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The terms risk management and hedging are often used together. Hedging is a component of risk management as it is one of the methods available to control risk, and there are many hedging tools and strategies that may be used to try and engineer an efficient hedging outcome. Hedging whereby the underlying spot asset is hedged by the corresponding futures contract is an important tool in the management of risk.

This article examines the hedging effectiveness of different hedging strategies in risk management. It details and compares a number of risk measures that can be used to measure the effectiveness of different hedging strategies. A key issue is the extent to which hedging reduces the volatility of investors positions. Since hedging can be interpreted as a form of insurance, it is worth considering how effective that insurance is in terms of risk reduction, and it is this issue we focus our attention on.

Risk measures and hedging performance metrics

While risk management tends to mean the implementation of strategies designed to reduce risk, an important consideration is the measure that is used to define risk. We examine three commonly applied measures of risk in terms of their attributes, and their suitability as risk measures in the context of evaluating hedging strategies from the perspective of risk reduction.

Variance and the standard deviation

The use of standard deviation is widespread in terms of measuring risk. Moreover, it is extensively used by hedgers following Ederington (1979), who suggests that the main purpose of hedging is to minimise the variance associated with the hedge, referred to as the Minimum Variance Hedge Ratio (MVHR). However, this measure has a number of shortcomings.

Firstly, it is not an intuitive measure, as it deals with manipulating deviations
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by first squaring them and then taking the square root of the outcomes. More importantly, the standard deviation cannot distinguish between positive and negative returns and therefore it does not provide an accurate measure of risk for asymmetric distributions (non-normal). Given asymmetry, hedging effectiveness metrics that cannot distinguish between tail probabilities may be inaccurate in terms of risk measurement. Also, since it cannot measure the left and right tails of the distribution, it fails as a risk measure to differentiate in terms of hedging effectiveness between short and long hedgers. Where asset return distributions are asymmetric as is generally the case, the standard deviation will over or underestimate tail risk. It is therefore not a adequate measure of risk for hedgers except in the event that the return distribution is symmetric (normal). Even in this case the semi-variance is more appropriate.

Value at Risk (VaR)

Recently VaR has become a very popular market risk measure. We can use it as an objective function in hedging when the user tries to minimise the VaR associated with their hedge. VaR is essentially a quantile of a loss distribution and is widely used in financial risk management and the evaluation of the effectiveness of hedge strategies. In particular, unlike the variance, it is estimated separately for upside and downside risk (see figure 1 for downside VaR). VaR has become popular despite a number of limitations as a risk measure. Its most serious theoretical shortcoming is that it is not a coherent measure of risk, as it is not sub-additive. A risk measure, \( \rho(X,Y) \) is sub-additive if \( \rho(X+Y) \leq \rho(X) + \rho(Y) \) implying that aggregating risk does not increase the risk of the portfolio over the sum of the risks of the constituent sub-portfolios. The fact that VaR is not sub-additive leads to strange negative diversification effects in the context of portfolio theory. Also, in practice, two portfolios may have the same VaR but exhibit very different potential losses. In other words, the VaR cannot tell us what the likely losses will be in the event that the VaR is exceeded (see figure 1). It is of limited use therefore as a valid measure of risk to use in the evaluation of hedge strategies in situations where hedging is concerned with protecting against extreme losses such as those associated with tail events in excess of the VaR.

These shortcomings can be addressed by the use of the Conditional Value at Risk (CVaR) measure that has the property of sub-additivity.

CVaR

CVaR is the expected loss conditional that we have exceeded the VaR, which is essentially a weighted average of the losses that exceed the VaR. CVaR is preferable to the VaR because it estimates not only the probability of a loss, but also the magnitude of a possible loss. Furthermore, CVaR exhibits the sub-additive property and is thus coherent. Risk measures such as CVaR are increasingly being incorporated into risk management systems as an additional tool that may be viewed in conjunction with a VaR statement, to give not only the probability of a tail loss, but also some indication of the potential losses that may arise from a tail event (see figure 1). We can use CVaR as an alternative objective function to VaR where the hedger tries to minimise the CVaR associated with the hedging strategy.

Hedging effectiveness

Having examined these three different risk measures that a hedging strategy may be concerned with protecting against extreme losses such as those associated with tail events in excess of the VaR. These shortcomings can be addressed by the use of the Conditional Value at Risk (CVaR) measure that has the property of sub-additivity.

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Hedging strategies

We examine hedging effectiveness for three separate strategies. First, investors may of course choose not to hedge their exposures, that we call a No hedge strategy. Second, in the event that hedging is considered, the simplest hedge strategy using futures is a Naïve hedge. This strategy uses a hedge ratio of 1:1 where each unit of the crude oil contract is hedged with equivalent units in an opposite position in a futures contract. Third, model based hedges such as moving window Ordinary Least Squares or GARCH models have become popular as a means of running a dynamic hedging strategy. These strategies involve continually monitoring the hedge over time and changing the hedge to reflect changes that may occur in the relationship between the spot asset being hedged and the underlying hedging instrument.

We now turn to some examples to investigate whether hedging is as effective at reducing VaR and CVaR as it is in reducing a more general risk measure such as the standard deviation. We examine the three risk measures outlined to determine both the possible

![Figure 1. VAR and Actual Loss](image)

Note: The shaded area indicates a set of actual losses whereas the VaR simply indicates that there is a 1% probability of a loss in excess of €15,000.
losses and the hedging effectiveness based on a No hedge, a Naïve hedge and a dynamic daily hedging strategy\textsuperscript{10} (model hedge) as applied to crude oil exposures. The hedging instrument used is the corresponding futures contract and hedging effectiveness is measured not just by the standard deviation, but also by VaR and CVaR. We also examined\textsuperscript{11} hedging effectiveness for both symmetric and asymmetric distributions to demonstrate how different distributional characteristics that are found in real world hedging situations would affect the various risk measures. Figure 2 presents estimated daily losses as measured by the Standard Deviation, VaR and CVaR metrics respectively.

