Using value-at-risk techniques in Latin America requires some special considerations. *by Gabriel Bousbib*

Variable Success

Significant market losses recently incurred by several financial institutions and industrial corporations have created renewed pressure for regulators and senior managers to develop and implement global risk measurement techniques. Value-at-risk techniques assess an institution's potential loss from market movements over a given time period. While VaR has important applications for Latin American institutions, its use in the region must take several factors into account.

The VaR concept, recommended by a growing majority of regulators around the world, measures the maximum unfavorable change in portfolio value that can be expected to occur over a specific time period and confidence interval, due to the movements of economic variables. The methodology, which has gained rapid acceptance in the United States and Europe, can be decomposed in four steps. First, it determines a set of market variables (interest rates, foreign exchange rates, equity prices, etc.) to represent the market. Second, it assumes a given behavior for these market variables modeled through a stochastic process, typically a normal distribution. Third, the portfolio of transactions is modeled as a function of the market variables, i.e., the change in the portfolio's value as a function of the market variables is computed. Finally, the VaR can be computed for the portfolio using various techniques, including historical simulations, Monte Carlo simulations or covariance analyses.

The simplicity of the VaR concept has led many to recommend that it become a standard risk measure for financial institutions around the world. However, its relevance and applicability as a risk management tool for Latin American institutions is hindered by several key elements. Domestic economic policies or temporary regulatory constraints can reduce or eliminate liquidity in given market segments,

> **A direct application of value-at-risk measurement techniques to a Latin American environment would provide an inaccurate measurement of the firm's true market exposure.**

thus creating anomalies in the hist cal data series. In some cases, the sence of liquidity can translate i absence of trading, resulting in m ing data points in time series. At same time, the analysis of time se of market variables shows that nor distributions do not usually repre accurately the behavior of some n ket variables, as the populations ca the combination of multiple distr tions. A number of transactions indexed against commodity-ba prices, mostly gold and copper, commodity prices follow complex chastic distributions which are univariate and require the inclusi additional stochastic variables (e.g. venience yield in the case of cop The market risk of complex strat which arbitrage relationships betv cash and future markets (e.g. a c box in Brazil which consists of simultaneous purchase and sa deep in- and out-of-the-money op on coffee future contracts to cre synthetic zero coupon bond) doe depend on the main underlying ket variable (in this case, the fi price of coffee), but rather on a thetic market variable (in this cas implied investment or lending rate in dollars).

