



RealVol[®] Indices

The Concept

Each RealVol Index has its own unique formula, but all are, at their core, based on the realized volatility of an underlying asset.

The Problem

Academics and market practitioners agree that risk cannot be accurately reflected in one number.

The Solution

In order to get a complete picture of risk, the team at RealVol settled on a set of 40 different indices — looking at risk from 40 different angles. The group consists of standard formulas and cutting-edge models, each over six time frames.

Realized Volatility Defined

Realized volatility is a measure of the magnitude of daily price movements, regardless of direction, of some underlying, over a specific period.

Realized vs. Implied

Realized volatility is functionally very different from implied volatility. Realized volatility is based on the actual movement of an underlying, while implied volatility is based on a value derived from associated options prices. In essence, realized volatility measures real risk.

Flagship Index

The flagship index is the 1-month RealVol index (VOLm or just VOL for short). This index will be used to settle all RealVol instruments.

RealVol Real-Time Index

The RealVol real-time index will use the real-time underlying price to estimate the RealVol daily index throughout the current trading day. At the close of the underlying market, the RealVol daily and real-time indices are equal.

RealVol Daily Indices

RealVol daily indices are based on only daily data of the underlying asset (i.e., open, high, low, and close). Note that the 1-day and 1-week correlations will not be calculated.

Six Time Frames

1. 1 day
2. 1 week (5 trading days)
3. 1 month (21 trading days)
4. 1 quarter (63 trading days)
5. 1 half year (126 trading days)
6. 1 year (252 trading days)

Seven Types

1. Realized volatility (vol)
2. Realized vol of vol
3. Overnight/intraday vol
4. Correlation (underlying vs. vol)
5. Realized variance
6. Rough forecast vol
7. HARK forecast vol

“What’s past is prologue.”

— William Shakespeare

Brochure updated: 1 September 2017

$$\sqrt{\frac{252}{n} \sum_{t=1}^n R_t^2}$$

Types of RealVol Indices

RealVol Real-Time Index

The flagship RealVol real-time index (VOL) uses time-weighted, intraday underlying prices to provide real-time, 1-month (21-day), realized volatility.

RealVol Daily Indices

All other RealVol indices are daily. This means that they are updated only once each trading day and are based only on daily observations of the underlying. In addition, all RealVol daily indices come in six time frames: 1 day, 1 week (5 trading days), 1 month (21 trading days), 1 quarter (63 trading days), 1 half year (126 trading days), and 1 year (252 trading days). The six time frames correspond to the investment horizon of most traders. For periods longer than one year, realized volatility deviates little from its very long-term average so is generally estimated to be a constant.

VOL Indices

The realized volatility indices (VOL) measure the interday (close-to-close) realized volatility of an underlying using the RealVol daily and real-time formula. As discussed, there are six time frames for all indices including VOL. The special flagship VOL Index is based on the 1-month time frame only. The reason for flagship status is that the 1-month version is the only one that will be used for tradable instruments.

VOV Indices

Realized volatility of realized volatility indices (VOV) measure the realized volatility of VOL using the RealVol daily formula a second time on the same data. Trading instruments on realized volatility compels one to discover the risk of those instruments. To do so, one needs to calculate the vol of vol. (Note: The second iteration through the data is always performed on a 1-month (21-day) basis, regardless of the time frame of VOL.)

DVOL Indices

The full day, overnight/intraday realized volatility indices (DVOL) measure the realized volatility based on the previous day's close and today's open, high, and low data of an underlying using the RealVol overnight/intraday formula. One can think of DVOL as another measure of 24-hour price risk of an underlying using additional data points for greater accuracy.

VCOR Indices

Correlation indices (VCOR) measure the correlation between the underlying and its VOL. They are calculated by using the RealVol correlation formula. Use VCOR for insight into the linear relationship between the underlying and its realized volatility. (Note: Two time frames, the 1-day and 1-week correlations, will not be calculated.)

VAR Indices

Realized variance indices (VAR) measure the interday realized variance of an underlying using the RealVar daily formula. VAR Indices are simply the square of VOL. One can think of VAR as another measure of interday price risk of an underlying. Variances are easier to sum, average, and combine because the result is linear as opposed to that of volatility, which is a curve function.

