The Effect of the United States Natural Gas Fund on NYMEX Near Month Natural Gas Futures

Price Volatility

Jacob Kastner
Abstract

Price volatility in futures markets is an important statistic; volatility can be used as a tool to measure risk in the marketplace. Using intraday price volatility data for near month natural gas futures contracts, combined with established control variables, this study investigates the impact of United States Natural Gas (USNG), a natural gas futures Exchange Traded Fund (ETF), on price volatility of natural gas futures contracts. Currently, USNG is the center of controversy as the Commodity Futures Trading Commission (CFTC) considers position limits on natural gas futures holdings. The *Wall Street Journal* has reported that these proposed limits are designed, in part, to “tamp down volatility.” Consistent with previous literature, maturity, volume, and open interest are confirmed as controls of price volatility. More importantly, nearly all variables relating to USNG are significant, most associated with large decreases in price volatility. This study is timely and important; findings suggest that, as USNG offers stability to the natural gas futures market. The CFTC may wish to further review USNG and the ETF’s effect on volatility before implementing position limits in the natural gas futures market.
Background

Price volatility, which has long been used as a tool to measure risk in the marketplace, is an especially important statistic in the futures market. Since unpredictable fluctuations in the price of an asset can result in rapid loss or return on investments, investors use volatility as a measure of market risk. Predicting volatility of futures contracts provides an effective method of evaluation for the effect of Exchange Traded Funds (ETF) on their underlying markets. This analysis will investigate the effect of a specific ETF, United States Natural Gas Fund (USNG), on near month New York Mercantile Exchange (NYMEX) natural gas futures, the asset that it is designed to track.

An ETF is a financial security designed to track an index, commodity, or portfolio of stocks. ETFs combine many of the advantages of equities with the positive characteristics found in traditional open-end mutual funds. Trading a basket of goods provides diversity similar to mutual funds. An ETF can be traded during market hours, allowing investors to take advantage of intraday returns. ETFs can also track international securities, providing flexibility for investors who can thereby avoid direct interaction with foreign exchanges. As an added bonus, ETFs often incur fewer management costs than mutual funds. The first ETF was created in 1993. Ever since, the popularity of this financial instrument has grown tremendously.

USNG is an ETF potentially affected by Commodity Futures Trading Commission (CFTC) proposed position limits. The CFTC is a federally mandated, independent agency, with the responsibility of monitoring commodity futures and options trading. As is detailed within its prospectus, USNG seeks to match the daily return of near month natural gas futures traded on the NYMEX. USNG is traded on the Arca platform of the New York Stock Exchange (NYSE) under the ticker UNG. USNG has seen massive investor inflows, at one point becoming the third-
largest commodity ETF measured by total net assets. To provide investors with returns, USNG purchases near month natural gas futures traded on the NYMEX. As the near month constantly changes, so must the composition of USNG’s portfolio. Over a period of four days in the middle of each month, USNG rolls its futures holdings, selling out of the current near month, and buying what will become the next near month contract. USNG has also increased holdings of swap contracts, traded on both the Intercontinental Exchange (ICE) and NYMEX, to provide value to investors.

Recently, the natural gas futures market has been the center of controversy. In the wake of the financial crisis of 2008, regulators have been pressed to reduce speculation, seeking to match market prices with demand for consumption of commodities. In 2010, the CFTC issued a proposal regarding position limits that would apply to natural gas, and three other types of energy futures contracts traded on both the NYMEX and the ICE. These limits would create a hard cap on the number of contracts that a single individual or entity could hold. Kara Scannell, of the Wall Street Journal (2010) reported that this proposal was designed, in part, to “tamp down volatility,” raising the question: how does USNG affect volatility in the futures market?

