Determining the Effectiveness of Exchange Traded Funds as a Risk Management Tool for Southeastern Producers

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Over the last few years producers have seen an increase in the volatility of commodity prices. This has caused agribusiness producers and the agricultural industry to face different types of price risk. While overall average commodity prices have also increased, it has also lead to an increase in volatility (Schweikhardt, 2009). Futures contracts and option contracts have existed for years as price risk management tools. Even though these instruments are available as a tool to help producers offset their price risk, previous research has shown that not many producers take advantage of them. One of the reasons for not using futures and options contracts is the size of the quantity requirements needed for futures and options contracts. These quantity requirements are usually too large for small and mid-sized producers and they are unable to take advantage of using futures or option contract to hedge their price risk.

As an example, the Chicago Mercantile Exchange (CME) Group offers a feeder cattle future contract that has a quantity requirement of 50,000 lbs. Feeder cattle are weaned calves that have been raised to be 600-800 lbs. In order to hedge their price risk using futures contracts, a cattle producer would need at least 83 head of feeder cattle weighing 600 lbs. In 2012, 72 percent of Mississippi cattle producers had less than 50 head of cattle (NASS, 2012). As a result, the majority of cattle producers in Mississippi are exposed to fluctuations in cattle prices without any real means of protection.

As another example, the CME offers a soybean futures contract with a quantity requirement of 5,000 bushels. In 2012, 46 percent of soybean farms had less than 100 acres (NASS, 2012). At the national average yield of 40 bushels an acre that year, a 100 acre farm would produce 4,000 bushels (NASS). This level of production does not allow for small scale soybean producers to hedge their price risk in the futures market.

Similarly, the CME offers a corn futures contract with a quantity requirement of 5,000 bushels. Based on the national average yield of 123 bushels an acre in 2012, in order to hedge their price risk in the futures market, a producer would need to have at least 40 acres of corn in production (NASS, 2012). In 2012, 34 percent of corn farms had less than 50 acres.

While there are futures contracts that have a quantity requirement of 1,000 bushels for both corn and soybeans, they face a liquidity problem that makes them unreliable for use by producers. These mini contracts trade on the CME but at a much lower volume than the regular contracts. For soybeans they are almost 15 times lower, and for corn they are almost 20 times lower. For a producer to know they can effectively hedge their price risk, they need the futures contract to be highly liquid.

Recent government policies, such as the Renewable Fuel Standard (RFS), it has been shown to have created strong linkage between agricultural commodity prices and energy prices (Harri, Nalley, and Hudson, 2009). Buguk, Hudson, Hanson (2003) and Harri and Hudson (2009) also have found that there is evidence of volatility spillover from energy markets into agricultural markets. While some risk management tools exist for such inputs as feed for cattle producers, no risk management tools exist for input products like fuel, fertilizer, propane, and feedstuffs.

A crude oil futures contract is offered with a quantity requirement of 1,000 barrels (or 4,200 gallons). This could be used by producers to hedge their input price risk of diesel fuel, but the quantity requirement is impractical for most producers. It takes 5 gallons of diesel fuel to grow one acre of soybeans (MSU, 2015). A producer would need to grow 840 acres of soybeans in order to use enough diesel fuel to be able to use one futures contract to hedge their price risk. In 2012, 89% of row crop operations had less than 1,000 acres.

This research proposes a new risk management tool that can provide small producers with the ability to protect themselves from price risk of their outputs. It also proposes a way for all producers to be protected from fluctuations in input price risk. This new tool would be the use of Exchange Traded Funds (ETFs). An ETF is an instrument that resembles a mutual fund, but is priced throughout the trading day and mimic a futures contract. The ETFs we will use are created from a combination of various futures contracts for that commodity. The value of the ETF is determined by the underlying future contracts' values. The advantage of an ETF is that they can be traded at much smaller increments than a futures contract. Some ETFs exist that are comprised solely of commodity futures contracts. Since they are priced and traded throughout the trading day, they provide good liquidity and flexibility to the user. Small and mid-sized producers are also able to take advantage since there are no quantity requirements. ETFs are also offered for inputs such as fuel, fertilizer, propane, and feedstuffs. This offers a potential useful tool to help offset input price risk for all producers. This research will look at the efficiency of ETFs as a viable instrument to use when hedging against price risk and the benefits an ETF hedge can provide to producers.

Literature Review

The body of minimum variance hedging literature is quite extensive. Alexander and Barbosa (2007) look at the effectiveness of various minimum variance hedging techniques and provide an extensive review of the literature. One of the highlights of this overview is Johnson (1960), who was the first to use a minimum variance criterion to calculate a hedging ratio based on a specific cash price. Many of the papers that followed looked at if a quadratic equation was the correct assumption to apply in the minimum variance framework as Johnson did.

Chen, Lee, and Shrestha (2003) did a comprehensive review of literature concerning hedge ratios. They compiled a review of articles that had developed both theoretical and empirical models for hedge ratios. This paper is a good reference to understand how the techniques to find hedge ratios have developed over time.

Ederington (1979) empirically calculated minimum variance hedge ratios using OLS regression methods. The paper found hedge ratios for Government National Mortgage Association futures, wheat, corn, and T-bill futures using weekly data. It was found that as the length of the hedging period increasing, the hedge ratio increase.

Baillie and Myers (1991) derived the minimum variance hedge ratios for beef, coffee, corn, cotton, gold, and soybeans using a bivariate GARCH model. This allowed for time-varying estimations of the conditional covariance matrix and thus time-varying hedge ratios to be derived. The authors found that the assumption of constant optimal hedge ratios is inappropriate. The authors also found that optimal hedge ratios contain a unit root and behave much like a random walk.

Kroner and Sultan (1993) proposed using a bivariate GARCH error correction model to derive the minimum variance hedge ratio. The error correction term allowed for the long run relationship between the cash and futures price to be included in the model. The GARCH parameters allowed for new information over time to influence the hedge ratio and for time varying hedge ratios to be derived.

In academic literature there are not many studies that have examined the ability of ETFs to track specific cash prices of the commodities in which they are designed to follow.

