Madrid, February 3, 2012

MEASURING HISTORICAL VOLATILITY

Close-to-Close, Exponentially Weighted, Parkinson, Garman-Klass, Rogers-Satchell and Yang-Zhang Volatility

Colin Bennett
Head of Derivatives Strategy
(+34) 91 289 3056
cdbennett@gruposantander.com

Miguel A. Gil
Equity Derivatives Strategy
(+34) 91 289 5515
mgil@gruposantander.com

The implied volatility of an option is usually compared against historical volatility to see if it is cheap or not. However, while there is only one implied volatility there are many different measures of historical volatility which can use some or all of the open (O), high (H), low (L) and close (C). Generally, for small sample sizes the Yang-Zhang measure is best overall, and for large sample sizes the standard close to close measure is best.

- **CLOSE-TO-CLOSE (C):** The simplest and most common type of calculation that benefits from only using reliable prices from closing auctions. We note that the volatility should be the standard deviation multiplied by $\sqrt{N/(N-1)}$ to take into account the fact we are sampling the population.

- **EXPONENTIALLY WEIGHTED (C):** Exponentially weighted volatilities are rarely used, partly due to the fact they do not handle regular volatility driving events such as earnings very well. Previous earnings jumps will have the least weight just before an earnings date, and the most weight just after earnings. It could, however, be of some use for indices.

- **PARKINSON (HL):** The first advanced volatility estimator was created by Parkinson in 1980, and instead of using closing prices it uses the high and low price. One drawback of this estimator is that it assumes continuous trading, hence it underestimates the volatility as potential movements when the market is shut are ignored. While other measures are more efficient based on simulated data, some studies have shown this to be the best measure for actual empirical data.

- **GARMAN-KLASS (OHLC):** Later in 1980 the Garman-Klass volatility estimator was created. It is an extension of Parkinson which includes opening and closing prices. As overnight jumps are ignored, the measure underestimates volatility. Yang-Zhang modified the Garman-Klass volatility measure in order to enable it to handle jumps.

- **ROGERS-SATCHELL (OHLC):** The Rogers-Satchell volatility created in the early 1990s is able to properly measure the volatility for securities with non-zero mean. It does not, however, handle jumps (hence it underestimates the volatility).

- **YANG-ZHANG (OHLC):** In 2000 Yang-Zhang created the most powerful volatility measure that handles both opening jumps and drift. It is the sum of the overnight volatility (close to open volatility) and a weighted average of the Rogers-Satchell volatility and the open to close volatility. The assumption of continuous prices does mean the measure tends to slightly underestimate the volatility.

MEASURING HISTORICAL VOLATILITY

The implied volatility for a certain strike and expiry has a fixed value. There is, however, no single calculation for historical volatility. The number of historical days for the historical volatility calculation changes the calculation, in addition to the estimate of the drift (or average amount stocks are assumed to rise). There should, however, be no difference between the average daily or weekly historical volatility. We also examine different methods of historical volatility calculation, including close-to-close volatility and exponentially weighted volatility, in addition to advanced volatility measures such as Parkinson, Garman-Klass (including Yang-Zhang extension), Rogers and Satchell and Yang-Zhang.

CLOSE TO CLOSE HISTORICAL VOLATILITY IS THE MOST COMMON

Volatility is defined as the annualised standard deviation of log returns. For historical volatility the usual measure is close-to-close volatility, which is shown below.

Log return = x_i= Ln$\left(\frac{c_i + d_i}{c_{i-1}}\right)$ where d_i = ordinary (not adjusted) dividend and c_i is close price

Volatility[1] (not annualised) = σ_x $\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$

where $\bar{x}$ = drift = Average (x_i)

BEST TO ASSUME ZERO DRIFT FOR VOLATILITY CALCULATION

For relatively short time periods (daily, weekly), the drift should be close to zero and can be ignored

The calculation for standard deviation calculates the deviation from the average log return (or drift). This average log return has to be estimated from the sample, which can cause problems if the return over the period sampled is very high or negative. As over the long term very high or negative returns are not realistic, the calculation of volatility can be corrupted by using the sample log return as the expected future return. For example, if an underlying rises 10% a day for 10 days, the volatility of the stock is zero (as there is zero deviation from the 10% average return). This is why volatility calculations are normally more reliable if a zero return is assumed. In theory, the expected average value of an underlying at a future date should be the value of the forward at that date. As for all normal interest rates (and dividends, borrow cost) the forward return should be close to 100% (for any reasonable sampling frequency i.e. daily/weekly/monthly). Hence for simplicity reasons it is easier to assume a zero log return as Ln(100%) = 0.