As complex financial instruments and markets become increasingly interconnected, oversight and regulation are not just important, they are essential to economic stability. Decisions regarding regulation, however, must be based on evidence and knowledge. This study explores the effect of USNG on price volatility of near month Henry Harbor natural gas contracts traded on the NYMEX. To do so, this paper first seeks to define the determinants of price volatility in futures contracts by reexamining the findings in previous studies on maturity effects in futures contracts, along with studies on the effects of daily trading volume and daily open interest. This study also investigates the effect of ETFs, as a collective of investors acting as one,
on the price volatility of futures. Specifically this study seeks to determine the effect that USNG’s holdings and size have on the price volatility of natural gas futures. In conclusion, this study will provide commentary on CFTC proposed position limits in futures markets.

**Literature**

Futures price volatility has been studied extensively. Previous literature provides suggestions for controls of the determinants of price volatility in futures contracts. Samuelson (1965) offers a theoretical framework for the prediction of price volatility, proposing that price volatility should increase as contracts approach maturity. Samuelson’s observations are based upon the assumption that spot prices follow a first-order linear autoregressive model. In more recent publications, however, other economists present alternative approaches to both the Samuelson hypothesis and price volatility. Rutledge (1976) suggested a new model, holding current price changes proportional to price changes of previous periods. In this model, contrary to findings of Samuelson, price volatility declines as contracts approach maturity. Investigation of the Samuelson hypothesis, or more specifically, controlling for any possible maturity effect, will be important to determining the effect of USNG on price volatility.

More recent studies consider of the effect of trade volume on price volatility. Grammatikos and Saunders (1986) examine the importance of maturity for contracts, but add a variable to account for volume of contracts traded daily. Grammatikos and Saunders find that a trade volume variable explains more price volatility than is explained by maturity. The trade volume variable, however, is limited in utility due to an unclear direction of causality. It is unclear whether higher price volatility results in greater trade volume or vice-versa.
Two studies, one by Serletis (1992), and the other by Herbert (1995), build upon previous literature, further exploring the prediction of futures contract price volatility. Serletis explores the effects of both trading volume and maturity on price volatility. Serletis uses daily high and daily low prices along with daily trading volume for 129 energy futures traded on the NYMEX, gleaning data from the inception of each contract until its maturity date. As a measure of volatility, Serletis selected the best intraday interval data available at that time. Volatility is measured as the difference in logarithmic daily high and daily low prices:

$$\text{Var}(t) = \left(\ln H(t) - \ln L(t)\right)^2/4\ln(2)$$

Serletis finds a negative relationship between maturity and price variation. He also finds that this relationship weakens after the inclusion of a variable for trade volume. His study, recognizing the causality issue with trade volume and volatility of prices, employs the Granger test to address this problem, finding that most often, trade volume Granger-causes price volatility to increase.

While Herbert’s study is similar to that of Serletis, there exist key differences. Unlike Serletis, Herbert only examines natural gas futures contracts that have reached the month nearest to maturity. Herbert uses the same estimator for price variation, and uses the same explanatory variables. Like Serletis, Herbert determines that volume explains the most volatility in prices. Herbert finds little evidence that maturity effects price volatility. This finding is likely due to a limited number of observations for each regression equation. Building upon the work of Grammatikos and Saunders, Herbert and Serletis demonstrate the importance of controlling for
trade volume when examining the determinants of price volatility. My study therefore includes a trade volume variable in addition to a maturity variable.

Ripple and Moosa (2009) also study the determinants of price volatility in futures contracts. Besides maturity and trade volume, Ripple and Moosa add open interest to their control variables. Open interest is defined as the number of contracts yet to be closed out. This variable provides a sense of the daily size of the futures market. Ripple and Moosa also aggregate individual contract data into a set, splicing in near month and next to near month data from 131 contracts. Ripple and Moosa use the autoregressive distributive lag methodology to estimate the model for the time series data. The researchers find that volume and open interest are both highly significant as predictors of price volatility. Following these findings, my study also incorporates open interest as a control variable.

Duong and Kalev (2008) further examine the determinants of price volatility in futures contracts. These researchers employ a new statistic for intraday volatility as the dependent variable, calculating the sum of squared returns using five-minute intervals. The use of five-minute intervals follows a precedent set in earlier studies by Areal and Taylor (2002) and Thomakos and Wang (2003). Taylor (2004) provides further support for five-minute intervals, arguing that this sampling frequency is optimal; the frequency is high enough to ensure observation of nearly all volatility, and yet low enough to provide prices that are not distorted by extreme volatility. My study keeps to the precedent of five-minute sampling intervals, and uses a measure of price volatility similar to the one calculated by Duong and Kalev.

