Measuring and reducing risk in financial markets

Evaluation and optimization of risk in a portfolio of financial assets

When an investor is faced with a selection of funds or assets displaying peformances which are, in general, correlated with those of the financial markets, he must measure the risk of his position. This document deals with the measuring instruments available to him and the influence of asset allocation and diversification on a portfolio's risk.

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2/1/2009

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MEASURING AND REDUCING RISK IN FINANCIAL MARKETS

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The period of extreme unrest which took place during the months of October and November 2008 clearly illustrates the necessity of measuring the risk of financial market investments. The allocation and selection of assets in a portfolio is dependent on their ability to resist periods of heavy decline and thus achieve a performance superior to that of the market. The ranking statistics of asset management companies show that there is nothing inevitable about a drop in performance and the taking of excessive risks. To begin with, this document will review the risk measuring instruments available then, after having assessed the consequences of a position in several currencies, as well as having determined the portfolio's risk, we will see how it is possible, without affecting the profitability of a portfolio or resorting to derivative products (options, futures, etc) to substantially reduce one's risk. It is not one of the objectives of this document to go into the mathematical aspects of risk measurement. However, readers wishing to go into these aspects can consult the extensive documentation relating to this subject which is available on the internet.

ASSET RISK MEASURES

1. Volatility

Volatility is a measure of the average degree of variation in the price of an asset or a fund. Typically, it is defined as the annualized standard deviation of these variations. The greater the variation the more the asset is considered a risk. Volatility has its origins in factors which are both internal and external to the asset.

Some shares whose fundamentals are weak have a volatility which is superior to that of the market (beta greater than 1). There are numerous possible causes for this such as, excessive debt in relation to other businesses within the same sector, lack of transparency and warnings over trading results etc. Generally speaking, a share's volatility is economically correlated with its past, present and future fundamentals. If the fundamentals deteriorate then volatility increases, if the fundamentals improve then volatility tends to decrease. But other external factors also influence volatility. In particular, when economic and geopolitical conditions display signs of weakness with some question marks about the future, the overall volatility in the financial markets has a tendency to increase. This was the case during the 2007-2008 period of crisis when the average volatility of the equity markets doubled in relation to the preceding period, thus conveying the anxiety which spread throughout the markets due to the risk of collapse of banks and financial establishments and strong fears of recession. In such a context all stock will be affected and even those considered as safe will see their volatility increase considerably while their fundamentals remain good. Funds consisting mainly or exclusively of shares will suffer from the same causes as those mentioned above and therefore carry the same risks for investors.

The diversification of risk through the acquisition of a certain number of securities traded on the same index (CAC 40, Dow Jones, S&P 500) only slightly decreases a

portfolio's volatility since the internal correlation of the securities making up these indexes is increased (by around 70% to 90%). These indexes are also correlated and an investment made over several of them through an ETF will not lead to a good diversification of these positions.

The volatility of bonds is assessed in the same way as that of shares, but its level and variations have very different causes. The price of these financial assets, whose volatility is, historically, weaker than that of shares, is determined by the evolution of interest rates, as well as by factors such as duration and the quality of the borrower. The price of bonds moves in the opposite direction to a change in interest rates, but is also subject to significant variations due, on the one hand, to anticipations of a rise or fall in rates and, on the other hand, to arbitrage between the different categories of assets. During the turbulent period of October - November 2008 significant price variations were recorded due to the shock wave created by the equity markets. The practise of investors flying to quality occured on some days though on others it did not. The likely failure of some borrowers also played a significant role. Bond funds therefore recorded a more significant level of volatility, thus conveying the increasing risk of this category of assets.

2. Downside volatility

When calculating risk, some investors only take into account price variations conflicting with their position. In other words, if it is a long position, only negative variations are considered and if it is a short position only positive variations are considered. Because why consider an asset as presenting a risk if its price varies in the same direction as that hoped for by the investor? Downside volatility is calculated in the same way as the volatility explained above, apart from the fact that only downside price variations are taken into account. In practice, the results are very close to those that include all types of variation and they vary in a very similar way. This indicator is therefore often used as a risk measure and, notably, it enables calculation of the Sortino ratio to measure the effectiveness of an asset.