Proposed Solutions: Liquidity

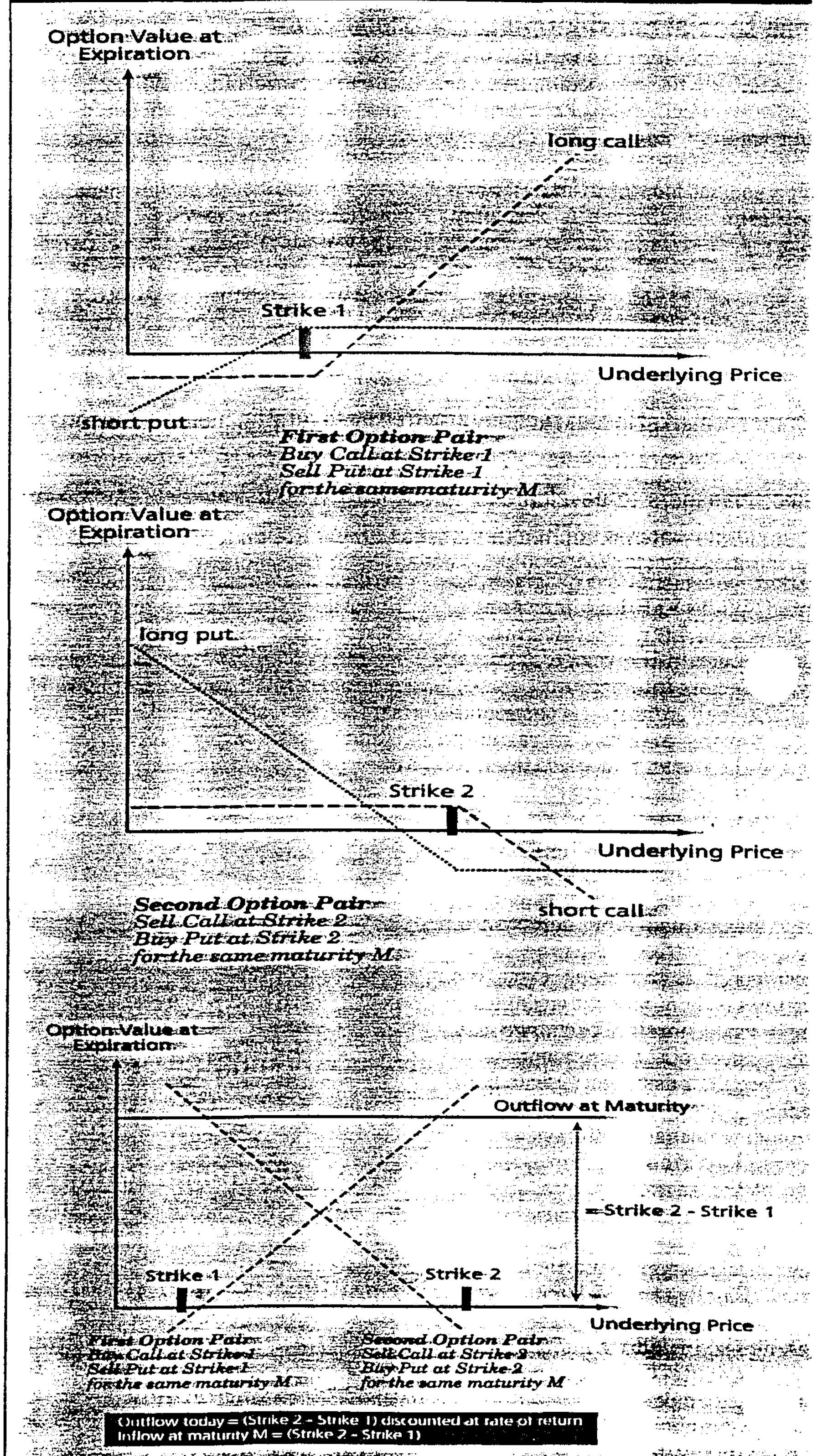
Liquidity issues in value-a measurements might be the res two distinct problems, namely th of the institution's position versu average daily trading volume and th ask spread. Ignoring the liquidity factor in Latin American markets can significantly underestimate the value-at-risk.

A firm might hold a large position in a given security, relative to the average daily volume traded for this security; if the firm tries to rapidly liquidate the position in the open market, it will likely see the market move significantly before the position has been fully liquidated.

Our proposed approach to mitigate this issue is to assign a different holding period or time-to-defease to different positions. In theory, this holding period could be precisely determined based on average volume traded, the distribution of trade sizes as well as the firm's position. More practically, the holding period can be roughly estimated by dividing the firm's open position in the given security by the daily volume traded in this security. The result will give the number of days needed to liquidate the position if one assumes that the firm will trade 100% of the volume over the period, which is clearly unrealistic. A multiplying factor should then be used to reflect the fact that the institution should not anticipate trading more than 20% of the daily traded volume. The implementation of this approach in a value-at-risk model will require that the time variable become a vector (so that different holding periods can be attached to individual securities) and that the theta (the position change in value due to time decay) be accurately computed. This applies to both a covariance analysis where the volatility vector must be adjusted for the holding period and a historical simulation analysis where market variable changes must be calculated over the holding period. Using this approach, we can separate our estimate of the value-at-risk into market risk portions and liquidity risk portions. The market risk portion is computed as the VaR when the holding period is set to zero for all securities. The liquidity portion is computed when the holding period is not equal to zero, i.e., with values assigned variable by variable, based on user-defined holding periods or time-to-defease estimates.

The bid-ask spread for a given as-

Constructing a Brazilian "Coffee Box"



set reflects the trading frequency and volume for the asset. In some cases, the bid and ask time series might exhibit very different patterns and using the mid-market prices could lead to inaccurate measures of the firm's value-at-risk.