Taking cues from all previous literature, this study examines the effect of United States Natural Gas Fund on price volatility of near month natural gas futures. Following the work of Samuelson, and Rutledge, a variable is included for maturity. As demonstrated by Grammatikos
and Saunders, Herbert and Serletis, a variable is included for trade volume. Ripple and Moosa provide support for the inclusion of an open interest variable. Finally, Duong and Kalev, following the precedent of Areal and Taylor, Thomakos and Wang, and Taylor, give precedence for a measurement of price volatility using a five-minute sampling interval.

**Methodology**

The data in this study consists of intraday information on natural gas futures contracts, along with data from USNG regarding both futures contract trades and holdings. Intraday market data includes the open, high, low and closing price sampled every five minutes. This intraday data is sourced from the NYMEX and is acquired through CQG Data Factory, a private data repository. USNG publishes daily information on total net assets, creation units outstanding, along with information on all pending trades and end of day holdings.

Data is spliced into a single time series, including only days when the near month contract is traded on the NYMEX floor. Data encompasses the full month immediately following inception of USNG on April 18, 2007 until January 27, 2010. Each month has an average number of just over 14 observations. The total number of observations is 473. Data is only kept for near month futures for a variety of reasons. Near month contracts are the most heavily traded, thus data is present for all five-minute intervals, necessary for the calculation of intraday volatility. More importantly, USNG attempts to replicate the returns of near month contracts -- the same contracts that constitute a majority of the fund’s total net assets. The variables from USNG should therefore have the greatest explanatory power regarding these near month contracts.
The dependent variable is the standard deviation of the logarithmic price changes for the close of natural gas futures prices sampled every five minutes:

\[
\text{STDEV}(T) = \text{SqRoot} \left[ \frac{\sum (X - \mu)^2}{n-1} \right]
\]

Where:

\[
X = \ln[(c(t)/c(t-1)]
\]

\[
\mu = E[X]
\]

Like the five-minute interval precedent established by Duong and Kalev (2008), this statistic improves upon the intraday measure employed by Serletis (1992), Herbert (1995), and Ripple and Moosa (2009), by picking up variation in prices throughout the trading day. Unlike Duong and Kalev, however, this statistic also incorporates the logarithmic difference in prices, similar to the calculations of Serletis, Herbert, and Ripple and Moosa.

Time to maturity, daily total volume, and daily open interest are included as control variables. Time to maturity is measured as a decreasing index of the number of days until maturity. The reliability of these controls will be examined, and the results will be compared to the findings of previous studies. Explanatory variables from USNG data are the total net assets of the fund, a dummy variable indicating roll periods, and the number of near month NYMEX futures contracts, NYMEX swap contracts, and ICE swap contracts held at the end of each trading day. These variables are used in the following regression equations:

\[
\begin{align*}
(1) \text{STDEV}(p_t) &= \beta_1 + \beta_2 \text{TTM} + \beta_3 \text{VOL} + \beta_4 \text{OI} \\
(2) \text{STDEV}(p_t) &= \beta_1 + \beta_2 \text{TTM} + \beta_3 \text{VOL} + \beta_4 \text{OI} + \beta_5 \text{ROLL} + \beta_6 \text{TNA} + \beta_7 \text{ICE} + \beta_8 \text{SWP} + \beta_9 \text{FUT}
\end{align*}
\]
Equation One tests the power of the control variables detailed in earlier literature. The methodology follows earlier studies, while using the improved measurement of intraday volatility. Equation Two adds the variables gathered from USNG data. These additional variables will display any effect that USNG has upon price volatility in the natural gas futures market.

