Advanced Statistics in Rock Creek Analysis

The Rock Creek Group
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This note provides a brief overview of a few of the advanced statistical measures used by The Rock Creek Group in managing hedge fund portfolios. More detailed information on these and other statistical measures are also available. We propose updating this paper on an ongoing basis with information on additional statistical measures.

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Risk Measures

GARCH Volatility

Traditional volatility over a given time period is calculated using an equally weighted returns series over that time period. This calculation assumes that volatility is unchanged over this time period. Experience suggests that volatility changes over time and that current volatility is likely to be closer to volatility in the recent past, rather than volatility in the distant past. If this observation has to be taken into account then the data in the return series should not be equally weighted but rather more heavily weighted towards more recent returns. To accomplish this, the weights for the returns in the data series are determined using a decay factor. However, this technique does not eliminate the problem as the volatility calculation is strongly dependent on the value of the decay factor which is wholly subjective.

To overcome the subjectivity associated with using decay factors, the Rock Creek Group uses the Generalized Auto Regression Conditional Heteroskedasticity (GARCH) model to estimate volatility. The GARCH model calculates current volatility as a function of an estimated volatility and the error of the estimated volatility in past periods. In brief, the GARCH model automatically learns from its volatility predictions in past periods and uses this to improve its current estimations. In the process it accounts for changes in the volatility of the return series. Consequently, GARCH volatility is a useful measure for monitoring the monthly changes in the volatility (or risk) of fund managers.

Besides volatility, the GARCH model is also used to estimate the other measures of a return distribution, such as its mean, skewness, shape factor etc. These parameters may be preset to improve the robustness of the GARCH model. However, presetting parameters tends to reduce the efficacy of the GARCH model to monitor changes in the volatility.

At Rock Creek we use GARCH (1, 1) model. This model is particularly effective in identifying changes in manager’s volatility in situations in which the manager does not experience a significant number of tail events. When a manager experiences a large number of tail events the model is less effective. In these cases the data is subject to further analysis to determine if additional parameters should be preset.

Some other risk measures that are related to volatility, e.g., Value at Risk (VaR) and Expected Shortfall (Conditional VaR) may also be estimated using the GARCH model.

Value at Risk and Expected Shortfall

Value at Risk (VaR) measure is a widely used risk measure that is measured at a given confidence level for a fixed time period. For example, VaR at 5% level for a year is a threshold value such that the probability of the loss exceeding this threshold value in one year is 5%. If a fund has a VaR for one year of 8%, then the probability of the fund losing more than 8% in one year is 5%. This VaR is essentially the best return in the worst 5% of the cases. Therefore, its value is, by definition, an underestimate of the potential loss 5% of the time.

The Expected Shortfall at 5% level is the expected return on the fund in the worst 5% of the cases. The Expected Shortfall is a better prediction of the potential loss since it is the average return (as opposed to the best return) in the worst 5% of the cases.

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Extreme Value Theory

Generally, both VaR and Expected Shortfall assume that returns are normally distributed. Empirically, it has been observed that the return distributions of hedge fund managers are not normal. Their return distributions exhibit fat tails on both the upside and downside: the probability of extreme events is much higher than would be indicated by a normal distribution. Hence, the traditional risk measures like VaR and expected shortfall underestimate the potential losses for hedge funds. The Cornish Fisher VaR seeks to correct for higher moments (like skew and kurtosis) in the distribution. However, this method is quite inadequate in estimating the tail risk of distributions. (1).

At the Rock Creek Group, we use the Extreme Value Theory to make suitable changes when estimating the Expected Shortfall (1). Under the Extreme Value Theory, the tails of the normal distributions are replaced by other tails that belong to a specific group of functions. The Expected Shortfall is estimated using the new tail functions. The underlying rationale is that in most cases a few less extreme events, (e.g. event with probability of 5% or 10%), would have occurred in the past. The tail distribution is first fitted to the less extreme events and then extrapolated for extremely rare events that have never occurred in the past. We tested the Extreme Value Theory on fund returns during the last financial crisis. From our general database, we identified 206 funds that had losses greater than 10% in September 2008. By using the return data for these funds from inception through August 2008, the Extreme Value Theory identified 124 funds as having the potential of losing more than 10% in a single month. On the other hand, the traditional VaR measure at 1% confidence level identified only 52 funds.

We also use the Extreme Value Theory to estimate the potential gain from an upside tail event. We call it the Expected Windfall. The asymmetry between the Extreme Shortfall and Extreme Windfall is yet another measure of risk.

Bias Ratio

The bias ratio (2) is a measure that seeks to measure the bias inherent in valuing illiquid assets. The bias ratio detects the distortion in return distributions around nominal zero value. The bias ratio positively correlates with liquidity of the assets managed by the manager i.e., the more illiquid the underlying assets the larger the bias ratio. In general, hedge funds with largely liquid assets that are exchange traded have relatively small bias ratios of between 1 and 2. A large bias ratio for such liquid funds would cause for more attention. For example, funds related to the Madoff's fraud traded in highly liquid securities but nevertheless had a bias ratio of 7.5 to 8.0.

