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Hog Options: Contract Redesign and Market Efficiency

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This article tests the efficiency of the hog options market and assesses the impact of the 1996 contract redesign on efficiency. We find that the hog options market is efficient, but some options yielded excess returns during the live hogs period but not during the lean hogs period. Our findings indicate that the hog options market is efficient and is consistent with the new contract improving the efficiency of the market. However, other market conditions such as lower transaction costs during the lean hogs period can also contribute to reduce expected option returns during the latter period.

Key Words: hog options, mispricing perceptions, contract redesign, trading returns

JEL Classifications: C15, G12, G14, Q13

Hog price variability is seen by hog producers as the main source of business risk (Patrick et al., 2007). The hog options market has served as a risk management tool for the last 30 years, but concerns about the pricing ability of this market have been raised. Lawrence and Grimes (2007) review changes in production and marketing practices and survey the reasons why producers do not use options when marketing hogs. Most small- and medium-sized producers cite high option premiums as a reason not to use the hog option market. Similar concerns about the cost of agricultural options have been noted previously (Irwin, 1990). Although scanty, the scientific literature about the hog options market supports the practitioners' view (Egelkraut and Garcia, 2006; McKenzie, Thomsen, and Phelan, 2007; Szakmary et al., 2003). The concerns surfaced after the Chicago Mercantile Exchange revised its hog futures and options contracts in an effort to improve performance. The hog futures contract was settled under a physical delivery system, but, after structural changes in the hog industry, the contract was renamed and the settlement procedure and contract's underlying asset were changed in 1996. After the contract redesign, Chan and Lien (2001) found that the price discovery ability of the hog futures contract had diminished. Because options and futures markets are closely intertwined by arbitrage relationships, it is likely that the redesign of the futures contract has also affected behavior of the options market.

The existing literature about hog options market efficiency is composed of only three studies, each of them indicating some degree of option mispricing. Egelkraut and Garcia (2006) and Szakmary et al. (2003) found biases in the implied volatility (IV) forecast of subsequent realized volatility—a precondition for market inefficiency. However, testing options market efficiency with IV has three important limitations. First, IV identifies biases in the volatility

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forecast, but this constitutes an indirect test of efficiency because even with biases in the volatility forecast, it still might not be possible to obtain systematic trading profits. Therefore, IV tests do not allow one to draw a definitive conclusion about options market efficiency. Second, the use of IV requires the use of an option pricing model. Therefore, volatility biases can be caused by using a wrong pricing model and not because of market inefficiency. Considerable debate exists as to what is the correct option pricing model. The aforementioned studies used Black's (1976) model, but more complex models that better describe agricultural option prices have been proposed recently (Koekebakker and Lien, 2004). Third, it is not possible to quantify the effect of transaction costs on trading returns using IV tests. Using a different approach, McKenzie, Thomsen, and Phelan (2007) examined simulated returns to long straddles established and exited on the days surrounding the release of the U.S. Department of Agriculture (USDA) Hogs and Pigs Reports. The authors show that returns are significant for low levels of transaction costs.

This discussion reveals that the evidence regarding the efficiency of the hog options market is scarce and inconclusive and the effects of the contract redesign are unknown. Therefore, the objective of this article is to test the efficiency of the hog options market by computing simulated trading returns and to assess the impact of the contract redesign on trading returns. To implement the analysis, returns from different simulated trading strategies are computed and used to test the sufficient condition for market efficiency—that expected returns equal zero. Trading strategies for calls, puts, straddles, and two types of strangles are simulated using decision rules that increase the likelihood of obtaining profitable trades. These strategies allow assessing the pricing ability of the market for options, are model-free, and allow the effect of transaction costs on trading returns to be quantified. The combined analysis of call, put, straddle, and strangle trading allows determining whether returns are caused primarily by movements of the futures price or by the presence of a risk premium in the market. Furthermore, returns from the live and the lean hog periods are compared to assess the impact of contract redesign on market efficiency.

Results of this study contribute to the literature in a number of ways. First, market efficiency is critical for a variety of market participants. Because options are normally used as price insurance, producers and processors may lose substantial amounts of money if they use overpriced options to hedge purchases and/or sales. Results of this study will indicate whether hog options constitute appropriate hedging tools. Also, the present study will inform about the effects of the contract redesign on market efficiency. The contract redesign aimed at improving the performance of the hog options market. However, the authors are not aware of any study evaluating the effects of the contract redesign on market efficiency. Finally, option mispricing is relevant to academic researchers because of competing models of asset pricing. For some time, the main model used to describe the behavior of market prices has been the efficient market hypothesis. In an efficient market, prices always "fully reflect" available information; thus, it is not possible to obtain systematic trading profits. However, the empirical evidence about the efficient market hypothesis is mixed and several anomalies have been documented for options markets (e.g., Bollen and Whaley, 2004; Brittain, Garcia, and Irwin, 2009; Coval and Shumway, 2001). Therefore, results of this study will contribute to the ongoing debate about the best model to represent commodity market behavior.