3. Value-at-risk

The value-at-risk of an asset is a measure derived from volatility but it is more meaningful as it indicates the probablility of decline calculated over a specified period of time and for a given confidence threshold (generally 95% or 99%). For example, if a fund has a value-at-risk of minus 2% this means that there is a 5% (or 1%) chance that this fund will display a cash-in value inferior to 98% within a period of one year (or other period of time). This is a widely-used indicator as it gives an immediate calculation of the risk taken by an investor. It can be calculated by using volatility, historical cash-in value trends and the Monte Carlo simulation. The causes of variations in value-at-risks are identical to those of variations in volatilities. The calculation of this indicator, derived directly from volatility, assumes however a Gaussian distribution of asset price variations. But the analysis carried out with the aid of historical price or cash-in-value trends proves that this is not the case. The frequencies of price variations are distributed assymetrically, following a different flattening-out and extremes which are, in general, thicker than on the Gaussian curves. There is therefore a more accurate way of evaluating this risk measuring instrument, by introducing a correction, which allows the preceding elements to be taken into account.

4. Corrected value-at-risk

In order to take into account the asymmetry and excess flattening-out of price variation frequencies, the value-at-risk is corrected by the Cornish-Fisher approximation. This enables a more accurate value, one which relies on historical volatility and includes non-Gaussian distortions, to be calculated. This approximation is considered appropriate by the financial community and gives a good estimate of risk. As an example, the value-at-risk of the CAC 40 index calculated using 18 months of historical data, with a confidence threshold of 95% at the end of 2007 was minus 19% for the year to come (2008). One must keep in mind that this is a probability indicator and doesn't therefore offer any guarantee of certainty. The maximum loss can therefore be much greater, the reality of the months of October and November 2008 has reminded us of this.

RISK ARISING FROM FOREIGN CURRENCY EXPOSURE

International diversification of risk makes it possible to profit from the opportunities of financial markets by diversifying one's positions over several geographical areas, thus taking advantage of high rates of growth in certain regions of the globe. This diversification, which is beneficial for performance, is accompanied by an additional risk which arises from the volatility of the currency, which can be distinct from that of the investor's country of residence. Some funds offer hedged exposure. Limiting oneself to this private category, however, deprives the investor from a much wider selection. It is therefore necessary, in general, to resolve oneself to accepting the currency risk and consequently the additional volatility which is added to that of the underlying asset. Investing in an asset expressed in a foreign currency may have a negative effect on performance or, on the contrary, it may lead to an improvement in performance. The selection of assets should therefore take into account both intrinsic performance and the performance of the currency.

EVALUATING A PORTFOLIO'S RISK

The risk taken by a fund or portfolio manager consists of all the value-at-risks of a portfolio. However, though the performance is equal to the weighted average of all of the lines, the same does not apply for the volatility and the value-at-risk. These values are not additive and depend, for the one part, on the volatilities of each of the assets and, for the other part, on the correlations of each of a portfolio's assets in relation to all the others.

1. The influence of a portfolio's construction

Each individual asset's risk directly influences the overall risk of the portfolio. Table 1 shows the annual volatility and performance of five funds. But how can you build a portfolio of two assets whose overall volatility is lower than the volatility of each element? One might think that it is wise to choose the two assets with the weakest volatilities (that being fund 2 and fund 3). A check carried out on the basis of the historical performances of these funds, with the help of the software Portfolio (JM Software), demonstrates that the resulting volatility of an equally-weighted portfolio, composed of funds 2 and 3 is 10.89% and that of a portfolio composed of funds 1 and 5 is 9.52%. This leads us to conclude that though the individual volatilities directly influence the overall risk, this is not the only element that should be taken into account. There is a second element, quantified in table 2, which should be considered. This is the internal

correlation of a portfolio or, in other words, the degree of correlation of each individual element in relation to the totality of assets within the position.