The USNG variables are important as they reveal any effects that the fund may have on the futures market. The variable for total net assets is perhaps the most interesting. Investors who hold shares of USNG cannot take advantage of intraday price variation as would liquidity traders or market makers. Growth in the total net assets of USNG is reflective of an interest in tracking the returns of natural gas. Importantly, this particular form of investment of trade volume does not raise issues with causality.

The trade variables are straightforward. The roll period indicator explains any changes in price volatility that may exist exclusively during the USNG’s transition between near month contracts. The three swaps and futures holdings variables determine whether changes in the fund’s composition explain any volatility in prices. These four variables are the most important for analyzing any effect of USNG trades on the natural gas futures market.

Both regressions are diagnosed for errors, including autocorrelation, heteroskedasticity, and collinearity. Of the potential errors listed, only heteroskedasticity is detected; this is corrected using robust standard errors in STATA. As time-series data is used, the independent variable will be tested for stationarity, using the Dickey-Fuller test. This test finds no evidence of a unit root within the time-series. Variables are also tested individually with F-tests. F-tests are again used to test both sets of variables for joint significance.
Results and Analysis

Descriptive statistics for all variables are listed in Table 1. This table includes the mean and standard deviation for each variable. Results for both equations are provided in Table 2. The Dickey-Fuller result rejects the null hypothesis of the presence of a unit root. Therefore, traditional OLS regression is appropriate.

<table>
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<td><strong>STDDEV</strong></td>
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</tr>
<tr>
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<td><strong>FUT</strong></td>
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The first equation tests for the determinants of price volatility using a similar methodology to that of previous literature, while also providing a baseline for comparison against the second equation. The results from this first model are consistent with the findings of Serletis (1992) and Herbert (1995); after the inclusion of a variable for daily trading volume, neither researcher found maturity to be an effective determinant of price volatility. The coefficient for maturity is also not significant and is positive; in the first equation, the coefficient offers no support for Samuelson’s hypothesis.

The coefficients for volume and open interest support the findings of Ripple and Moosa (2009). In their study, Ripple and Moosa find that the coefficients for volume and open interest are both significant, with the volume coefficient three times greater than that of open interest.
My study produces similar comparative effects; I find that the coefficient for volume is two and a half times the coefficient for open interest. Volume carries a positive coefficient and open interest has a negative coefficient.

The interpretations of the coefficients reveal more about the magnitude of each variable’s effect. Maturity, as an index of observed days until expiry, never exceeds sixteen. In comparison, as shown in Table 1, the average observation for total net assets is over $14,000,000,000, average daily volume is over 200,000 contracts and average daily open interest is over 750,000 contracts. As the variables are so different in scale, multiplying coefficients by the average size of observations gives a better sense of the magnitude of effect. After multiplying coefficients by average variable size, open interest has nearly a one and a half times greater effect than daily volume upon price volatility. These findings demonstrate the importance of including open interest as a control for price volatility. While volume may have a larger coefficient than open interest, the difference in variable size results in a much larger effect from open interest.

The second equation includes the explanatory variables for USNG along with the controls for price volatility. This regression reveals the effect of USNG variables on price volatility. Notably, the explanatory power of this second regression is much improved over the original model of prediction. Also, unlike the first model, the coefficient for maturity is now significant. The coefficients from the first regression also undergo fairly dramatic changes. While the sign of each control remains the same, the magnitude of effects is much different. The coefficient for volume becomes more than one and a half times larger; the coefficients for maturity and open interest increase by more than three times. The coefficients for the controls, ranked highest to lowest are: maturity, volume, and open interest. This ranking does not change from the first
model. While maturity still has the largest coefficient, the coefficients for open interest and volume are much more similar.

These control variables can be interpreted as before. After adjusting coefficients for the average size of observations, open interest has by far the greatest effect on price volatility. This effect is three times the effect of daily volume. The volume effect is nearly twice the size of the maturity effect. I find that open interest is found to be more powerful than did Ripple and Moosa (2009).