[1] We take the definition of volatility of John Hull in “Options, futures and other derivatives” in which n day volatility uses n returns and n+1 prices. We note Bloomberg uses n prices and n-1 returns.

LOG RETURNS CAN BE APPROXIMATED BY PERCENTAGE RETURNS

As returns are normally close to 1 (=100%) the log of returns is very similar to return – 1 (which is the percentage change of the price). If the return over the period is assumed to be the same for all periods, and if the mean return is assumed to be zero (it is normally very close to zero), the standard deviation of the percentage change is simply the absolute value of the percentage return. Hence an underlying which moves 1% has a volatility of 1% for that period. As volatility is usually quoted on an annualised basis, this volatility has be multiplied by the square root of the number of samples in a year (i.e. $\sqrt{252}$ for daily returns, $\sqrt{52}$ for weekly returns and $\sqrt{12}$ for monthly returns).

Number of trading days in year	= 252	=> Multiply daily returns by $\sqrt{252}$	≈ 16
Number of weeks in year	= 52	=> Multiply weekly returns by $\sqrt{52}$	≈ 7
Number of months in year	= 12	=> Multiply monthly returns by $\sqrt{12}$	≈ 3.5

WHICH HISTORICAL VOLATILITY SHOULD I USE?

When examining how attractive the implied volatility of an option is, investors will often compare it to historical volatility. However, historical volatility needs two parameters.

- Length of time (e.g. number of days/weeks/months)
- Frequency of measurement (e.g. daily/weekly)

LENGTH OF TIME FOR HISTORICAL VOLATILITY

Historical volatility should be a multiple of 3 months to have a constant number of quarterly reporting periods

Choosing the historical volatility number of days is not a trivial choice. Some investors believe the best number of days of historical volatility to look at is the same as the implied volatility of interest. For example, 1 month implied should be compared to 21 trading day historical volatility (and 3 month implied should be compared to 63 day historical volatility, etc). While an identical duration historical volatility is useful to arrive at a realistic minimum and maximum value over a long period of time, it is not always the best period of time to determine the fair level of long dated implieds. This is because volatility mean reverts over a period of c8 months. Using historical volatility for periods longer than c8 months is not likely to be the best estimate of future volatility (as it could include volatility caused by earlier events, whose effect on the market has passed). Arguably a multiple of 3 months should be used, to ensure that there is always the same number of quarterly reporting dates in the historical volatility measure. Additionally, if there has been a recent jump in the share price that is not expected to reoccur, the period of time chosen should try to exclude that jump.

The Best Historical Volatility Period Does Not Have to be the Most Recent

If there has been a rare event which caused a volatility spike, the best estimate of future volatility is not necessary the current historical volatility. A better estimate could be the past historical volatility when an event which caused a similar volatility spike occurred. For example, the volatility post credit crunch could be compared to the volatility spike after the Great Depression, or during the bursting of the tech bubble.