Murdoch and Richie (2008) looked at the ability of the United States Oil Fund (USOF) to be used as a hedging instrument. They looked at the relationship of the price of the USOF ETF and the price of the West Texas Intermediate (WTI) oil futures and spot price. To investigate the use of the USOF ETF as a hedging instrument, the authors performed a correlation analysis of the USOF with the spot and futures price. Based off these correlations the USOF appears to be a useful hedging tool for investors. The authors further looked at the degree in which the USOF price deviates from the futures market it is supposed to replicate. They found that the futures-USOF basis is significantly more volatile than the futures-spot basis. This led the authors to conclude that "although the fund prices and price changes are reasonably correlated with oil markets, an investor faces more uncertainty with the USOF and may or may not be able to sustain an effective hedge against volatile oil prices" (341). They also found that the futures-USOF basis is greater during periods of contango, which can play an important role in the effectiveness of the hedge.

Plamondon and Luft (2012) built upon the work of Murdoch and Richie (2008), and compared the returns of physical and derivative commodity ETFs to the returns of their underlying spot commodity returns. ETFs were split into two groups, those that held the physical commodity and those that used futures to derive the ETFs value. They regressed the returns of the spot price on the returns of the corresponding ETF to estimate a beta and R^2 values. The authors found that for both ETF groups, there was no statistical difference between the ETF returns and the spot commodity returns. It was observed that the futures based ETFs had a larger mean difference that the physical ETFs.

Conceptual Framework

The most basic hedging strategy is a naïve hedge. With this strategy a producer with a long position in the cash market would take a short position in the futures market. When the producer sells a unit of goods in the cash market, they would then buy back the futures contracts. The producer would then have been perfectly hedged as long as both the cash and futures prices changed by the same amount.

Since the cash and futures prices do not always follow each other exactly, it might be necessary to under or over hedge the cash position. Ederington (1979) proposed the following regression

(1.1) $$C_t - C_{t-1} = \alpha + \beta(F_t - F_{t-1}) + \varepsilon_t$$

where C_t is the cash price, F_t is the futures price and the optimal hedging ratio is β^*. The optimal hedge ratio shows the producer how much of their position needs to be hedged. This strategy is referred to as the conventional hedging strategy.

Following the work of Kroner and Sultan (1993) the conventional hedging strategy can be derived as follows. The returns to a producer who has a hedged position is

(1.2) $$R = \Delta C - b\Delta F$$

where R is the returns, ΔC is the change in cash price, and ΔF is the change in futures prices. It is then assumed that the producer faces a mean-variance expected utility function

(1.3) $$EU(R) = E(\mathrm{R}) - \gamma\,\mathrm{var(R)}$$

where γ is the degree of risk aversion $(\gamma > 0)$.

Using the objective function for the variance of returns as proposed by Johnson (1960) the optimal hedge ratio is solved using

(1.4) $$\max_b EU(R) = \max_b \left\{ E(\Delta C) + \mathrm{bE}(\Delta\,\mathrm{F}) - \gamma\left[\sigma^2_{\Delta C} + b^2\sigma^2_{\Delta F} - 2b\sigma_{\Delta C\Delta F}\right]\right\}$$

The equation is solved for b, which gives the optimal hedging ratio as

(1.5) $$b^* = \frac{E(F) + 2\gamma\sigma_{\Delta C\Delta F}}{2\gamma\sigma^2_{\Delta F}}$$

Assuming the futures rate follows a martingale, the equation can be further reduced to

(1.6) $$b^* = \frac{\sigma_{\Delta C\Delta F}}{\sigma^2_{\Delta F}}$$

This hedge ratio assumes that the distribution of cash and futures prices are constant over time. Kroner and Sultan (1993) showed that the hedge ratio could be expressed as time-varying by specifying the returns equation as

(1.7) $$R_t = \Delta C_t - b_{t'}\Delta F_t$$

where $t' > t$. The producer now calculates the optimal hedging position by maximizing the expected utility function

(1.8) $$E_t U(R_{t+1}) = E_t(R_{t+1}) - \gamma\sigma^2_t(R_{t+1})$$

where risk is now measured by conditional variances, and it is shown that the expectation and variance operators are conditioned on information available at time t. The utility maximizing hedge ratio at time t assuming that futures prices are a martingale is

(1.9) $$b_t^* = \frac{\sigma_t(\Delta C_{t+1}, \Delta \mathrm{F}_{t+1})}{\sigma_t^2(\Delta \mathrm{F}_{t+1})}$$

The optimal hedge ratio is similar to the conventional hedge ratio, but the variance and covariance are now time-varying conditioned.

Data

The data for this study will use weekly historical cash and futures prices of corn, soybeans, live cattle, and on the input side, diesel fuel. The weekly historical closing price of the relevant ETFs will be used for each commodity. Corn and soybean cash prices are the local prices from Greenville, Mississippi. Live cattle prices are an average for 1,000 to 1,300 pound cattle in Texas and Oklahoma. Diesel prices were obtained from the U.S. Energy Information Administration and cover the Gulf Coast region.

The ETF used for corn will be the Teucrium Corn Fund (NYSE: CORN) and was created June 9, 2010. The time period this study will look at for corn will therefore be June 2010 to July 2015. The purpose of CORN is for its Net Asset Value (NAV) to reflect the daily changes in percentage terms of a weighted average for the closing settlement prices of three CBOT corn futures. These three CBOT futures are the second to-expire-contract weighted 35%, the third-to-expire contract weighted at 30% and the contract expiring in the December following the third-to-expire contract weighted 35%.

The ETF used for soybeans will be the Teucrium Soybean Fund (NYSE: SOYB) and was created September 16, 2011. The time period this study will look at for soybeans will be September 2011 to July 2015. The purpose of SOYB is for its NAV to reflect the daily changes in percentage terms of a weighted average for the closing settlement prices of three CBOT soybean futures. These three CBOT futures are the second to-expire-contract weighted 35%, the third-to-expire contract weighted at 30% and the contract expiring in the November following the third-to-expire contract weighted 35%. The CBOT soybean contracts for August and September are not used in the fund due to the less liquid markets for these contracts.