Table 1

	VOLATILITY	PERFORMANCE
FUND 1	16%	9%
FUND 2	12%	7%
FUND 3	14%	8,16%
FUND 4	17%	7,58%
FUND 5	15%	8,75%

Table 2

Correlations	Fund 1	Fund 2	Fund 3	Fund 4	Fund 5
Fund 1	100%				
Fund 2	30,00%	100%			
Fund 3	50,00%	40,00%	100%		
Fund 4	20,00%	25,00%	25,00%	100%	
Fund 5	-20,00%	10,00%	15,00%	20,00%	100%

2. The influence of internal correlation

The average internal correlation of a portfolio is the second element that influences its overall risk. The second portfolio built using funds 1 and 5 displays a volatility of 9.52%. This total appears paradoxical in relation to the volatilities of 16% and 15% of each of its elements, while the first portfolio whose elements have volatilities of 12% and 14% appears, at first sight, as less risky. The explanation for this result finds its source in the correlations summarized in table 2. The first portfolio has an internal correlation of 40% while the second portfolio displays a negative internal correlation of 20%.

A portfolio's internal correlation is therefore an important factor when it comes to calculating the overall risk. The stronger the internal correlation and the less the investor takes advantage of diversification, the greater his risk. This element is made all the more important today when we are witnessing a strong correlation on the equity markets, which is considerably limiting the possibility of diversification on the major world indexes. One ought therefore to pay particular attention to this factor which, though it does not appear in any published statistics, plays a major role in the construction of portfolios.

3. Calculating the volatility of a group of assets

The volatility of a portfolio is determined by using the following formula:

- ωi is the weight of the asset i ($\sum \omega i = 1$)
- vi is the volatility of the asset i
- ρij is the correlation of the assets i and j
- V is the volatility of the portfolio

$V=\sqrt{\sum_1^n \sum_1^n \rho ij\ \omega i \omega j\ vivj}$ which can also be written as:

$V=\sqrt[2]{\sum_1^n \omega_i^2 v_i^2 + 2\sum_1^n \sum_{j<i}^n \rho ij\ \omega i \omega j\ vivj}$

The first member of the equation reveals the dependence of the overall risk in relation to the risk of each of the assets and the second member reveals the dependence with the degree of internal correlation. The number of elements within the portfolio also influences the overall volatility, all the more so when the internal correlation tends towards zero.

4. The influence of the number of lines

Increasing the number of lines in a portfolio increases the diversification and therefore reduces risk. However, this reduction in risk is far from being uniform and decreases mathematically with the number of lines. For example, on the basis of a volatility of 23% and a correlation of 20% for all the assets, the resulting volatility, calculated using the formula above, is 7.3% for a portfolio of 12 assets. If we increase this portfolio to 20 lines, all things remaining otherwise equal, the resulting volatility is 5.6%. If we increase this position to 50 lines, the volatility becomes 3.6%. The reduction in volatility is therefore much less significant, as one goes along, than the addition in the number of elements.

Each addition in a portfolio must comply with a certain number of criterias which, irrespective of the performances of the added element, will allow a reduction of the position's risk.

- On the basis of historical correlation with the portfolio, to evaluate the new risk of the portfolio created by the new investment.
- Does the candidate asset display a weak correlation with the existing position?
- Is its correlation historically stable?

This analysis should be carried out independently of all other asset allocation analyses such as the Black-Litterman model and selection and performance persistence analysis.

However, other factors such as liquidity or discretion can lead a fund manager to add assets irrespective of a reduction in volatility.

5. The Influence of individual asset weighting

The above analyses were carried out on the basis of portfolios in which each line weighed the same. The investor can also use the Markowitz Portfolio Theory to optimize weightings and therefore achieve maximum portfolio effectiveness. Simulations carried out with the aid of the software Portfolio (JM Software) on the basis of several thousands of investment funds marketed in the United States demonstrated the importance of such an optimization, without it being considered as a key element; principally due to the weight sensivities of each asset in future market conditions which were unknown at the moment of simulation.