Table 2
OLS Regression Results and Diagnostics

<table>
<thead>
<tr>
<th></th>
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<td>Obs.</td>
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</tr>
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<td>TTM</td>
<td>.0104857</td>
<td>.0348498**</td>
</tr>
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<td>0.0009683</td>
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<td>FUT</td>
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<td>-.0283113***</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.0167</td>
<td>0.1017</td>
</tr>
<tr>
<td>DW</td>
<td>1.607077</td>
<td>1.789609</td>
</tr>
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</table>

*: Significant at 90% level
**: at 95% level
***: at 99% level

Even in the second model, while significant, maturity does not carry the correct sign to support the Samuelson hypothesis. Instead, the findings of this second regression support the theories of Rutledge (1976); price volatility falls as maturity approaches. Rutledge’s proposal follows the logic that as a contract gets closer to expiry, the contract becomes less risky. With
each day, the risk of some massive, price-shifting event, becomes lower and lower. As this risk falls and market predictability increases, price volatility decreases.

The second equation also demonstrates that the variables related to USNG are important. These variables reveal the impact of the fund, particularly as it grew, both in size and in holdings, on natural gas futures price volatility (Table 2). Consider the coefficients for the USNG variables in the second equation. Total net assets, futures holdings and the roll period indicator are all negative, the coefficients on ICE swap holdings and NYMEX swap holdings are both positive. Of the coefficients, three were significant: total net assets, NYMEX futures holdings and ICE swap holdings. The significant coefficients are listed in order of highest to lowest: maturity, NYMEX futures holdings, volume, open interest, ICE swap holdings, and total net assets. As with the control variables from the first equation, all coefficients are then multiplied by the average size of observations to determine the average effect generated by each variable. After controlling for size of observations, the magnitude of each variable’s effect is again listed in order of highest to lowest: open interest, volume, maturity, total net assets, NYMEX futures holdings, and ICE swap holdings.

Of the significant USNG variables, NYMEX futures holdings has the largest coefficient. This negative coefficient is nearly as large as the coefficient on maturity, the most powerful coefficient. Every 1,000 contracts held has nearly the equivalent effect of an additional day closer to maturity. As USNG makes its holdings public, futures holdings should have a strong effect on price volatility. Investors can learn exactly when these units will be traded, and can estimate price points. The more holdings, the more likely a prediction will be accurate. Additionally, NYMEX futures is the asset in which price volatility is being measured. This variable should have a strong effect on price volatility.
Total net assets has the smallest coefficient, yet has one of the greatest magnitude of effect. This discrepancy is explained by the enormous size of the total net assets variable. Single dollar increases in the value of USNG will not have much of an effect on price volatility. As the ETF became the largest of its kind, it began to strongly influence price volatility. The average magnitude of effect for total net assets is nearly as large as the maturity effect. Just like NYMEX futures holdings, it is clear that total net assets can have a strong, calming influence on price volatility.

ICE swaps contracts have the second smallest coefficient, and the smallest magnitude of effect. The effect of ICE swaps on price volatility is not nearly as large as the effect of either NYMEX futures holdings or total net assets. That holdings in ICE contracts are associated with increases in price volatility is surprising, but can be explained. If futures holdings, the main asset of USNG, were associated with decreases in volatility, it would follow that holdings in similar contracts would also decrease volatility. While the opposite occurred, logic can be used to explain the deviation from expectations. USNG does not attempt to track the returns of swaps. These assets are derivatives of futures, used to substitute the NYMEX futures contracts. Swaps contracts are also not directly integrated into the measure of price volatility. The unexpected sign of the two swaps coefficients is likely a result of this distance from the both the objective of USNG and the measurement of the dependent variable. Swaps are imperfect substitutes for futures contracts; as such they should not add the same predictability to the futures market.

Overall, it is clear that the variables representing USNG are associated with decreases in price volatility. Additionally, the interpretations of these variables make intuitive sense. UNSG, as it grew both in size and in holdings, granted predictability to the marketplace. USNG data is available to the public. Informed traders can find the exact amount of contracts held by USNG.
Together with data regarding roll period dates, traders can build accurate estimates of the quantity of transactions that will be performed by the fund. The prospectus of USNG, combined with mandatory statements of holdings, forces the fund to be extremely predictable. As such, the existence of the fund should have a negative effect on price volatility.