To hedge diesel fuel this study will be using a heating oil ETF, United States Diesel-Heating Oil Fund LP (NYSE: UHN). This fund was created April 9^{th}, 2008. The time period of April 2008 to August 2015 will be looked at by this study. UHN is designed to mimic the daily changes in percentage terms of heating oil (No. 2 Fuel) for delivery at the New York harbor, as measured by the daily changes in the NYMEX heating oil (No. 2 Fuel) futures contract. The UHN uses the near month contract, and begins to roll them over when they are within two weeks of expiration. The fund also may invest in forward and swap contracts.

For live cattle an Exchange Traded Note (ETN) will be used instead of an Exchange Traded Fund (ETF). The difference between the two is that ETNs fall under the governance of the Securities ACT of 1933, while ETFs falls under the governance of the Investment Company Act of 1940. ETNs may be managed like a fund and traded like ETFs, but they do not report the same way and are governed under slightly different rules. (Ferri, 2009) For live cattle the iPath Bloomberg Subindex Total Return ETN (NYSE: COW) will be used. This note was created on October 23, 2007. This study will therefore look at the price series from October 2007 to May 2015. COW's index is a combination of live cattle and lean hogs futures contracts.

Methods

This paper will use three different regression techniques to derive optimal ETF hedge ratios, as well as optimal futures hedge ratios for comparison purposes. The three regressions will be an ordinary least squares, error-correction model, and a bivariate generalized autoregressive heteroscedasticity model with an error correction term.

We will use the ordinary least squares (OLS) regression technique proposed by Ederington (1979) to find the optimal hedging ratio. Elam and Davis (1990) employed such a technique in which they researched the optimal hedging ratios for feeder cattle. OLS regression sets the dependent variable as the change in cash price and regresses it against the change in futures price. In the following notation, future and ETF prices are interchangeable.

The resulting regression equation is:

$$\Delta Cash_t = \alpha + \beta \Delta Fut_t = e_t \quad (1.10)$$

where Δ is the difference operator, $\Delta Cash_t = Cash_t - Cash_{t-1}$, which is the change in the cash price during the hedging period, and similarly $\Delta Fut_t = Fut_t - Fut_{t-1}$, which is the change in the futures price during the hedging period. The parameter β is a slope coefficient and represents the optimal hedge ratio.

Sometimes the cash and futures price might be cointegrated. A no arbitrage condition means that between futures and cash markets in the long run, the two price series cannot drift far apart. In the short run though, there might be some effect that causes the local cash price to change that is not accounted for by the futures market price. This can cause the OLS regression to be biased because of an omitted variable problem.

To address the problem of conintergration an error correction model was developed by Engle and Granger (1987). This model is:

(1.11) $$\Delta Cash_t = \gamma u_{t-1} + \beta \Delta Fut_t + \sum_{i=1}^{p} \delta_i \Delta Cash_{t-i} + \sum_{j=1}^{q} \phi_j \Delta Fut_{t-j} + v_t$$

where $u_{t-1} = Cash_{t-1} - \left(\alpha + \alpha_1 Fut_{t-1}\right)$ is the error correction term. This term accounts for the long term effects and the other variables in the model account for the short term influences. β is again the optimal hedging ratio. Depending on a test for cointergration, either the OLS or the ECM will be used.

Along with OLS and ECM hedging ratios, we will obtain time varying hedge ratios. This will be done by estimating hedge ratios that are conditional on past information, I_{t-1}.

(1.12) $$\beta_{t-1} = \frac{\text{cov}\left(\Delta Fut_t, \Delta \text{Cash}_t \middle| I_{t-1}\right)}{\text{var}\left(\Delta Fut_t \middle| \text{I}_{t-1}\right)}$$

Since β_{t-1} is conditional on I_{t-1}, the optimal hedging ratio is time varying. To estimate the time varying hedging ratios, a bivariate generalized autoregressive conditional heteroskedasticity (BGARCH) with an error correction term model will be used. Engle and Granger (1987) showed that an error correction term should be included when cointergration is present between two variables. The conditional mean will be specified as

(1.13) $$R_t = A + \prod u_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta R_{t-i} + \varepsilon_t$$

where $R_t = \begin{bmatrix} \Delta Cash_t \\ \Delta Fut_t \end{bmatrix}$ and u_{t-1} is again the error correction term. The conditional variance will be specified as

(1.14) $$h_{ii} = \omega_i + \eta_i h_{ii,t-1} + \varphi_i \varepsilon_{i,t-1}^2$$

for $i = 1(Cash)$, $2(Fut)$.

The BGARCH model will be estimated using the constant conditional correlation (CCC) specification for the covariance matrix of ε_t. The conditional time-varying optimal hedge ratios can be obtained using

(1.15) $$\hat{B}_{t-1} = \frac{\hat{h}_{12,t}}{\hat{h}_{22,t}} = \frac{\hat{h}_{Cash\,Fut,t}}{\hat{h}_{Fut,t}}$$

This will give us the optimal hedging ratio to use at the time the hedge is placed.

Results

Summary statistics for the levels and log-levels of the cash, futures, and ETF prices for each commodity can be found in tables 1-4. A skewness and kurtosis value close to zero means no departure from normality.

The optimal hedge ratios for each commodity can be found in table 5. Conintergration was not found to be present between the ETF and cash price series for any of the commodities. Therefore an ECM model was not used to find optimal ETF hedge ratios. The reported GARCH ratio is the average of the time-varying ratios found using the GARCH model. The time-varying ratios can be found in figures 1-8. Futures hedge ratios and ETF hedge ratios were calculated over the same period of time.

It was found that hedge ratios do not vary greatly across the different types of models. For corn, soybeans, and live cattle the GARCH model provides slightly more effective hedge ratios, but are not that much greater than the OLS and ECM hedge ratios. The hedge ratios for diesel fuel are nearly identical across all three models.

