stock returns that the estimated beta is generally very similar. However, it will again affect your estimate and interpretation of the intercept.

Outliers

The possibility of errors in estimated betas is likely to be larger when there are outliers in the returns data. For example, on October 19, 1987 the Standard & Poor's Index declined by nearly 21% in a single day. Subsequent estimates of beta using daily or weekly data from that period would have been heavily dependent on how particular stocks moved on that one day. When there is an unusual movement in the stock price or in the market index, it may be helpful to omit that observation.

Measuring the Market

Generally the market index should include all stocks in the market weighted by their market capitalization. In practice, it is often more convenient to use a well-known index such as the Standard & Poor's Composite, and this may even produce better estimates if the prices of the omitted smaller company stocks are unreliable (see comments on thin trading below).

Time Period

You need a lot of observations to make sure that your estimate of beta is not affected by chance patterns in the returns. In practice, therefore, to get a reasonable estimate of beta you need far more than the three observations that we used above. One way to achieve a large sample is to go back in time, but in this case you run the risk that the true relationship between stock and market may have changed. The alternative is to measure returns more frequently. For large, frequently traded stocks there is no problem in using weekly data, but for small illiquid stocks using shorter time intervals brings with it a *thin-trading* problem. This occurs when the returns on the stock and the market are not perfectly synchronized (e.g., the last trade occurs at different points in the day). The effect of such thin-trading is to underestimate the true beta.[1]

This suggests that the choice of time period involves a trade-off. Where the sample includes illiquid stocks, it may make sense to use up to 5 years of monthly data. Where the sample consists of large-company stocks, there may be an advantage to using a couple years of daily or weekly data.[2] Beta services use different time intervals. For example, Yahoo! uses three years of monthly returns, whereas Bloomberg uses two years of weekly returns.

Adjusted Betas

Calculated betas are simply estimates. If good company news happens to come out on a day when the market rises, then you will get a misleading impression of the effect of the market on the stock price. If your estimated beta is very high, then there is a good chance that you have an overestimate and that the true beta is lower. Conversely, if the estimated beta is very low, then it is odds on that you have underestimated the true beta.

Your best estimate of beta is therefore closer to 1.0 than the raw beta that comes out of the regression. Therefore, estimates of beta sometimes include an adjustment that pushes the beta towards 1.0. Yahoo! does not make any adjustment, but Bloomberg provides an adjusted beta that is (.67 x raw beta) + (.33 x 1.0). The betas that we report are all raw (unadjusted) betas.

Adjustments to the raw beta usually take one of two forms. In the one case, raw betas are estimated for successive periods and the betas in the second period are regressed on those in the first to measure how far betas should be pushed back to the average of 1.0. In the other case, the size of the adjustment depends on the standard error of the beta, so that a larger adjustment is made to raw betas that have a large potential error. The adjusted beta is a weighted average of the raw beta and the average beta of 1.0:

$$\text{Adjusted } \beta = w \times \text{raw } \beta + (1 - w) \times 1.0$$

[1] The inclusion of these stocks in the market index will also lead to an *overestimate* of the beta of the more liquid stocks.

[2] For thinly traded stocks frequent data involve a number of problems in addition to thin trading. For example, the difference between bid and ask prices may be large for illiquid stock and the bounce between bid and ask can be relatively large when looking at daily prices.

Where $w = se_{\beta}^2/(se_{\beta}^2 + \sigma_{\beta}^2)$ $se\beta$ is the standard error of the estimated beta, and σ_{β}^2 is the estimated cross-sectional variance of the betas of stocks in the index.[3]

[3] Note, this is usually measured as the cross-sectional variance of the *estimated* betas less the average squared standard error of the estimated betas.