RVOL Indices

The Rough Vol model (Rough Fractional Stochastic Volatility or "RFSV") forecasts realized volatility. According to the model, created by Professor James Gatheral of Baruch College, the log of daily high/low realized volatilities is well approximated by fractional Brownian motion with a Hurst parameter H close to zero. The Rough Vol model is used to create the RVOL indices, which forecast realized volatility over six standardized time frames.

HVOL Indices

HARK (Heterogeneous auto-regressive model cast into a Kalman filter framework) is a forecast of realized volatility. It is a dynamic extension of the asymmetric (i.e., with leverage effects) HAR model where the parameters are continuously and optimally updated by the Kalman filter according to the statistical properties of an intraday realized volatility input. This allows flexibility and fast adaptation to the original HAR model, which was created by Professor Fulvio Corsi of Ca' Foscari University of Venice. The HARK model is used to create the HVOL indices, which forecast realized volatility over six standardized time frames.

Our preliminary research has shown that the HARK Vol and Rough Vol models approximate future realized volatility more accurately than the market (based on implied volatility).

RealVol Index Symbols

| Base Symbol | Description | Day | Week (5-day) | Month (21-day) | Quarter (63-day) | Half Year (126-day) | Year (252-day) |
|-------------|--|-------|--------------|----------------|------------------|---------------------|----------------|
| VOL | Realized Volatility | VOLd | VOLw | <u>VOLm</u> | VOLq | VOLh | VOLy |
| VOV | Realized Volatility of Realized Volatility | VOVd | VOVw | VOVm | VOVq | VOVh | VOVy |
| DVOL | Overnight/Intraday "Daily" Realized Volatility | DVOLd | DVOLw | DVOLm | DVOLq | DVOLh | DVOLy |
| VCOR | Correlation of Underlying vs. VOL | N/A | N/A | VCORm | VCORq | VCORh | VCORy |
| VAR | Realized Variance | VARd | VARw | VARm | VARq | VARh | VARy |
| RVOL | RFSV "Rough" Model Forecast of VOL | RVOLd | RVOLw | RVOLm | RVOLq | RVOLh | RVOLy |
| HVOL | HARK Model Forecast of VOL | HVOLd | HVOLw | HVOLm | HVOLq | HVOLh | HVOLy |

Note: The highlighted index (VOLm) is the flagship index. The *real-time* version of the flagship index may be used to settle tradable RealVol instruments. The *daily* indices could be used to guide investment decisions.

