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Last Updated: 11/16/2009

### **Introduction**

Risk is a rather vague notion. Most people understand, generally, what you mean when you say something is risky. For example, most people believe that stocks are risky, that stock mutual funds are less risky than individual stocks and that bond mutual funds are even less risky than stock mutual funds. But just how much riskier are stock mutual funds than bond mutual funds? To answer this question and similar ones, we need metrics to gauge risk. Further, to manage investment risk we need rigorous approaches to position portfolios given different risk and return objectives. Our objective here is to introduce the concepts of volatility, a return distribution and correlation.

### **Defining Volatility**

The term volatility is used frequently in asset management. It refers to the price stability of an asset. Volatility is defined as the standard deviation of an asset's return. Knowing the standard deviation of an asset's return allows one to associate chance with a particular return. The standard deviation of return can be understood further through the return distribution.

A return distribution characterizes the chance and magnitude of future returns: for example whether next month's return will be greater than 8%, or the chance that next month's return will be between -2% and +5%. Let's build more intuition behind this concept.

We've gathered S&P 500 monthly prices between January 1999 and January 2009, and used these to compute the 120 monthly returns during this period, which we show in Exhibit 1 as a histogram.

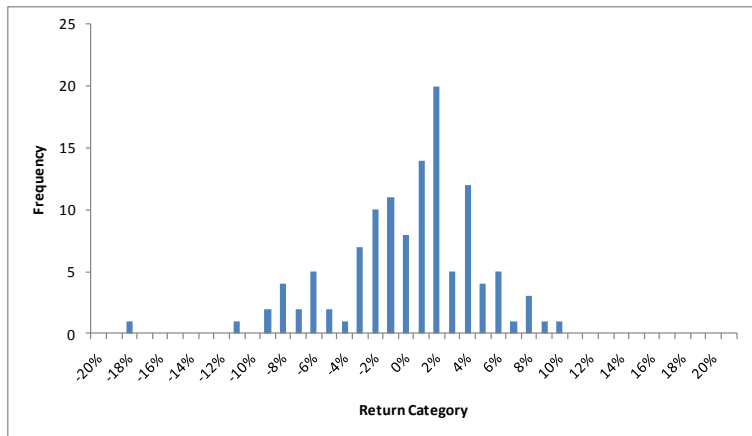


Exhibit 1: Histogram of monthly S&P 500 returns from 1-1999 – 1-2009

The height of each bar on the histogram indicates how many times of the 120 returns that the return fell in the range listed on horizontal axis. For example, the highest bar indicates that during the past 10 years 20 months had a return that was between 1% and 2%. The central tendency (the mode) of the returns is clustered near 1%, but due to several large negative returns the average return is -.3% per month. The standard deviation of this return data (volatility) is 4.4%. Assuming a normal return distribution, this means that roughly 68% of the time the monthly return of the index was within +/- 4.4% of the mean, -.3% and that 95% of the time the monthly return was within +/- 8.8%<sup>1</sup>.

Although a histogram characterizes past returns, it is also very useful for assessing future risk. For example, if we take the standard deviation of the past returns as an estimate of the future volatility we can compute the chance that a return will be greater or less than some value. For example, a standard deviation of 4.4% indicates that there is a 2.5% chance that in any given month the return could be lower than 8.8%. The ability to associate chance with the size of a return is the basis for managing risk, and for ranking assets on a risk scale.

Let's examine how we might compare the risk of stocks and bonds. The Lehman Aggregate Bond index over the same period used above has a volatility of 1.1%. Using the same normal approximation as above, this means that there is a 2.5% chance that the Lehman Aggregate will fall more than 2.2% in any month. This compares rather favorably to the S&P 500, which has a 2.5% chance of falling more than 8.8%. To say that bonds are riskier than stocks is true, but it is hardly accurate enough for portfolio construction purposes. More precise methods of measuring risk are necessary, and that is why quantitative portfolio strategists work with return distributions and concepts such as volatility.

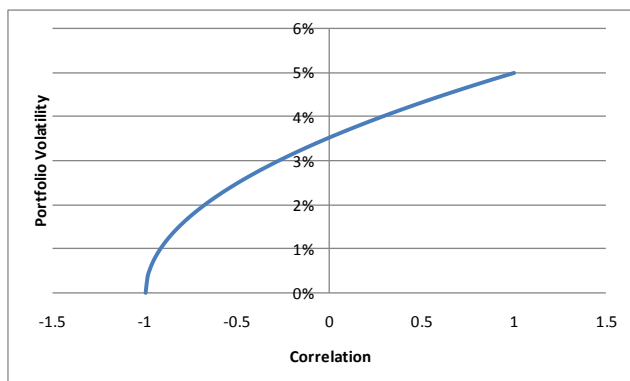
### Defining Correlation

Another important metric used to characterize risk is correlation. Correlation is a statistical measure of dependence. We will not venture quite as deep into the meaning of correlation as we did with volatility, but we will build intuition. When two assets are positively correlated this implies that their prices go up

<sup>1</sup> We have made the approximation that returns are normally distributed, and have computed these values using well known facts about the normal distribution.

and down in unison. If their returns are negatively correlated then their prices tend to move in opposite directions. Assets are said to be uncorrelated when their prices move independently of one another. Correlation, measured by the correlation coefficient varies between 1 and -1. A value of -1 indicates that the prices move in opposite directions always, a value of +1 indicates that the prices move in exact tandem, and a value of 0 indicates that the prices are independent of one another.

Why is correlation important? Combining assets with low correlation can reduce the risk of their combination in a portfolio. Consider the following example: stock A with a monthly volatility of 5% and stock B with a monthly volatility of 5%. Consider a portfolio in which 50% of the wealth is invested in stock A and 50% in Stock B. Exhibit 2 shows the volatility of the portfolio for each possible correlation of the two stocks.



First note that when the correlation is -1 the portfolio has no volatility: it is riskless. Only when the correlation of the two stocks is 1 does the portfolio have the same risk as holding just one of the stocks. This example demonstrates that the lack of perfect correlation between assets allows an investor to reduce risk by diversifying. As Exhibit 2 shows, the extent to which one can reduce portfolio risk depends on the correlation of the assets held within the portfolio.

### **Conclusion**

Above we introduced the concepts of volatility and correlation, used for measuring and dealing with portfolio risk. Our goal was to give an introduction to the topic so that our clients understand how we measure and control risk. In practice, we use multivariate mathematics to analyze the risk and correlations of many asset classes simultaneously, allowing us to accurately characterize risk and build optimally diverse portfolios. In our approach to portfolio construction, we measure volatility and correlation monthly, leading us to make minor changes to our portfolios on a monthly basis.