It was also found that an ETF hedge performs just as well as a futures hedge. For corn and soybeans the ETF hedge ratio is higher that the futures hedge ratio for each model. The ETF hedge ratio for live cattle and diesel are nearly identical to the future hedge ratio for each model.

Conclusion

This study has shown that ETFs have the potential to be used as an effective price risk management tool just as futures contracts. The effectiveness of ETFs will provide small producers a tool to manage their price risk in areas where they currently have no price risk management tools.

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Table 1. Summary Statistics of Corn Cash, Futures, and ETF prices (Levels and Log-Prices)

Variable	Sample Mean (s.d.)	Min	Max	# of obs	Skewness	Kurtosis
Cash Price	5.61(1.35)	3.06	7.83	263	-0.099	-1.412
Futures Price	5.58(1.45)	3.21	8.30	263	-0.026	-1.442
ETF Price	36.41(8.01)	22.63	52.50	263	-0.056	-1.148
Log Cash Price	1.69(0.25)	1.12	2.06	263	-0.326	-1.263
Log Futures Price	1.68(0.27)	1.17	2.12	263	-0.245	-1.414
Log ETF Price	3.57(0.23)	3.12	3.96	263	-0.333	-1.109

Notes: Cash Price - Greenville, Mississippi, ETF- Teucrium Corn Fund

Table 2. Summary Statistics of Soybeans Cash, Futures, and ETF prices (Levels and Log-Prices)

Variable	Sample Mean (s.d.)	Min	Max	# of obs	Skewness	Kurtosis
Cash Price	13.24(2.09)	9.13	17.53	197	-0.209	-0.984
Futures Price	13.05(2.12)	9.17	17.63	197	-0.195	-0.832
ETF Price	23.01(2.16)	18.51	28.53	197	-0.004	-0.436
Log Cash Price	2.57(0.16)	2.21	2.86	197	-0.429	-0.971
Log Futures Price	2.55(0.17)	2.21	2.87	197	-0.450	-0.865
Log ETF Price	3.13(0.09)	2.92	3.35	197	-0.213	-0.523

Notes: Cash Price - Greenville, Mississippi, ETF- Teucrium Soybean Fund

Table 3. Summary Statistics of Live Cattle Cash, Futures, and ETF prices (Levels and Log-Prices)

Variable	Sample Mean (s.d.)	Min	Max	# of obs	Skewness	Kurtosis
Cash Price	113.86(24.16)	79.97	172.00	371	0.559	-0.600
Futures Price	113.74(2.12)	80.15	170.90	371	0.436	-0.677
ETF Price	31.35(2.16)	25.66	49.48	371	1.836	2.382
Log Cash Price	4.71(0.21)	4.38	5.15	371	0.244	-0.969
Log Futures Price	4.71(0.20)	4.38	5.14	371	0.131	-1.027
Log ETF Price	3.43(0.16)	3.24	3.90	371	1.591	1.641

Notes: Cash Price - Texas and Oklahoma, ETF- iPath Bloomberg Livestock Subindex Total Return ETN

Table 4. Summary Statistics of Diesel Cash, Futures, and ETF prices (Levels and Log-Prices)

Variable	Sample Mean (s.d.)	Min	Max	n	Skewness	Kurtosis
Cash Price	3.41(0.62)	1.97	4.74	348	-0.419	-0.840
Futures Price	2.56(0.61)	1.16	4.10	348	-0.306	-0.7651
ETF Price	31.23(8.19)	17.80	65.68	348	1.783	4.7995
Log Cash Price	1.01(0.20)	0.68	1.56	348	-0.700	-0.522
Log Futures Price	0.91(0.26)	0.15	1.41	348	-0.730	-0.336
Log ETF Price	3.41(0.24)	2.88	4.18	348	0.635	1.454

Notes: Cash Price - Greenville, Mississippi, ETF- Teucrium Soybean Fund

Table 5. Futures and ETF Hedge Ratios for Corn, Soybeans, Live Cattle, and Diesel

	Hedge Ratios		
	OLS	**ECM**	**GARCH**
Corn			
Futures	0.78	0.77	0.82
ETF	1.02	n/a	1.03
Soybeans			
Futures	0.83	0.87	0.87
ETF	0.96	n/a	0.99
Live Cattle			
Futures	0.47	0.48	0.50
ETF	0.45	n/a	0.49
Diesel			
Futures	0.15	0.15	0.14
ETF	0.15	n/a	0.16