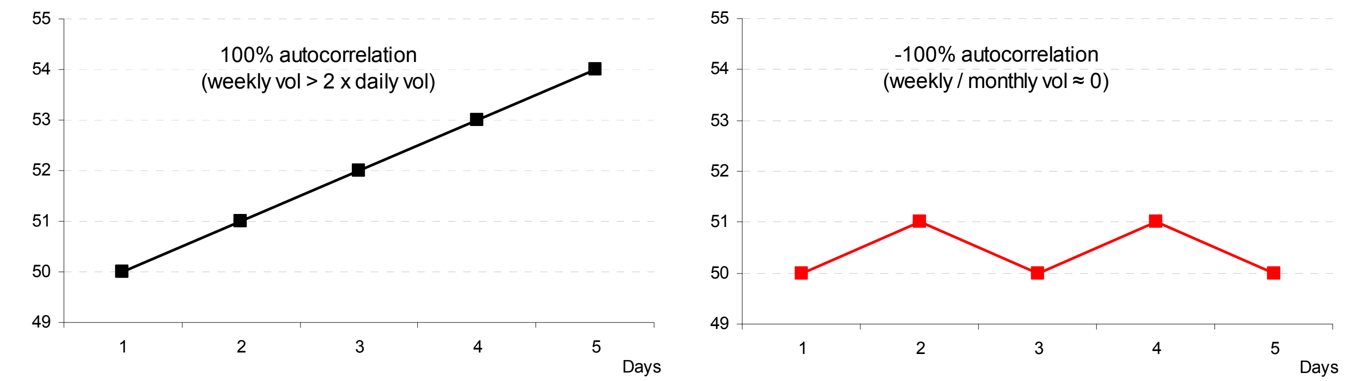
FREQUENCY OF HISTORICAL VOLATILITY

While historical volatility can be measured monthly, quarterly or yearly it is usually measured daily or weekly. Normally, daily volatility is preferable to weekly volatility as 5 times as many data points are available. However, if volatility over a long period of time is being examined between two different markets, weekly volatility could be the best measure to reduce the influence of different public holidays (and trading hours[2]). If stock price returns are independent, then the daily and weekly historical volatility should on average be the same. If stock price returns are not independent, there could be a difference. Autocorrelation is the correlation between two different returns so independent returns have an autocorrelation of 0%.

Trending Markets Imply Weekly Volatility is Greater Than Daily Volatility

With 100% autocorrelation, returns are perfectly correlated (a positive return is followed by a positive return, i.e. trending markets). Should autocorrelation be -100% correlated then a positive return is followed by a negative return (mean reverting or range trading markets). If we assume markets are 100% daily correlated with a 1% daily return, this means the weekly return is 5%. The daily volatility is therefore c16% (1% × √252) while the weekly volatility of c35% (5% × √52) is more than twice as large.

Figure 1. Stock Price with 100% Daily Autocorrelation **Stock Price with -100% Daily Autocorrelation**



Source: Santander Investment Bolsa estimates.

High Market Share of High Frequency Trading Should Prevent Autocorrelation

Historically (decades ago), there could have been positive autocorrelation due to momentum buying, but once this became understood this effect is likely to have faded. Given the current high market share of high frequency trading (accounting for up to three-quarters of US equity trading volume), it appears unlikely that a simple trading strategy such as 'buy if security goes up, sell if it goes down' will provide above average returns over a significant period of time.

Panicked Markets Could Cause Temporary Negative Autocorrelation

While positive autocorrelation is likely to be arbitraged out of the market, there is evidence that markets can overreact at times of stress as market panic (rare statistical events can occur under the weak form of efficient market hypotheses). During these events human traders and some automated trading systems are likely to stop trading (as the event is rare, the correct response is unknown), or potentially exaggerate the trend (as positions get "stopped out" or to follow the momentum of the move). A strategy that is long daily volatility and short weekly volatility will therefore usually give relatively flat returns, but occasionally give a positive return.

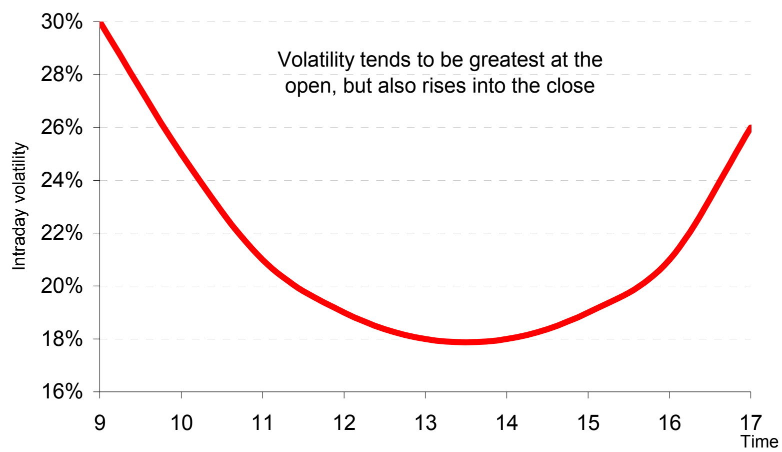
[2] Advanced volatility measures could be used to remove part of the effect of different trading hours

INTRADAY VOLATILITY IS NOT CONSTANT

Advanced volatility measures should be used by traders wishing to take into account intraday prices

For most markets, intraday volatility is greatest just after the open (as results are often announced around the open) and just before the close (performance is often based upon closing prices). Intraday volatility tends to sag in the middle of the day, due to the combination of a lack of announcements and reduced volumes/liquidity due to lunch breaks. For this reason using an estimate of volatility more frequent than daily tends to be very noisy. Traders who wish to take into account intraday prices should instead use an advanced volatility measure.

Figure 2. Intraday Volatility



Source: Santander Investment Bolsa.