Table of Assets and Symbols

| <u>Asset Class</u> | <u>Symbol</u> | <u>Index Name</u> | <u>Underlying Asset</u> | <u>Start</u> |
|--------------------|---------------|------------------------------------|--|--------------|
| Equities | | | | |
| | VOLSPY | RealVol SPY Indices | SPDR® S&P 500® ETF | 1993 |
| Equity Indices | | | | |
| | VOLES | RealVol US 500 Indices | E-mini® S&P 500® Futures – CME | 1997 |
| | VOLYM | RealVol Indu 30 Indices | E-mini Dow® (\$5) Futures – CBT | 1997 |
| | VOLNQ | RealVol Tech 100 Indices | E-mini NASDAQ 100® Futures – CME | 1999 |
| | VOLMD | RealVol Mid 400 Indices | E-mini S&P® MidCap 400® Futures – CME | 1992 |
| | VOLNK | RealVol Japan 225 Indices | Nikkei®/USD Futures – CME | 1990 |
| Commodities | | | | |
| | VOLCC | RealVol Cocoa Indices | Cocoa Futures – ICE | 1970 |
| | VOLKC | RealVol Coffee Indices | Coffee Futures – ICE | 1973 |
| | VOLC | RealVol Corn Indices | Corn Futures – CBT | 1962 |
| | VOLCT | RealVol Cotton Indices | Cotton Futures – ICE | 1972 |
| | VOLFC | RealVol Feeder Cattle Indices | Feeder Cattle Futures – CME | 1974 |
| | VOLLC | RealVol Live Cattle Indices | Live Cattle Futures – CME | 1966 |
| | VOLLN | RealVol Lean Hogs Indices | Lean Hog Futures – CME | 1970 |
| | VOLOJ | RealVol Orange Juice Indices | Orange Juice Futures – ICE | 1967 |
| | VOLS | RealVol Soybean Indices | Soybean Futures – CBT | 1970 |
| | VOLSM | RealVol Soybean Meal Indices | Soybean Meal Futures – CBT | 1964 |
| | VOLBO | RealVol Soybean Oil Indices | Soybean Oil Futures – CBT | 1962 |
| | VOLSB | RealVol Sugar Indices | Sugar Futures – ICE | 1964 |
| | VOLW | RealVol Wheat Indices | Wheat Futures – CBT | 1962 |
| Currencies | | | | |
| | VOLBP | RealVol GBP/USD Indices | British Pound Futures – CME | 1976 |
| | VOLEC | RealVol EUR/USD Indices | Euro FX Futures – CME | 1999 |
| | VOLJY | RealVol USD/JPY Indices | Japanese Yen Futures – CME | 1977 |
| | VOLSF | RealVol CHF/USD Indices | Swiss Franc Futures – CME | 1975 |
| Interest Rates | | | | |
| | VOLTU | RealVol 2 Yr Note Indices | 2 Yr Note Futures – CBT | 1990 |
| | VOLFV | RealVol 5 Yr Note Indices | 5 Yr Note Futures – CBT | 1988 |
| | VOLTY | RealVol 10 Yr Note Indices | 10 Yr Note Futures – CBT | 1982 |
| | VOLUS | RealVol U.S. Treasury Bond Indices | U.S. Treasury Bond Futures – CBT | 1977 |
| | VOLBS | RealVol Euro-Schatz Indices | Euro-Schatz – EUREX | 1997 |
| | VOLBM | RealVol Euro-Bobl Indices | Euro-Bobl – EUREX | 1995 |
| | VOLBL | RealVol Euro-Bund Indices | Euro-Bund – EUREX | 1990 |
| | VOLR | RealVol Long Gilt Indices | Long Gilt – LIFFE | 1990 |
| Energy | | | | |
| | VOLNG | RealVol Natural Gas Indices | Natural Gas (Henry Hub) Physical Futures – NYMEX | 1990 |
| | VOLB | RealVol Brent Crude Oil Indices | Brent Crude Oil Futures – ICE | 1994 |
| | VOLCL | RealVol Crude Oil Indices | Crude Oil Futures – NYMEX | 1983 |
| | VOLG | RealVol Gasoil Indices | Gasoil Futures – ICE | 1990 |
| | VOLHO | RealVol Heating Oil Indices | NY Harbor ULSD Futures – NYMEX | 1980 |
| | VOLRB | RealVol NYH RBOB Gas Indices | RBOB Gasoline Physical Futures – NYMEX | 1996 |
| Metals | | | | |
| | VOLGC | RealVol Gold Indices | Gold Futures – CEC | 1975 |
| | VOLHG | RealVol Copper Indices | Copper Futures – CEC | 1962 |
| | VOLSI | RealVol Silver Indices | Silver Futures – CEC | 1965 |

RealVol LLC:
www.realvol.com
info@realvol.com
 1-888-865-9267

*Subject to change. The information provided herein must not be relied upon and Demand Derivatives Corp. and its subsidiaries will not be liable for actions taken or not taken in reliance thereon. SPDR® S&P 500® ETF Trust is sponsored by PDR Services, LLC, and the trustee of the Trust is State Street Bank and Trust Company. Nasdaq-100® is a registered trademarks of The Nasdaq Stock Market, Inc. SPDR®, S&P®, S&P 500®, and Midcap 400® are registered trademarks of Standard & Poor's Financial Services LLC. Nikkei® is a registered trademark of Kabushiki Kaisha Nihon Keizai Shimbun Sha. DOW® is a registered trademark of S&P Dow Jones Indices LLC, a division of S&P Global. E-mini is a registered trademark of the Chicago Mercantile Exchange Inc.