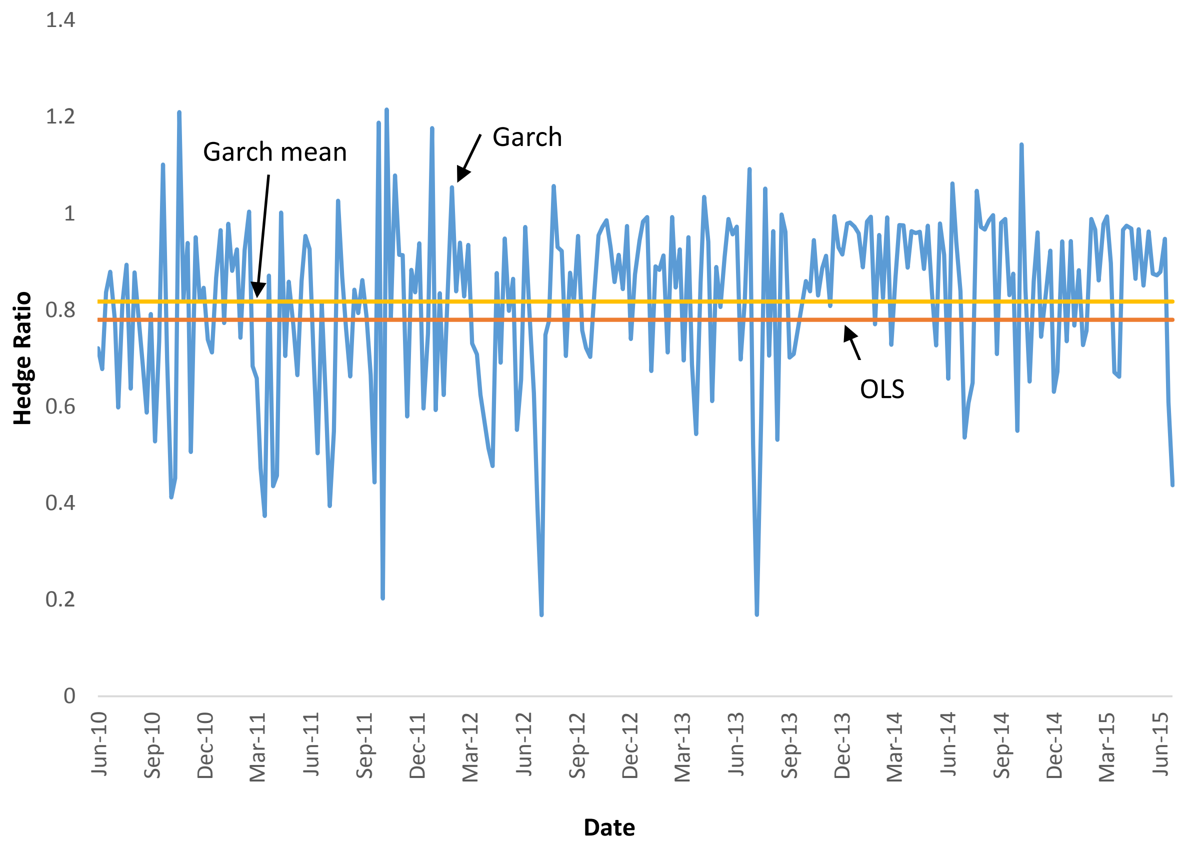

Figure 1. Optimal Corn-Futures Hedging Ratios.

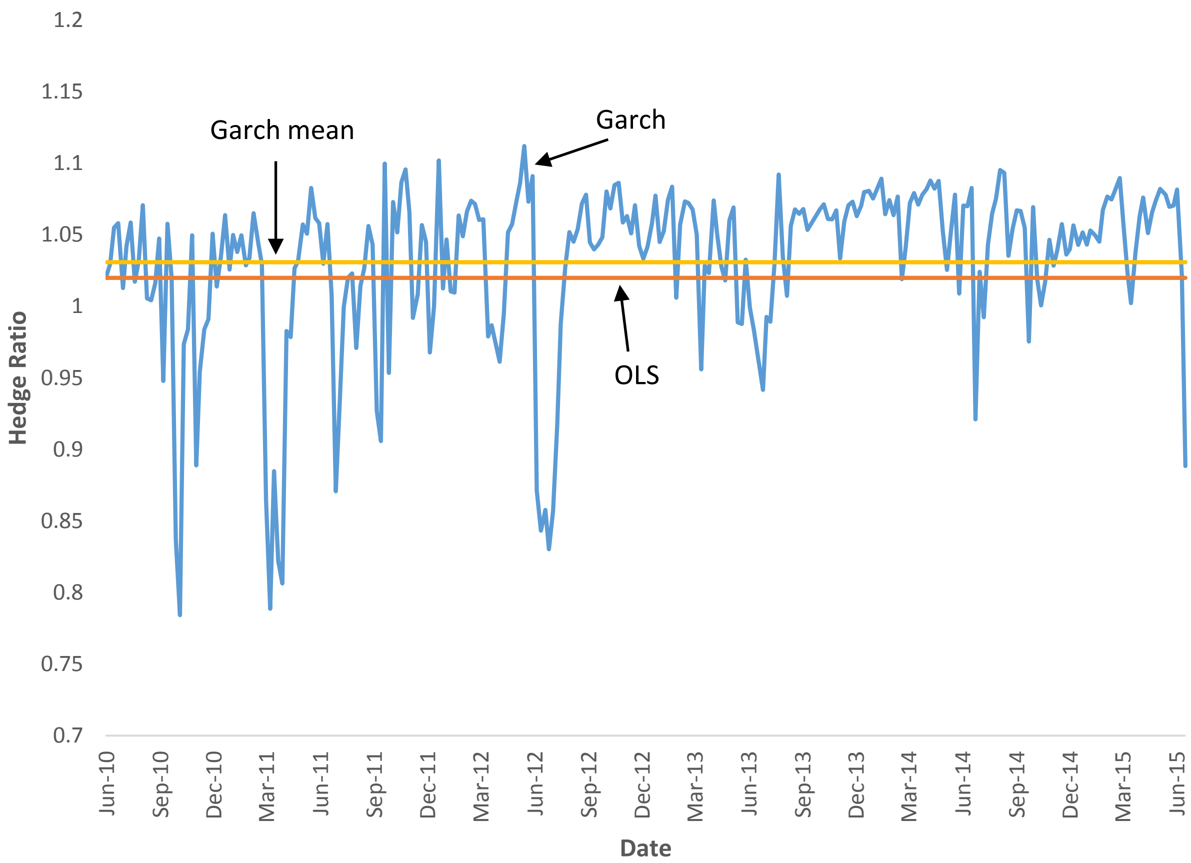

Figure 2. Optimal Corn-ETF Hedging Ratios.