EXPONENTIALLY WEIGHTED VOLATILITIES ARE RARELY USED

Exponentially weighted moving average can be used to reduce effect of spikes in volatility disappearing

An alternate measure could be to use an exponentially weighted moving average model, which is shown below. The parameter λ is between zero (effectively 1 day volatility) and 1 (ignore current vol and keep vol constant). Normally, values of c0.9 are used. Exponentially weighted volatilities are rarely used, partly due to the fact they do not handle regular volatility driving events such as earnings very well. Previous earnings jumps will have least weight just before an earnings date (when future volatility is most likely to be high), and most weight just after earnings (when future volatility is most likely to be low). It could, however, be of some use for indices.

$$\sigma_i^2 = \lambda \sigma_{i-1}^2 + (1-\lambda) x_i^2$$

Exponentially Weighted Volatility Avoids Volatility Collapse of Historic Volatility

Exponential volatility has the advantage over standard historical volatility in that the effect of a spike in volatility gradually fades (as opposed to suddenly disappearing causing a collapse in historic volatility). For example, if we are looking at the historical volatility over the past month and a spike in realised volatility suddenly occurs the historical volatility will be high for a month, then collapse. Exponentially weighted volatility will rise at the same time as historical volatility, and then gradually decline to lower levels (arguably in a similar way to how implied volatility spikes, then mean reverts).

ADVANCED VOLATILITY MEASURES

Volatility measures can use open, high and low prices in addition to closing price

Close-to-close volatility is usually used as it has the benefit of using the closing auction prices only. Should other prices be used, then they could be vulnerable to manipulation or a "fat fingered" trade. However, a large number of samples need to be used to get a good estimate of historical volatility, and using a large number of closing values can obscure short-term changes in volatility. There are, however, different methods of calculating volatility using some or all of the open (O), high (H), low (L) and close (C). The methods are listed in order of their maximum efficiency (close to close variance divided by alternative measure variance).

- **Close to close (C)**: The most common type of calculation that benefits from only using reliable prices from closing auctions. By definition its efficiency is 1 at all times.

- **Parkinson (HL)**: As this estimate only uses the high and low price for an underlying, it is less sensitive to differences in trading hours. For example, as the time of the EU and US closes are approximately half a trading day apart, they can give very different returns. Using the high and low means the trading over the whole day is examined, and the days overlap. As it does not handle jumps, on average it underestimates the volatility, as it does not take into account highs and lows when trading does not occur (weekends, between close and open). Although it does not handle drift, this is usually small. The Parkinson estimate is up to 5.2 times more efficient than the close to close estimate. While other measures are more efficient based on simulated data, some studies have shown it to be the best measure for actual empirical data.

- **Garman-Klass (OHLC)**: This estimate is the most powerful for stocks with Brownian motion, zero drift and no opening jumps (i.e. opening price is equal to closing price of previous period). While it is up to 7.4 times as efficient as the close to close estimate, it also underestimates the volatility (as like Parkinson it assumes no jumps).

- **Rogers-Satchell (OHLC)**: The efficiency of the Rogers-Satchell estimate is similar to that for Garman-Klass, however it benefits from being able to handle non-zero drift. Opening jumps are, however, not handled well, which means it underestimates the volatility.

- **Garman-Klass Yang-Zhang extension (OHLC)**: Yang-Zhang extended the Garman-Klass method that allows for opening jumps hence it is a fair estimate, but does assume zero drift. It has an efficiency of 8 times the close to close estimate.

- **Yang-Zhang (OHLC)**: The most powerful volatility estimator which has minimum estimation error. It is a weighted average of Rogers-Satchell, the close-open volatility and the open-close volatility. It is up to a maximum of 14 times as efficient (for 2 days of data) as the close to close estimate.

Figure 3. Summary of Advanced Volatility Estimates

Estimate	Prices Taken	Handle Drift?	Handle Overnight Jumps?	Efficiency (max)
Close to close	C	No	No	**1**
Parkinson	HL	No	No	**5.2**
Garman-Klass	OHLC	No	No	**7.4**
Rogers-Satchell	OHLC	Yes	No	**8**
Garman-Klass Yang-Zhang ext.	OHLC	No	Yes	**8**
Yang-Zhang	OHLC	Yes	Yes	**14**

Source: Santander Investment Bolsa.

EFFICIENCY AND BIAS DETERMINE BEST VOLATILITY MEASURE

Standard close-to-close is best for large samples, Yang-Zhang is best for small samples

There are two measures which can be used to determine the quality of a volatility measure: efficiency and bias. Generally, for small sample sizes the Yang-Zhang measure is best overall, and for large sample sizes the standard close to close measure is best.