The article is organized as follows. The next two sections review the hog futures contract and the theory of efficient markets. The third section outlines the data used. The fourth and fifth sections describe the simulated trading strategies and present the empirical returns for the entire sample period and separately for the live and the lean hog contract periods. The conclusion section closes the article.

The Hog Futures Contracts

Most agricultural futures contracts are settled using the physical delivery method. Under this system, a seller (buyer) that maintains an open position until the contract expiration must make (take) delivery at a number of specified locations to liquidate the position. The settlement mechanism should guarantee the convergence between the cash and future price at the contract expiration date; otherwise, arbitrage opportunities would arise. The physical delivery method can entail relatively high costs given that the commodity must be transported and the delivery facilities must be inspected periodically. Additionally, the list of delivery locations must be revised periodically to accurately represent usual business practices (Lien and Tse, 2003).

Alternatively, futures contracts can be settled against a cash index that determines cash payment transfers to liquidate the positions standing at expiration. The effectiveness of this type of contract depends critically on the construction of a reasonable index (Lien and Tse, 2003). A critical feature of the cash index is the number of delivery locations it includes. For instance, a broad-based index including prices from several reporting stations reduces the likelihood of market manipulation. However, a narrow-based index improves hedging effectiveness (Chan and Lien, 2001). If the contract specification does not represent common business practices, the futures price would not represent the expected cash price. Such distortions would introduce option mispricing, because option premiums are function of the futures price.

During the 1990s, the hog industry experienced significant changes in size, degree of horizontal and vertical coordination, and concentration; as a consequence, some authors assessed the benefits of a cash-settled hog futures contracts. These studies concluded that a cash-settled hog futures would provide better convergence between cash and futures, have lower basis variability, and improve hedging effectiveness with respect to the existing physically settled contract (Ditsch and Leuthold, 1996; Kimle and Hayenga, 2004).

With the goal of reflecting changes in the hog industry, the Chicago Mercantile Exchange redesigned its hog futures and options contract beginning with the February 1997 contract, which began trading in November 1995. The new lean hog contract settles against a 2-day weighted average index of the USDA cash prices for producer-sold swine or pork market transactions. Because terminal prices are not included, the index reflects prices paid by slaughterhouses to hog producers, thus better representing a market with increasing levels of horizontal and vertical integration.

The main contract specifications for the live and lean hog contracts are presented in Table 1. The changes include the underlying commodity, the settlement method, the introduction of the May futures contract in 2001, and the change in the option expiration date. The May futures and options initial trading volume is relatively low compared with other contracts. To assess possible biases in returns introduced by this contract, the May options were initially

Table 1. Live and Lean Hog Contract Specifications Comparison

	CME Live Hog Contract	CME Lean Hog Contract
Size of contract	40,000 lbs live weight	40,000 lbs carcasses
Settlement	Physical delivery	Cash transfer
Weight range	230–260 lbs	170–191 lbs (carcass weight)
Approximate head/contract	173–153 (average 163)	235–209 (average 221)
Months	February, April, June, July, August, October, December	February, April, June, July, August, October, December
Minimum price fluctuation	2 cents per 100 lb	2 cents per 100 lb
Limit	1 cents per lb	1 cents per lb
Options months	February, April, June, July, August, October	February, April, June, July, August, October, December, and serial months January, March, November
Options expiration	Two–3 weeks before the futures last trading day	On the tenth business day of the contract month

Note: Contract specifications are taken from the Chicago Mercantile Exchange Rulebook, Chapter 152 Lean Hog Futures and Chapter 152A Options on Lean Hog Futures and from the Management Marketing Memo, MMM 343, Department of Agricultural Economics, Clemson University.

excluded from the returns computations. However, the same qualitative results were obtained; thus, May options were maintained in the analysis. Also, during the live hog period, options expired 2 to 3 weeks before the futures last trading day. However, during the lean hog period, options expire on the last trading day of futures. This modification should not change the fact that, whatever the expiration date, expected option returns should equal zero under market efficiency.