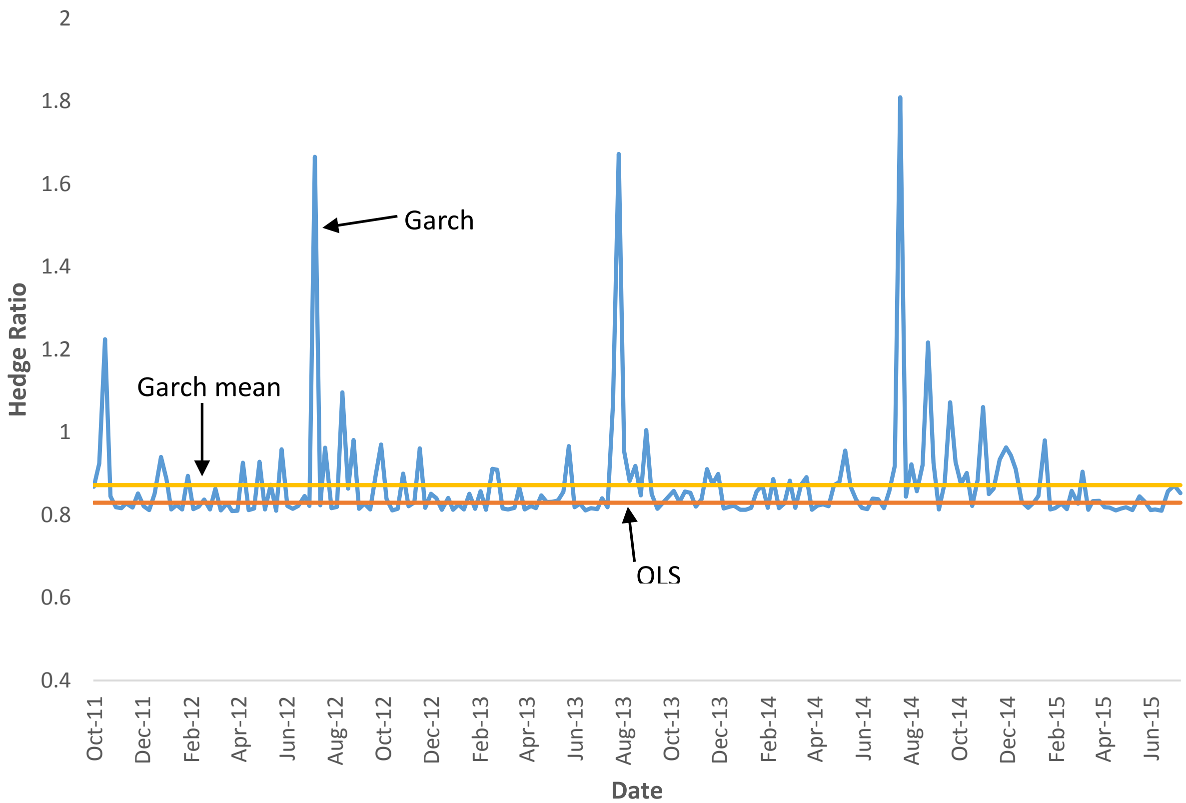

Figure 3. Optimal Soybeans-Futures Hedging Ratios.

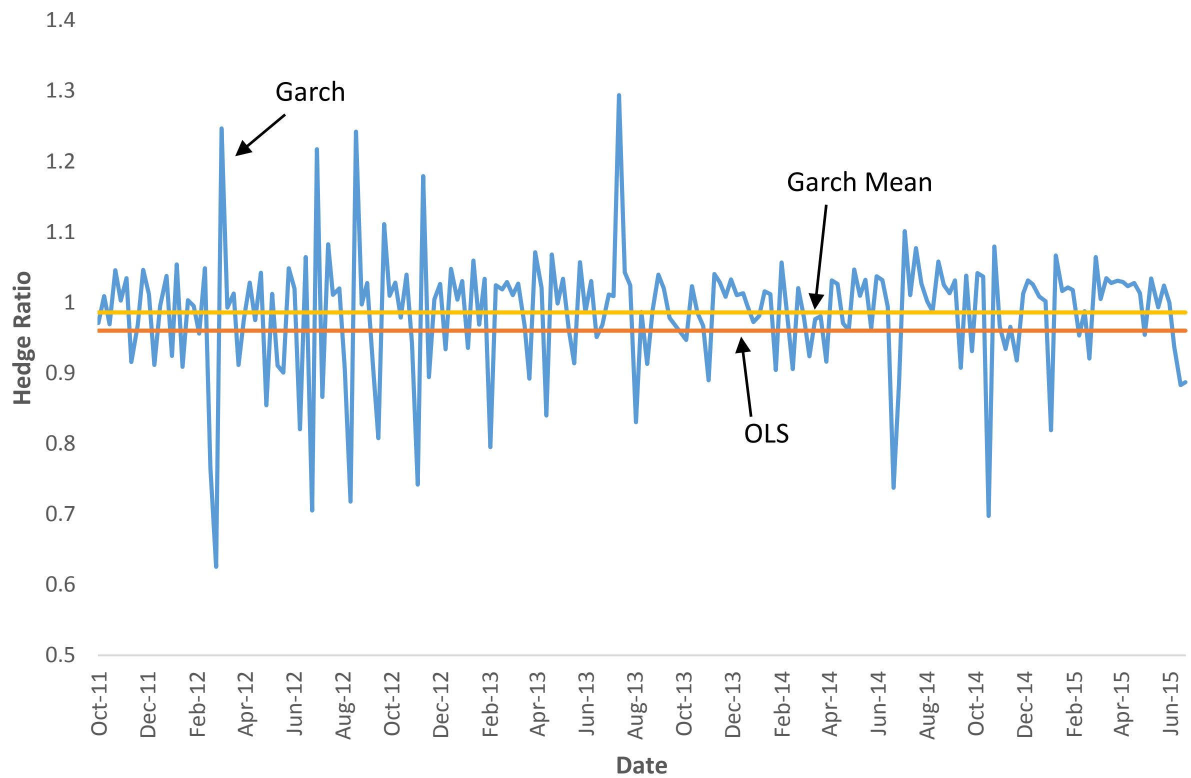

Figure 4. Optimal Soybean-ETF Hedging Ratios.