**Conclusion**

This study tests the natural gas futures market for any effect associated with the United States Natural Gas Fund ETF. Preliminary tests also examine the determinants of price volatility in futures markets, including maturity, trade volume, and open interest. OLS regression analysis is used, with a measure of daily-realized volatility as the dependent variable. No support for the Samuelson hypothesis, that price volatility increases as maturity approaches, was discovered. Trade volume and open interest, however, are confirmed as controls for price volatility. Overall, USNG was found to have a negative effect on price volatility of natural gas futures.

As demonstrated in this study, USNG is a very important determinant of price volatility in natural gas futures. The fund, due to its immense size, has an effect greater than any single investor would ever likely generate. The magnitude of the effect is not surprising, nor is the direction of the effect. Not only were nearly all of the USNG variables significant, nearly all pointed to a decrease in price volatility. John Hyland, a representative of USNG has stated, in response to the CFTC, that as the ETF only completes trades at the settle price at the end of each day, the fund has only a limited effect on the market for natural gas futures (2009). This study finds that while USNG does have an effect on price volatility, the effect is negative. If the intention of the CFTC, as has been reported, is to reduce volatility in futures markets, perhaps focus should be on entities other than USNG.
It must be noted, however, that this study does not apply to all traders of natural gas products. Those intent on manipulating the market will not operate with the same methods as USNG. USNG only trades to match changes in its investor base. The fund does not strictly seek return from intraday transactions, as a market manipulator might. This study merely demonstrates that this particular ETF, USNG, as a holder of futures contracts, does not increase volatility in the futures market. If the objective of the CFTC proposed position limits is to reduce volatility within the marketplace, this study suggests that ETFs, as index funds, should stand as exceptions to these regulations. The CME Group, a conglomerate of futures exchanges that includes the NYMEX, supports enactment of hard position limits, with exemptions for index funds (2009).

It is also important to remember that while this study may relate to other ETFs and similar futures contracts, the study is only of natural gas futures and USNG. Different commodities and ETFs could display alternative effects on price volatility. Additional studies, therefore, would be necessary to examine the effects of other ETFs on their underlying commodity futures markets.

Additional studies could also explore USNG and its tracking power to natural gas futures. An independent variable representing tracking efficiency, or accuracy of returns, with the different types of holdings, swaps, and futures, as explanatory variables seems appropriate. Such a study could reveal how changes in holdings composition affect the ability of USNG to provide accurate returns. A question to ask is: if USNG shifted holdings from the NYMEX to less transparent markets, how would tracking quality of the fund change? Less transparent markets could decrease tracking quality of the fund, resulting in a riskier investment vehicle. As position
limits would force USNG to purchase swaps contracts to substitute natural gas futures, a study of tracking accuracy could be used to estimate the effect that regulations would have on USNG.

USNG is a useful investment tool; the fund offers the ability to capitalize on returns from natural gas without risk from intraday transactions. Beyond providing utility to investors, this study finds that USNG also grants stability and predictability to the market for natural gas futures. While oversight is necessary to maintaining fair and orderly markets, it is important that regulation address problems based on real evidence. Similarly, evidence should be provided to defend entities that provide utility to investors and markets. This study, revealing the stabilizing forces granted by USNG, provides verification that financial instruments need not always be harmful to financial markets.
Table 1

Descriptive Statistics of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
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<tr>
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<td>FUT</td>
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Where:

STDEV = Standard deviation

TTM = Observations to maturity

VOL = Daily Volume (thousands of contracts)

OI = Daily Open Interest (thousands of contracts)

ROLL = Roll period indicator (=1 if USNG is rolling futures contracts, =0 otherwise)

TNA = USNG total net assets (hundreds of thousands of dollars)

ICE = Holdings of ICE swap contracts (thousands of contracts)

SWP = Holdings of NYMEX swap contracts (thousands of contracts)

FUT = Holdings of NYMEX futures contracts (thousands of contracts)
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DW = Durbin-Watson statistic
References


http://www.ici.org/research/stats/etf/etfs_02_10