Market Efficiency Theory

The efficient market hypothesis states that an efficient market is one in which market prices reflect all information available about the asset. Although individual market participants might incorrectly assess expected prices, in aggregate, the market makes no systematic mistakes about true asset prices. Because prices reflect the true value of the assets, it is not possible to consistently make profits by trading those assets. In other words, the efficient market hypothesis says that no one can "beat the market." Fama (1970) formally stated the hypothesis as:

$$(1) \qquad \mathrm{E}[r_{j,T}|\mathbf{\Phi}_t] = 0.$$

where $r_{j,T}$ represents the return to trading the jth option realized at time T, $\mathbf{\Phi}_t$ is the information set available at time t, and $\mathrm{E}[\cdot]$ is the expectation operator.

Jensen (1978) defines economic profits as the risk-adjusted returns net of all costs. Therefore, this definition implies that market efficiency has to be tested taking into account not only transaction costs, but also the risks inherent in the trading strategies used. Jensen also identifies three versions of the efficient market hypothesis according to the definition of the information set $\mathbf{\Phi}_t$. These groups are weak form, semistrong form, and strong form when $\mathbf{\Phi}_t$ is formed by historical price up to time t only; all publicly available information; and all information known to anyone at time t, respectively. This last form includes both public and private information.

Over the years, mixed evidence has been reported about the validity of the efficient market hypothesis. However, Fama (1998) reviews a large body of literature concluding that the efficient market hypothesis is a valid representation of market behavior and that anomalies such as over-, underreaction, trends, and mean reversion are chance results that are in most cases the result of methodology. Nevertheless, the efficient market hypothesis does not appear to predict well the expected returns of put and call options. Several authors analyze trading strategies in the Standard & Poor's 500 futures option markets and find evidence against efficiency (Bollen and Whaley, 2004; Coval and Shumway, 2001). These studies conclude that simple strategies that sell options yield significant excess returns.

Similarly, several studies have found evidence of mispricing for agricultural options. In particular, implied volatility appears to be a biased forecast of subsequent realized volatility for corn, soybeans, and wheat futures (Egelkraut and Garcia, 2006; Szakmary et al., 2003). However, in contrast with these studies, Simon (2001) uses a combination of IV methods and of simulated trading strategies and finds that corn, soybean, and wheat options are not mispriced. A different set of studies finds excess returns and biased volatility forecasts when analyzing cattle options (e.g., Brittain et al., 2009; Hauser and Liu, 1992; Manfredo, Leuthold, and Irwin, 2001). Recently, studies by Egelkraut and Garcia (2006) and Szakmary et al. (2003) raise questions about the pricing ability of the hog options market because these studies find implied volatility to be a biased forecast of subsequent realized volatility. Such biases indicate that options are either over- or underestimating the volatility of the futures price. Consequently, abnormal returns potentially can be made by trading these options.

Egelkraut and Garcia (2006) and Szakmary et al. (2003) use Black's (1976) model to derive IV from option premiums and forecast the futures volatility. Szakmary et al. (2003) study IV forecasts in 35 different options markets, including agricultural markets. This study uses IV to forecast the subsequent market volatility expected to prevail during the next calendar month. In contrast, Egelkraut and Garcia (2006) use IV to forecast the realized volatility of corn, soybeans, soybean meal, wheat, and hogs futures during an intermediate future time interval. The authors define this forecast as implied forward volatility.

Analyzing the relationship between hog options IV and realized volatility, Szakmary et al.

(2003) find that when IV is relatively high, realized volatility tends to be lower, and vice versa, which indicates that options are mispriced. The authors also test whether option premiums efficiently incorporate all the information regarding the futures volatility. If option prices reflect all available information, then historical volatility should not contribute to improving the IV forecast, because all the information contained in past volatility realizations should be already incorporated in IV. However, Szakmary et al. (2003) find that historical volatility does improve the IV forecast suggesting that hog option premiums do not reflect all the available information about expected future price volatility. Similar to Szakmary et al. (2003), Egelkraut and Garcia (2006) also find biases of the implied forward volatility when predicting future realized volatility. However, these authors find that historical volatility does not improve the forecast provided by IV.