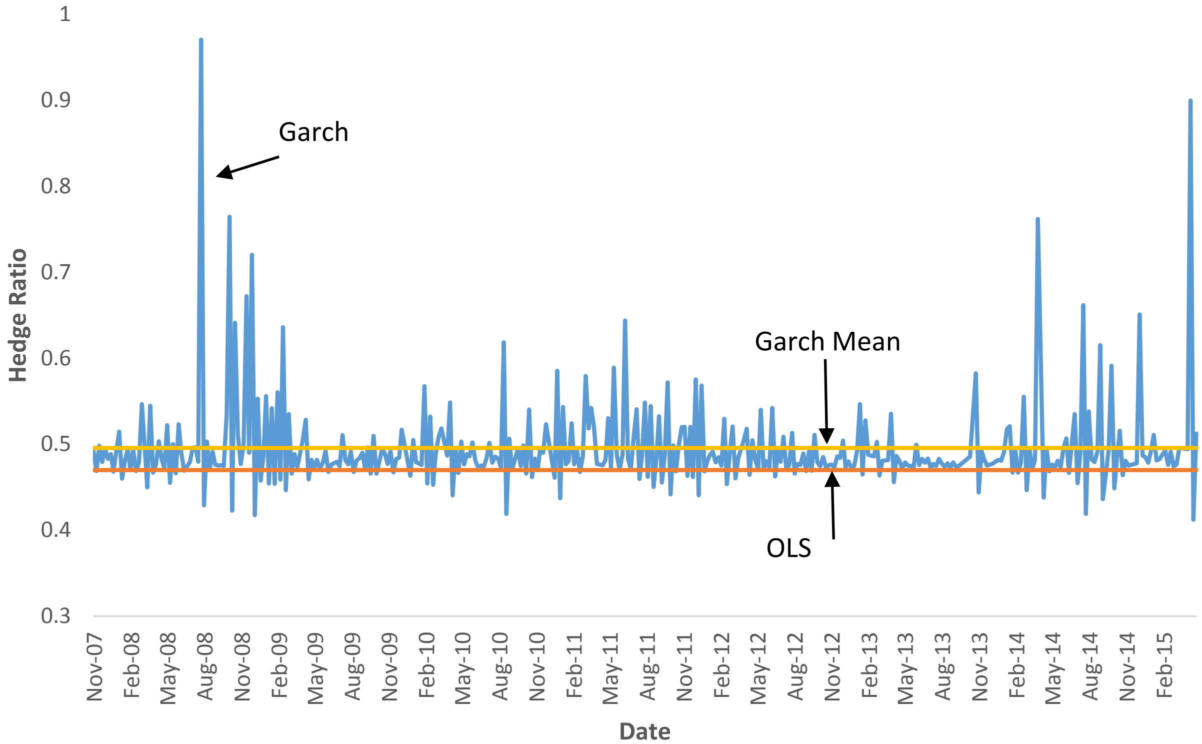

Figure 5. Optimal Live Cattle-Futures Hedging Ratios.

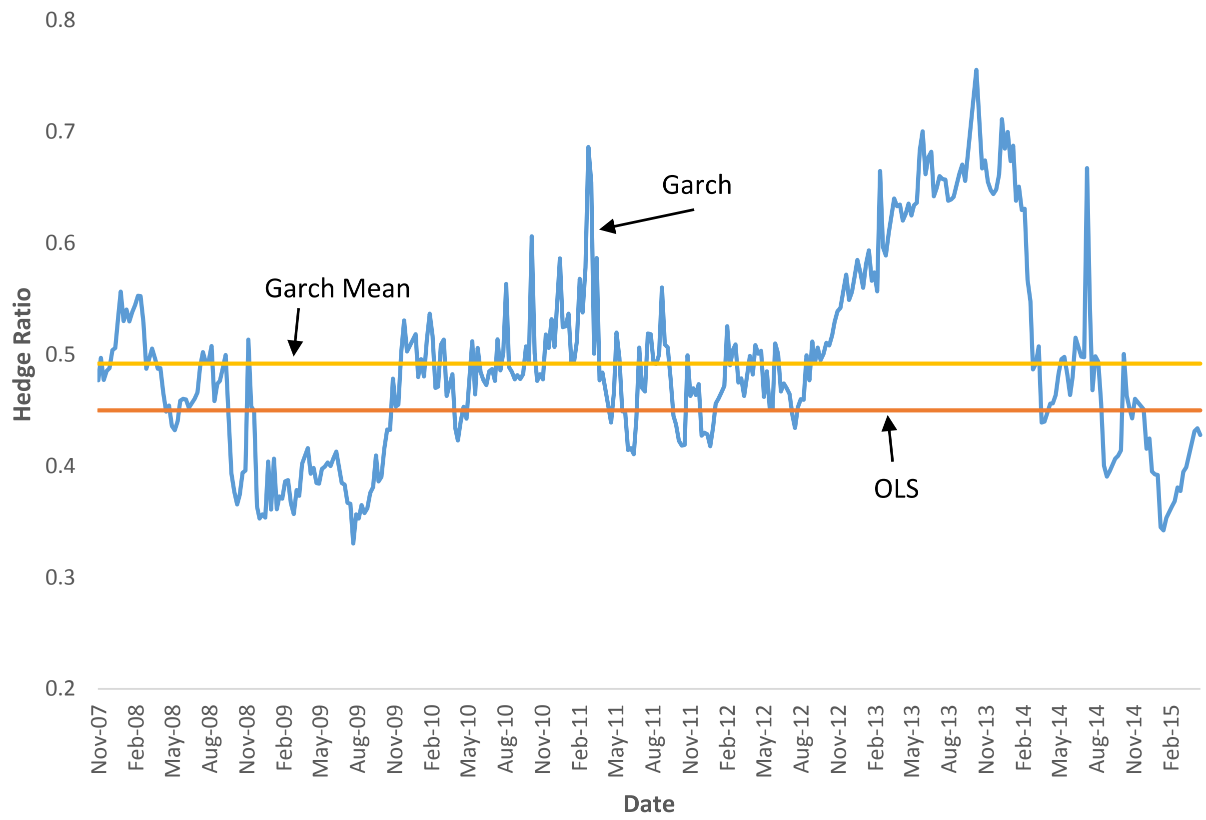

Figure 6. Optimal Live Cattle-ETF Hedging Ratios.