Missing Data Points

Individual data points may be missing from the data set for several reasons. First, on some days (e.g., holidays) the market for these securities in some countries may not have been open. This is true across markets and, for individual countries, within markets. Second, the market for individual bonds may be effectively closed due to lack of interest on any particular day. Third, individual data points may be missing because the physical collection of the data was unfeasible or uneconomical. Correcting for these missing data points is important to increase the credibility of value-at-risk calculations. This is especially true since an individual security price that is missing in a series causes two missing data points in the series used to compute the covariance matrix used in traditional value-at-risk calculations. The problem is also compounded in the case of multiple series when missing data points may not occur on the same dates.

To mitigate this problem, the EM (expectation/maximization) algorithm can be used to correct for missing data points. The EM algorithm uses the principle of maximum likelihood to determine the optimal values for the missing data points, given the statistical properties of the entire data set. This method has been successfully used in financial research in both academic studies (e.g., Warga [1992]) and practitioner applications (e.g., JP Morgan [1994]).

Multiple Distributions

A common problem that arises from the observation of prices at which transactions are executed at various times and for various amounts is the fact that they may not arise from the same underlying population. More specifically, each transaction is concluded either at the bid or at the ask price, or at the inter-bank market price. Unfortunately, it is impossible to identify which individual transactions were executed at the bid or the ask price. As a consequence, when taking all transactions together to compute descriptive statistics, for example an average price, we would fail to consider that we should in fact consider separate sets of observations. In one example, derived from swap prices on the São Paulo futures exchange, the average price is actually the average of the bid, ask and inter-bank average prices. These prices represent three separate distributions.

One way to remedy this problem is to attempt to separate the three populations using statistical techniques. Using a kernel density estimation technique to estimate the underlying density (e.g. the frequency distribution), we find in the example above that the swap prices appear to actually come from three different distributions with three different means: the bid at about 50.15%, the ask at about 51% and the inter-bank price at 50.5%. Value-At-Risk calculations ought to take into account these three separate distributions for the relevant swap transactions (bid side, ask side, inter-bank trade).

Commodity Exposure

The modeling of future commodity prices requires the inclusion of additional variables, as illustrated below with the example of copper. The theory of storage is the dominant model for determining future commodity prices and uses the concept of convenience yield, which quantifies the convenience of holding the physical commodity in storage.

$$F(t,T) - S(t) = S(t)*R(t,T) + W(t,T) - C(t,T)$$

$S(t)$ is the spot price and $F(t,T)$ the forward price at t for delivery at time T

$R(t,T)$ is the interest rate between t and T

$W(t,T)$ is the marginal warehousing cost

$C(t,T)$ is the marginal convenience yield between t and T

The convenience yield does not follow a normal distribution, however. Traditional covariance or Monte Carlo methodologies assume a stable normal distribution for the price changes of the underlying asset. An efficient way to address this issue is to use the historical simulation approach, which makes no assumptions regarding the shape of the distribution of the underlying pric series. It values the current portfoli against the historical time series (afte transforming these time series in cor stant maturity time series to adjust fc time decay) and calculates the change in the portfolio value for one day to th other, thus deriving a real distributio of value changes over the period.

Synthetic Market Variables

A coffee box uses the put-call pa ity relation to create a synthetic loan (borrowing rate. The strategy uses tw pairs of options on coffee contract fi tures with the same maturity, the san underlying and different strikes. Tł box strategy is equivalent to a zer coupon investment or a borrowing wi a principal amount of the differen between the two option strikes for tl maturity. (*See chart on page 76*).

So even though the underlyir market variable is the coffee futur price, the true exposure is a dolla based interest rate. One possible wa to address this issue in a VaR ris management system is to allow for tl definition of risk types for individu market variables. Assuming for sir plicity purposes that the institutic trades options on coffee futures on for the box operations, the risk type these relevant market variables (this example coffee future price would be defined as US dollar intere rate. Going one step further, such system could even allow for the defir tion of this risk as coffee box ris facilitating further the identificatic of the special risk characteristics these trades.

Value-at-risk measurements r main a powerful tool for institutions assess their overall exposure to mark movements, as well the contribution various market factors to the firm's ove all exposure. The key issues discuss in this article show that a direct applic tion of value-at-risk measurement tec niques to a Latin American enviro ment would provide inaccurate me surements and representation of tl firm's true market exposure. Howeve a number of solutions are available ar can be fairly implemented. LF

Gabriel Bousbib is a vice president of r management at Reuters America I