Performance Measures

RCG Performance Ratio

There are many performance measures that account for both the risk and the return of an investment. The most widely used performance measure is the Sharpe ratio. The Sharpe ratio uses volatility as the risk measure, and is inaccurate when the return distribution is not normal. It is also subject to miss-interpretation generally by the use of instruments with non linear payoffs like options. The use of such instruments tends to convert a normal distribution into a bi-modal distribution that could lead to an underestimation of volatility, and in turn lead to higher Sharpe ratios. Furthermore, when returns are negative, the Sharpe ratio becomes negative, and its meaning is ambiguous at best. For example, let us consider two funds both with an annualized return of -2% over the past 3 years. Let us assume that fund one has a volatility of 10%, while fund 2 has a volatility of 20%. Fund 2 would have a higher Sharpe ratio than Fund 1, even though it is the worse fund.

The RCG performance ratio (1) is designed to overcome the shortcomings of the Sharpe ratio. In the calculation, we assume the fund is on the risk frontier of a given power-law utility function and then use this function to calculate the return of the risk free assets. The RCG performance ratio is calculated using this risk free return of instead of the exogenous return of a risk free asset. This measure is strongly correlated with the Sharpe ratio when the Sharpe ratio is meaningful. When the Sharpe ratio is negative or the return distribution is not normal, the RCG performance ratio should still be a correct estimation of risk adjusted performance. This measure is particularly useful now, as many funds have had negative Sharp ratios as a result of the recent crisis.

Marginal Utility and Marginal Risk

One technique for integrating returns, volatility and the investor's risk aversion into a single measure is to use a mean-variance utility function. The objective is to maximize this measure for a portfolio.

Within a portfolio, the marginal utility of an individual fund is its utility contribution to the portfolio for each unit of investment. This marginal utility depends not only on the individual fund, but also on the other funds in the portfolio. Consequently, the same individual fund that has positive marginal utility for one portfolio can contribute negative marginal utility for another. The marginal utility takes into account the correlation between the individual fund and an entire portfolio.

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The marginal risk of an individual fund is the risk contribution of that fund to a portfolio for each unit of investment. While the risk of a fund is always positive, its marginal risk may be negative, depending on the other funds in the portfolio. For example, a fund that is negatively correlated with the other funds in the portfolio would reduce the overall risk of the portfolio, therefore, it has negative marginal risk.

Marginal utility and marginal risk measures the portfolio-dependent performance of a fund. They are used in portfolio construction at The Rock Creek Group.

The incremental risk of an individual fund is the marginal risk of that fund multiplied by the amount allocated to the fund in the portfolio. The sum of the incremental risk across all individual managers will be equal to the total risk of the portfolio.

Rock Creek Alpha and Beta Percentage

Rock Creek Group, studies suggest that a portion of the returns of hedge funds may be attributed to the performance of a few investable market factors. At Rock Creek, we have used sophisticated time series modeling to replicate the performance of the HFRI index. We have invested capital in The Rock Creek Index Replication Fund and generated attractive returns in 2009. This return is generated by factor beta and can be achieved with low cost and high liquidity.

Similarly, we find that some fraction of the returns of individual hedge funds can be attributed to the same market factors that we used in the Rock Creek Index Replication Fund. Of course, the beta of individual managers to these market factors varies by manager, region and strategy. The total percentage of an individual manager's return that can be attributed to these market factors we term as the Rock Creek beta percentage while the residual is called Rock Creek alpha percentage. The Rock Creek alpha percentage is the return due to the fund manager's skill. In general, we favor the hedge funds with small Rock Creek beta and large Rock Creek alpha.

Cluster Analysis

At The Rock Creek Group, we use agglomerative (i.e., "bottom-up") hierarchical cluster analysis. In the first step, each individual fund is assigned its own cluster. The algorithm then assigns multiple managers to a cluster or group depending on the similarity among them. The hierarchical algorithm then groups these multiple clusters of managers into even larger clusters and so on until all funds belong to a cluster. The position of a fund in multi-level clusters depends on its similarity to all other funds, not just to its nearby neighbors.

The similarity among funds is quantified by the distance matrix. The current distance matrix is based on the correlation. The correlation can be the simple linear correlation between funds' historic returns, or the rank correlation between different performance or risk measures. A dendrogram is used to visualize the multi-level cluster structure.

Entropy and Mutual Information

Entropy and Mutual Information analysis can be used to overcome shortcomings of traditional correlation measures. Entropy (3) is a measure of the uncertainty associated with a random variable. More specifically, it quantifies the missing information necessary to determine the value of a random variable. For example, if the underlying distribution of the return of a hedge fund is normal, the missing information is related to the standard deviation (i.e., the volatility). In this case, the entropy of a normally distributed random variable is the logarithm of its volatility. However, the entropy can be calculated for random variables that follow a much wider range of return distributions. In fact, it is a good measure of risk when the returns are not normally distributed.

If we have two return series, we can calculate the conditional entropy of one return series, which is the missing information of that return series given the knowledge of the other. If the two return series are correlated, knowing one will reduce the missing information of the other. Therefore, the difference between entropy of a return series and conditional entropy of a return series given the other return series in effect, quantifies the correlation between two return series. This is called "mutual information". The Rock Creek Group calculates the correlation measure between different individual managers based on the mutual information (3).

The traditional correlation measure is the Pearson correlation. It has two shortcomings. 1) It requires the distribution of the data sample to be normal. When outliers exist, its value is strongly biased by the outliers. 2) The traditional correlation only detects linear correlations. Those two shortcomings are particularly important when analyzing hedge fund returns because they are not normally distributed and generally have non-linear dependence due to optionality. The mutual information correlation doesn't suffer those two shortcomings. It detects the correlation even with outliers and with non-linearity.

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