- **Efficiency**: Efficiency $(\sigma_x{}^2) = \frac{\sigma_{cc}{}^2}{\sigma_x{}^2}$ where σ_x is the volatility of the estimate and σ_{cc} is the volatility of the standard close to close estimate.
- **Bias**: Difference between the estimated variance and the average (i.e. integrated) volatility.

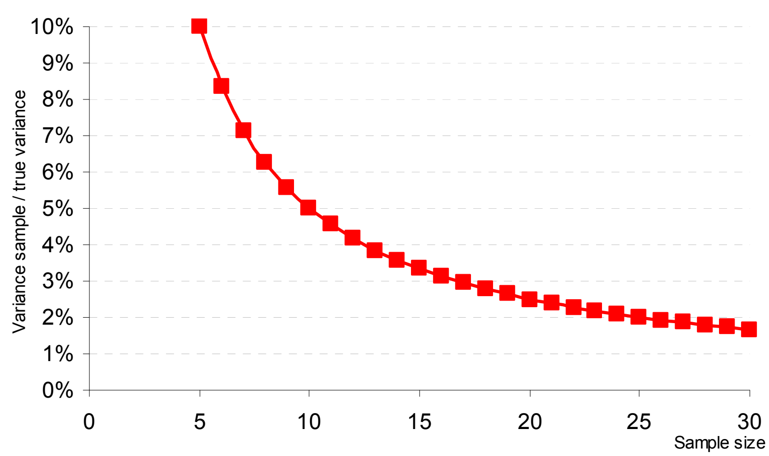
Efficiency Measures the Volatility of the Estimate

The efficiency describes the variance, or volatility of the estimate. The efficiency is dependent on the number of samples, with efficiency decreasing the more samples there are (as close to close will converge and become less volatile with more samples). The efficiency is the theoretical maximum performance against an idealised distribution, and with real empirical data a far smaller benefit is usually seen (especially for long time series). For example, while the Yang-Zhang based estimators deal with overnight jumps if the jumps are large compared to the daily volatility the estimate will converge with the close-to-close volatility and have an efficiency close to 1.

Close To Close Volatility Should Use At Least 5 Samples (and Ideally 20 or More)

The variance of the close-to-close volatility can be estimated as a percentage of the actual variance by the formula 1/(2N) where N is the number of samples. This is shown in Figure 4 below, and demonstrates that at least 5 samples are needed (or the estimate has a variance of over 10%) and that only marginal extra accuracy is gained for each additional sample above 20.

Figure 4. Variance of Close-To-Close Volatility/Actual Variance



Source: Santander Investment Bolsa.

Bias Depends on the Type of Distribution of the Underlying

Bias can be positive or negative depending on the distribution

While efficiency (how volatile the measure is) is important, so too is bias (is the measure on average too high or low). Bias depends on the sample size, and the type of distribution the underlying security has. Generally, the close-to-close volatility estimator is too big[3] (as it does not model overnight jumps) while alternative estimators are too small (as they assume continuous trading, and discrete trading will have a smaller difference between the maximum and minimum). The key variables which determine the bias are:

- **Sample size**: As the standard close-to-close volatility measure suffers with small sample sizes, this is where alternative measures perform best (the highest efficiency is reached for only 2 days of data).

- **Volatility of volatility**: While the close-to-close volatility estimate is relatively insensitive to a changing volatility (vol of vol), the alternative estimates are far more sensitive. This bias increases the more vol of vol increases (i.e. more vol of vol means a greater underestimate of volatility).

Approximately 1/6 of total volatility occurs overnight

- **Overnight jumps between close and open**: Approximately one-sixth of equity volatility occurs outside the trading day (and approximately twice that amount for ADRs). Overnight jumps cause the standard close-to-close estimate to overestimate the volatility, as jumps are not modelled. Alternative estimates which do not model jumps (Parkinson, Garman Klass and Rogers-Satchell) underestimate the volatility. Yang-Zhang estimates (both Yang-Zhang extension of Garman Klass and the Yang-Zhang measure itself) will converge with standard close-to-close volatility if the jumps are large compared to the overnight volatility.

- **Drift of underlying**: If the drift of the underlying is ignored as it is for Parkinson and Garman Klass (and the Yang Zhang extension of Garman Glass), then the measure will overestimate the volatility. This effect is small for any reasonable drifts (i.e. if we are looking at daily, weekly or monthly data).