6. The Influence of internal correlation stability

The analysis described above only has meaning if the chosen assets have stable fundamentals and, in particular, display certain regularity in terms of internal correlation. Because, each increase in internal correlation and volatility directly increases the risk. The volatility of assets increases during periods of market unrest and correlation also has a tendency to vary in periods of crisis or euphoria. It is therefore impossible to forecast it with any level of accuracy or to calculate with certainty a forseeable risk. However, while the performances present a risk, volatility fluctuates within known ranges and the correlations display good stability over the mid and long term. One can therefore rely on this criterion for evaluating potential risk. The portfolio's internal weighted-average correlation must therefore be the subject of monitoring to avoid going through an unfavourable risk trend.

REDUCING PORTFOLIO RISK

There are two ways to reduce the risk of a position for a given total amount. The first is by reducing the value-at-risk of each asset and the second is by changing the construction of the portfolio.

1. Reducing the value-at-risks of each element

The selection of assets displaying historically lower volatilities leads us to think that, projecting into the future; the past will repeat itself and therefore lead to a reduction in the overall risk. It is worth noting however, that, in general, the Markowitz Portfolio Theory teaches us that profitability and volatility are correlated. The selection of less risky assets will therefore have a detrimental effect on profitability, which is not the desired objective. A rigourous selection based on the Sharpe ratio (or the Sortino ratio) however, allows a customization of assets whose Price/ Volatility ratio remains acceptable. This selection; however, is subject to the uncertainty of future profitability which remains high since the price factor (or performance) is always much more difficult to predict than the volatility factor.

2. Reducing risk through construction

The risk components within a portfolio have been analysed above and a portfolio's internal correlation plays an important role in its overall risk. This correlation is defined as the weighted average of all of the elements taken two by two. The correlation can be synthesized with the aid of a symmetric matrix (see table 2). Reducing each of the elements in this matrix reduces the risk of the portfolio in a definite fashion (see the above equations). Better still, this reduction of risk, contrary to that created through selection, has no offset in performance. It is therefore a method which should be closely looked at. To do this, one must have at their disposal reliable historic data, (no missing data, the adjusted share price, taking into account transactions that have altered the capital base, historical dividends trend data etc), covering a period of several years. The analysis consists, within the context of an allocation strategy which has been precisely defined by the investor, of searching in a database for the collections of assets which correspond to a minimum correlation. In order to be really effective, one must have access to a very large collection of assets traded on several financial markets throughout the globe. This can represent several tens of thousands of assets and therefore an astronomical number of possible combinations. In practice it is therefore advisable to proceed by successive preselections so as to identify a range of assets which satisfy, on the one hand, the allocation strategy and, on the other, the criteria of performance,

stability and persistence (see « Portfolio construction and diversification »). It would be, in effect, totally ineffective to deteriorate a portfolio with assets of an inferior quality or even to include in the preselection elements which do not, in any way, form part of the investor's asset allocation strategy.

Using such filtering enables you to drastically reduce the number of potential candidates. Because, having eliminated a number of classes, all that remains is to make a selection on the basis of performance criteria. A study, carried out with the aid of the software Portfolio (JM Software), on an allocation strategy for North American mutual funds, with more than 10 years of historical data available (around 6000 funds) demonstrated that in order to display significant effectiveness a final selection should be made of, at the most, 500 or 600 funds. The use of the software's algorithms allowed the creation of portfolios with an internal correlation of minus 10%. These portfolios mainly include equity funds and bond funds. Their volatility proves to be slightly lower than that of the bond market indexes and their performances superior to those of the share indexes. These portfolios display a regularity in performance superior to that of all indexes and a maximum loss recorded during periods of crisis far lower than that of the bond and share indexes.

Adding new elements to a portfolio can also, under certain conditions, reduce the risk (see § The influence of the number of lines, above).

3. Optimizing the weightings of each asset

The optimization described above can be improved further by introducing different weightings for each of the assets so as to minimise the overall volatility. The method consists of playing with the weight of each element so that the functions explained above (equations) go through their minimum. Such an optimization, which requires the Markowitz Portfolio theory, necessitates the use of appropriate software.

CONCLUSION

The reduction of risk through the selection of assets and through diversification is of indeniable importance within the context of fund or asset management. The investor will record a regularity in performances superior to those of the indexes, allowing withdrawals or significant arbitrage operations in good market conditions if the need arises. At the time of writing this document, the financial crisis that we are experiencing has proved, more than ever, the principles set out in this document.