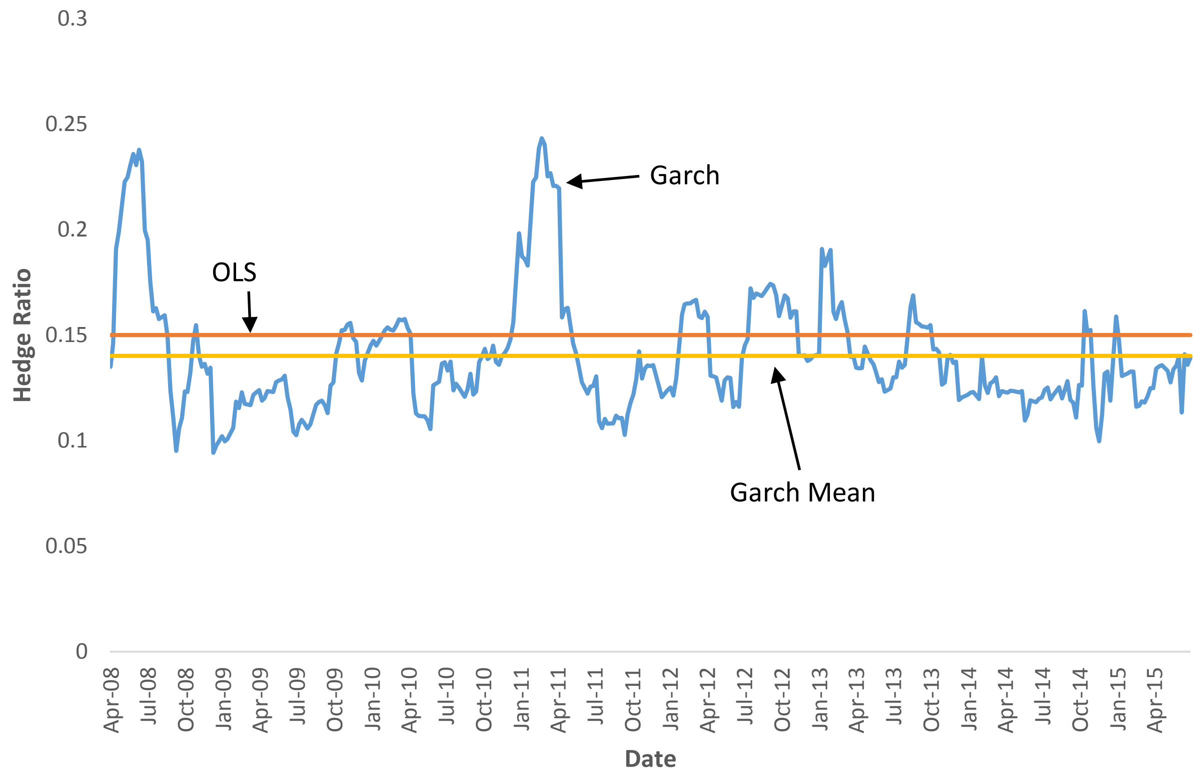

Figure 7. Optimal Diesel-Futures Hedging Ratios.

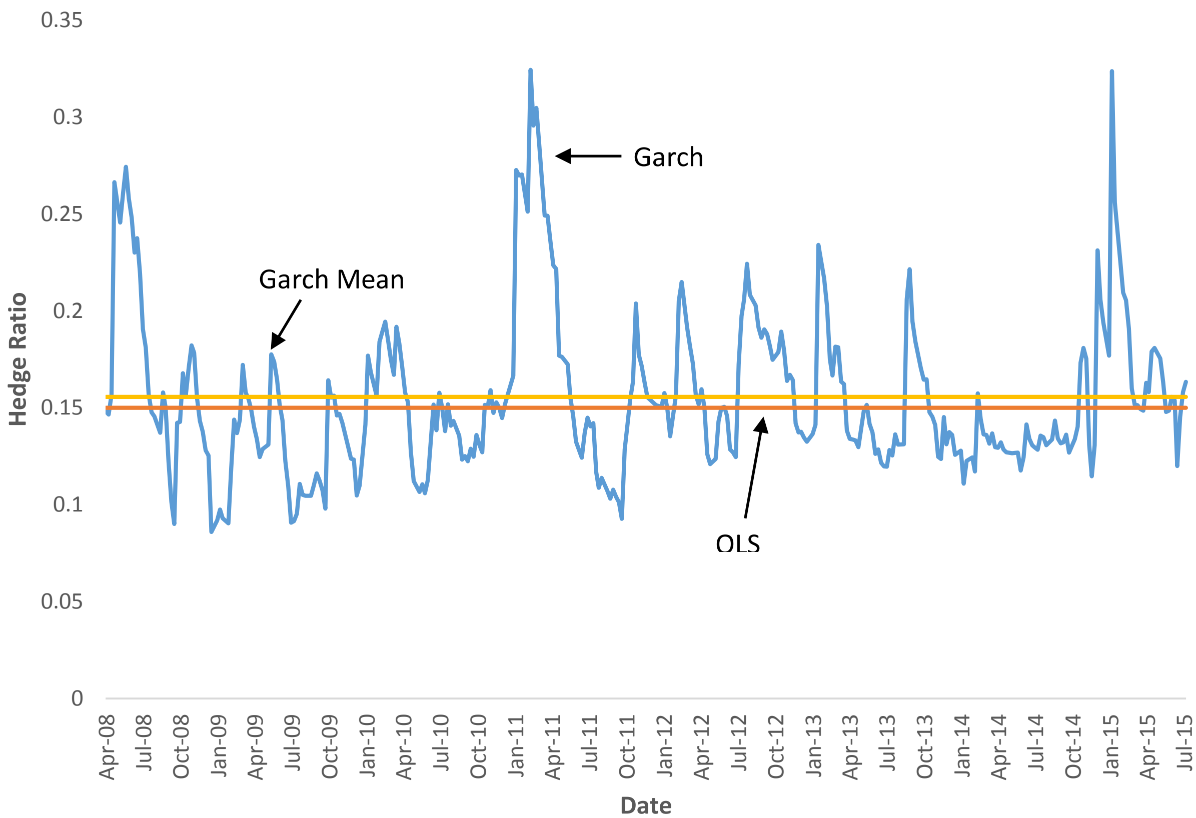

Figure 8. Optimal Diesel-ETF Hedging Ratios.