- **Correlation daily volatility and overnight volatility**: While Yang-Zhang measures deal with overnight volatility, there is the assumption that overnight volatility and daily volatility are uncorrelated. Yang-Zhang measures will underestimate volatility when there is a correlation between daily return and overnight return (and vice versa), but this effect is small.

Variance, Volatility and Gamma Swaps Should Look at Standard Volatility (or Variance)

As the payout of variance, volatility and gamma swaps are based on close-to-close prices, the standard close-to-close volatility (or variance) should be used for comparing their price against realised. Additionally, if a trader only hedges at the close (potentially for liquidity reasons) then again the standard close-to-close volatility measure should be used.

[3] Compared to integrated volatility

CLOSE-TO-CLOSE

As the average is taken from the sample, close-to-close volatility has N-1 degrees of freedom

The simplest volatility measure is the standard close-to-close volatility. We note that the volatility should be the standard deviation multiplied by √N/(N-1) to take into account the fact we are sampling the population (or take standard deviation of the sample)[4]. We ignored this in the earlier definition as for reasonably large n it √N/(N-1) is roughly equal to zero.

Standard dev of x = $s_x = \sqrt{\frac{F}{N}}\sqrt{\sum_{i=1}^{N}(x_i - \bar{x})^2}$

As $\sigma = \sqrt{\sigma^2} = \sqrt{E(s^2)} < E(\sqrt{s^2}) = E(s)$ by Jensens´s inequality

Volatility = $\sigma_x = s_x \times \sqrt{\frac{N}{N-1}}$

$$\text{Volatility}_{\text{close to close}} = \sigma_{cc} = \sqrt{\frac{F}{N-1}}\sqrt{\sum_{i=1}^{N}(x_i - \bar{x})^2} = \sqrt{\frac{F}{N-1}}\sqrt{\sum_{i=1}^{N} Ln(\frac{c_i}{c_{i-1}})} \text{ assuming zero drift}$$

PARKINSON

The first advanced volatility estimator was created by Parkinson in 1980, and instead of using closing prices it uses the high and low price. One drawback of this estimator is that it assumes continuous trading, hence it underestimates the volatility as potential movements when the market is shut are ignored.

$$\text{Volatility}_{\text{Parkinson}} = \sigma_P = \sqrt{\frac{F}{N}}\sqrt{\frac{1}{4\,Ln(2)}\sum_{i=1}^{N}\left(Ln(\frac{h_i}{l_i})\right)^2}$$

GARMAN-KLASS

Later in 1980 the Garman-Klass volatility estimator was created. It is an extension of Parkinson which includes opening and closing prices (if opening prices are not available the close from the previous day can be used instead). As overnight jumps are ignored the measure underestimates the volatility.

$$\text{Volatility}_{\text{Garman-Klass}} = \sigma_{GK} = \sqrt{\frac{F}{N}}\sqrt{\sum_{i=1}^{N}\frac{1}{2}\left(Ln(\frac{h_i}{l_i})\right)^2 - (2Ln(2)-1)\left(Ln(\frac{c_i}{o_i})\right)^2}$$

[4] As the formula for standard deviation has N-1 degrees of freedom (as we subtract the sample average from each value of x)

ROGERS-SATCHELL

All of the previous advanced volatility measures assume the average return (or drift) is zero. Securities which have a drift, or non-zero mean, require a more sophisticated measure of volatility. The Rogers-Satchell volatility created in the early 1990s is able to properly measure the volatility for securities with non-zero mean. It does not, however, handle jumps, hence it underestimates the volatility.

$$\text{Volatility}_{\text{Rogers-Satchell}} = \sigma_{\text{RS}} = \sqrt{\frac{\text{F}}{N}}\sqrt{\sum_{i=1}^{N} Ln(\frac{h_i}{c_i})Ln(\frac{h_i}{o_i}) + Ln(\frac{l_i}{c_i})Ln(\frac{l_i}{o_i})}$$

GARMAN-KLASS YANG-ZHANG EXTENSION

Yang-Zhang modified the Garman-Klass volatility measure in order to let it handle jumps. The measure does assume a zero drift, hence it will overestimate the volatility if a security has a non-zero mean return. As the effect of drift is small, the fact continuous prices are not available usually means it underestimates the volatility (but by a smaller amount than the previous alternative measures).