A number of interesting points arise. Firstly, we can see that both the VaR and CVaR risk measures are useful in that they can distinguish performance for short hedgers from those of long hedgers. Using these risk measures we can see that there are significant differences in terms of the potential losses associated with the separate tails of the distribution. For example, the one-day CVaR figures (symmetric distribution) using a Naïve Hedge are $37,330 for short hedgers as compared with $29,780 for long hedgers. Secondly, we can see that potential tail losses are quite different for symmetric as compared with asymmetric distributions. For example, while the estimated losses are similar for opposite tails of the symmetric distribution, there are large differences between left and right tails in the case of the asymmetric distribution. This means that the estimated losses of short and long hedgers differ significantly, and differences would become more pronounced for the (more) skewed distributions. This implies that hedgers who fail to use tail specific hedging performance metrics may choose inefficient hedging strategies that result in them being mishedged vis à vis their hedging objectives.

Figure 3 demonstrates the benefits of hedging as compared with leaving crude oil exposures unhedged. The percentage reductions in the relevant risk measure are calculated using the figures presented in figure 2. For example, a Naïve Hedge strategy reduces the VaR for a short hedger under the symmetric distribution by 42\% (i.e. from a one-day VaR of $51,150 for No Hedge to $29,660 for a Naïve Hedge). The model based hedge is even better with a 46\% reduction in the one-day VaR. Also from figure 3, we can see that both the Naïve and Model based hedges outperform a No Hedge position in all cases bar one. This demonstrates the value of hedging as a method of reducing risk across each of the different risk metrics employed.

A second point relates to the hedging performance for symmetric as compared with the asymmetric distributions. We can see that hedging performance is significantly better for the symmetric distribution with reductions in standard deviation of around 60\% and VaR and CVaR reductions of the order of 40-50\%. For the asymmetric distribution however, the story...
changes with significantly worse hedging effectiveness observed across each risk measure. Using the case of short hedgers for example, the Model Based Hedge will only reduce the VaR by 21% and the CVaR by 10%. This may indicate that hedging may not be as effective during periods of high volatility associated with asymmetric return distributions. Thus hedgers may face the risk that their hedges may not be as effective during periods when they most require them. Again demonstrated are the different hedging outcomes for short as compared with long hedgers. In this example, the long hedgers benefit more than short hedgers as measured by larger reductions in both VaR and CVaR. This demonstrates the ability of the VaR and CVaR metrics to model tail events and to differentiate between the tails of the distribution whereas the standard deviation is limited in this respect.

**Conclusion**

This article has put forward some justifications for the use of a number of risk measures as part of an overall risk management strategy. We have highlighted that traditional measures based on standard deviation are not capable of measuring risk in the same way as tail specific ones, as they cannot distinguish between left and right tail probabilities as required by short and long hedgers. While the VaR is tail specific, we have also noted some potential shortcomings of the measure and put forward an alternative measure – the CVaR which addresses some weaknesses of VaR. The message for investors is that a number of risk measures should be considered when designing a hedging strategy, but more importantly, they need to decide which risk measure they are seeking to minimise, as hedging effectiveness may vary, depending on the risk measure used. Also, hedgers may not be as effective at reducing risk in volatile markets that are skewed. In hedging terms, this means that investors may face the risk that their hedges will not fulfill their function of risk reduction during stressful markets conditions when they are most needed.

**References**


*Jim Hanly is at the School of Accounting and Finance, Dublin Institute of Technology, John Cotter is director of the Centre for Financial Markets, School of Business, University College Dublin

**Footnotes**

1 Hedging can be static or dynamic by definition. Static hedging refers to a hedging strategy that does not change to accommodate changes in the underlying relationship between the asset being hedged and the hedging instrument. Dynamic hedging accounts for the changing relationship between the spot asset and the hedging instrument by changing the ratio of futures contracts to spot exposure based on a time-varying relationship.

2 The standard deviation is the square root of the variance. Minimising the variance is equivalent to minimising the standard deviation.

3 The variance or standard deviation makes no distinction between positive and negative deviations from the mean and it does not measure separate loss probabilities for non-symmetric distributions. For example, assume the mean return is 0% and there are four returns [1, -2, 6, -12]. The standard deviation is 13.8 and does not say anything about the greater potential for downside risk (negative deviations from the mean) than upside risk (positive deviations from the mean).

4 Short hedgers are investors who hold the spot asset and seek to go short the futures contract in order to reduce risk whereas long hedgers are short the spot asset and long the futures contract.

5 The semi-variance is half the variance for a symmetric distribution.

6 A quantile is the quantity associated with a particular cumulative probability. This is the loss level of a portfolio over a certain period that will not be exceeded with a specified probability. VaR has two parameters, the time horizon (N) and the confidence level (x). Generally VaR is the (100-x)th percentile of the portfolio over N days.

7 See Cotter and Hanly (2006a).

8 We use the Nymex West Texas light sweet crude contract to examine energy prices. This is the most liquid and highly traded contract by volume and is used as an oil price benchmark.

9 The hedge ratio refers to the number of futures contracts used to hedge a given spot exposure. It is usually chosen to minimise an appropriate risk measure, for example the variance (standard deviation), the VaR or the CVaR.

10 We used both a Rolling window Ordinary Least Square (OLS) and two GARCH models, the DVECH and the Asymmetric DVECH models to calculate optimal hedging strategies. The results reported are from the best performing model.

11 Results shown are out-of-sample based on forecasted hedging strategies to reflect real world hedging situations. See Cotter and Hanly (2006b).