$$\text{Volatility}_{\text{GKYZ}} = \sigma_{\text{GKYZ}} = \sqrt{\frac{\text{F}}{N}}\sqrt{\sum_{i=1}^{N}\left(Ln(\frac{o_i}{c_{i-1}})\right)^2 + \frac{1}{2}\left(Ln(\frac{h_i}{l_i})\right)^2 - (2Ln(2)-1)\left(Ln(\frac{c_i}{o_i})\right)^2}$$

YANG-ZHANG

Yang-Zhang is the sum of overnight volatility, and a weighted average of Rogers-Satchell and open-to-close volatility

In 2000 Yang-Zhang created a volatility measure that handles both opening jumps and drift. It is the sum of the overnight volatility (close-to-open volatility) and a weighted average of the Rogers-Satchell volatility and the open-to-close volatility. The assumption of continuous prices does mean the measure tends to slightly underestimate the volatility.

$$\text{Volatility}_{\text{Yang-Zhang}} = \sigma_{\text{YZ}} = \sqrt{\text{F}}\sqrt{\sigma_{\text{overnight volatility}}{}^2 + k\,\sigma_{\text{open to close volatility}}{}^2 + (1-k)\sigma_{RS}{}^2}$$

where k = $\dfrac{0.34}{1.34 + \dfrac{N+1}{N-1}}$

$$\sigma_{\text{overnight volatility}}{}^2 = \frac{1}{N-1}\sum_{i=1}^{N}\left[Ln(\frac{o_i}{c_{i-1}}) - \overline{Ln(\frac{o_i}{c_{i-1}})}\right]^2$$

$$\sigma_{\text{open to close volatility}}{}^2 = \frac{1}{N-1}\sum_{i=1}^{N}\left[Ln(\frac{c_i}{o_i}) - \overline{Ln(\frac{c_i}{o_i})}\right]^2$$

The products and strategies addressed in this report are complex, typically involve a high degree of risk and are intended for sale only to sophisticated investors who are capable of understanding and assuming the risks involved. The market value of any structured security may be affected by changes in economic, financial and political factors (including, but not limited to, spot and forward interest and exchange rates), time to maturity, market conditions and volatility, and the credit quality of any issuer or reference issuer. Any investor interested in purchasing a structured product should conduct their own investigation and analysis of the product and consult with their own professional advisers as to the risks involved in making such a purchase.

The opinions and recommendations included in this report are not necessarily those of the Equity Research Department of Santander Investment Bolsa or of its affiliates. A “Trading Places” rating on a specific company equating to that associated with a conventional “Buy, Hold or Underweight” recommendation should not be construed as a fundamental or official rating of a Santander Investment Bolsa analyst. Furthermore, the opinions and strategies contained in this report are completely independent of those that the Equity Research and Sales/Trading Departments of Santander Investment Bolsa may have from time to time.

Some investments discussed in this report may have a high level of volatility. High volatility investments may experience sudden and large falls in their value causing losses when that investment is realised. Those losses may equal your original investment. Indeed, in the case of some investments the potential losses may exceed the amount of initial investment and, in such circumstances, you may be required to pay more money to support those losses. Income yields from investments may fluctuate and, in consequence, initial capital paid to make the investment may be used as part of that income yield. Some investments may not be readily realisable and it may be difficult to sell or realise those investments, similarly it may prove difficult for you to obtain reliable information about the value, or risks, to which such an investment is exposed.

Past performance should not be taken as an indication or guarantee of future performance, and no representation or warranty, express or implied, is made regarding future performance. Information, opinions and estimates contained in this report reflect a judgement at its original date of publication by Grupo Santander and are subject to change without notice. The price, value of and income from any of the securities or financial instruments mentioned in this report can fall as well as rise. The value of securities and financial instruments is subject to exchange rate fluctuation that may have a positive or adverse effect on the price or income of such securities or financial instruments.

Information and opinions presented in this report have been obtained or derived from sources believed by Grupo Santander to be reliable, but Grupo Santander makes no representation as to their accuracy or completeness. Grupo Santander accepts no liability for loss arising from the use of the material presented in this report, except that this exclusion of liability does not apply to the extent that such liability arises under specific statutes or regulations applicable to Grupo Santander. This report is not to be relied upon in substitution for the exercise of independent judgment. Grupo Santander may have issued, and may in the future issue, other reports that are inconsistent with, and reach different conclusions from, the information presented in this report. Those reports reflect the different assumptions, views and analytical methods of the analysts who prepared them and Grupo Santander is under no obligation to ensure that such other reports are brought to the attention of any recipient of this report.

See back cover of this report for further disclaimer disclosures.

Important Disclosures

ANALYST CERTIFICATION: I, Colin Bennett, hereby certify that the views expressed in this research report accurately reflect my personal views about the subject company and its securities. I also certify that I have not been promised compensation either directly or indirectly for expressing the recommendation in this report.

This report has been prepared by Santander Investment Bolsa, Sociedad de Valores, S.A. ("Santander Investment Bolsa") and is provided for information purposes only. This document must not be considered as an offer to sell or a solicitation of an offer to buy. Any decision by the recipient to buy should be based on publicly available information on the related security and, where appropriate, should take into account the content of the related prospectus filed with the CNMV (Spanish National Securities Market Commission) and available from the CNMV, the company governing the related market (Sociedad Rectora de la Bolsa) and the company issuing the security. This report is issued in the United States by Santander Investment Securities, Inc. ("SIS"), in Spain by Santander Investment Bolsa and in the United Kingdom by Banco Santander, S.A., London Branch ("Santander London"). Santander London is authorised by the Bank of Spain. SIS, Santander Investment Bolsa and Santander London are members of Grupo Santander. This report is not being issued to private customers.

The information contained herein has been compiled from sources believed to be reliable, but while all reasonable care has been taken to ensure that the information contained herein is not untrue or misleading at the time of publication, we make no representation that it is accurate or complete and it should not be relied upon as such. All opinions and estimates included herein constitute our judgement as at the date of this report and are subject to change without notice. Santander Investment Bolsa may change the recommendation it has on a stock at any given time. It may also cease to cover a stock or initiate coverage of new stocks. There is no specific calendar for any such actions. From time to time, Grupo Santander and/or any of its officers or directors may have a position, or otherwise be interested in, transactions in securities which are directly or indirectly the subject of this report. Santander Investment Bolsa has internal rules of conduct that contain, among other things, procedures to prevent conflicts of interest with respect to recommendations, including: the consideration of its Research Department as a separate area, Chinese Walls, and the possibility of establishing specific restrictions on research activity where appropriate. Santander Investment Bolsa's research reports contain a certification stating that they reflect the authors' own opinions.

Grupo Santander may from time to time perform services for or solicit business from any company mentioned in this report. Neither Grupo Santander nor any other person accepts any liability whatsoever for any direct or consequential loss arising from any use of this report or its contents. This report may not be reproduced, distributed or published by any recipient for any purpose. Santander Investment Bolsa is under the supervision of the CNMV.

Any US recipient of this report (other than a registered broker-dealer or a bank acting in a broker-dealer capacity) that would like to effect any transaction in any security discussed herein should contact and place orders in the United States with the company distributing the research, SIS at (212) 692-2550, which, without in any way limiting the foregoing, accepts responsibility (solely for purposes of and within the meaning of Rule 15a-6 under the US Securities Exchange Act of 1934) under this report and its dissemination in the United States. US recipients of this report should be advised that this research has been produced by a non-member affiliate of SIS and, therefore, by rule, not all disclosures required under NASD Rule 2711 apply.

Key to Investment Codes*

		% of Companies	
Rating	**Definition**	**Covered with This Rating**	**Provided with Investment Banking Services in Past 12M**
Buy	Upside of more than 15%.	45.10	26.09
Hold	Upside of 10%-15%.	32.68	39.13
Underweight	Upside of less than 10%.	13.07	34.78
Under Review		0.00	0.00

NOTE: Given the recent volatility seen in the financial markets, the recommendation definitions are only indicative until further notice.
(*) Target prices set from January to June are for December 31 of the current year. Target prices set from July to December are for December 31 of the following year.

Local Offices

Madrid
Tel: 34-91-257-2309
Fax: 34-91-257-1811

Lisbon
Tel: 351-21-381-6580
Fax: 351-21-389-3680

London
Tel: 44-207-756-6605
Fax: 44-207-756-5033

New York
Tel: 212-692-2550
Fax: 212-407-4540

Bogotá
Tel: 571-644-8006
Fax: 571-592-0638

Buenos Aires
Tel: 54114-341-1052
Fax: 54114-341-1226

Caracas
Tel: 582-401-4306
Fax: 582-401-4219

Lima
Tel: 511-215-8100
Fax: 511-215-8185

Mexico City
Tel: 5255-5629-5040
Fax: 5255-5629-5846

Santiago
Tel: 562-336-3300
Fax: 562-697-3869

São Paulo
Tel: 5511-5538-8226
Fax: 5511-5538-8407

Tokyo
Tel: 813-3211-0356
Fax: 813-3211-0362