McKenzie, Thomsen, and Phelan (2007) use the trading strategy approach to test the efficiency of the hog options market by computing the profitability of long straddles established around the release dates of the Hogs and Pigs Report. Long straddles are profitable whenever the underlying futures volatility increases or when there are large price movements in either direction. Analyzing data from 1985 through 2005, McKenzie, Thomsen, and Phelan (2007) show that if transaction costs are low enough, a floor trader could obtain systematic profits. However, profits are heavily dependent on the level of transaction costs, and the hog options market appears efficient for off-floor traders. It is worth noting that McKenzie, Thomsen, and Phelan (2007) analyzed options market efficiency only in the days surrounding the release of the Hogs and Pigs Report. Thus, the authors analyze the hog options market efficiency during specific trading days only.

This discussion indicates that the efficient market hypothesis may fail to describe the behavior of option markets. However, the existing evidence regarding the hog options market is based on only three studies. Two of these studies use almost identical research methods and the third analyzes the market only during specific days of the year. The next section describes the data used in the present analysis.

Data

Daily settlement prices for hog futures and options are used in this study. Option and futures data come from the Chicago Mercantile Exchange and from Barchart. The short-run interest rate is proxied by the 3-month Treasury Bill rate and is from the Federal Reserve Bank. All data cover the period February 1, 1985 to December 31, 2005. Hog options traded at the Chicago Mercantile Exchange are American-type options that can be exercised at any time before expiration, as opposed to European-type options, which can only be exercised at expiration. The analysis conducted in this article does not use any option pricing model and should not be affected by the option's type.

Daily settlement prices of options are used in the analysis. At the Chicago Mercantile Exchange, the underlying futures and the options are traded side by side, which implies that the options and futures prices should be highly synchronized, alleviating the problem of nonsynchronous/stale prices. Another advantage of using settlement prices is that these prices are first scrutinized by the settlement committee and then by exchange staff members, because they are used by the Clearing Corporation to compute the margin requirements.[1] Because of this double inspection, settlement prices are less likely to constitute stale prices, to have clerical measurement errors, or to violate nonarbitrage restrictions. Therefore, settlement prices provide a good approximation to prices at which options could have been actually traded.

Also, the data set is filtered to exclude uninformative observations according to volume traded, strike price convexity, and minimum option premium. Options with zero volume are reported by the exchange but do not constitute actual trades; thus, they are not used in the analysis. Also, options with premiums inconsistent with monotonic strike prices are removed from the data set. Finally, options whose prices are less

[1] The settlement committee, also called the pit committee, is composed of a group of designated traders that propose settlement option prices taking into account their order books and other market information.

than three times the minimum tick size are also excluded. These filters are intended to exclude illiquid options whose prices contain little market information and that can bias the computations toward extreme returns. Similar filters have been applied in previous option studies (Coval and Shumway, 2001; Egelkraut and Garcia, 2006).

Call and Put Options Returns

Call and put returns are computed from a trading strategy that buys options with 30 calendar days to expiration and holds them until expiration.[2] Then, a new set of identical options is bought and held until they expire and so on. Returns from this trading strategy are relevant for any risk-averse trader, producer, or processor that uses hog options in his or her business. This trading scheme yields nonoverlapping return observations. Overlapping holding periods (i.e., one holding period starts before the previous one ends) can be problematic because they introduce autocorrelation in the return time series and can potentially bias statistical tests that commonly assume independent observations. Also, the trading strategies used minimize the effects of transaction costs and/or bid-ask spreads because they involve trading each option only once.

Options markets trading costs can be broadly divided into brokerage commissions and the bid-ask spread.[3] Brokerage commissions are readily available from brokerage service providers. Estimates of bid-ask spreads for agricultural options markets are scarce.[4] In this study, the approach used is to compute trading returns excluding all trading costs (brokerage fees and bid-ask spread) from the analysis. Then, if trading profits are found, the maximum level of transaction costs that can be applied while maintaining statistically significant returns will be determined. This approach allows interpreting which type of trader can obtain speculative profits without requiring arbitrary specifications of transaction costs.

Because long option positions are established, put (call) options earn money when the futures price decrease (increase). When these long positions make money, the complementary short position loses money. Consequently, determining that long positions earn positive returns indicates that short positions earn negative returns. The percentage returns to a call, $r_{c,K}$, and to a put, $r_{p,K}$, are computed respectively as:

$$(2) \qquad r_{c,K} = (\max[F_T - K, 0]/c_{K,t} - 1) * 100$$

$$(3) \qquad r_{p,K} = (\max[K - F_T, 0]/p_{K,t} - 1) * 100$$

where $c_{K,t}$ and $p_{K,t}$ are, respectively, the price of the call and of the put with strike price K at time t and F_T is the price of the underlying futures at the expiration of the option. To better assess the economic significance of option returns, mean percentage returns are also expressed in dollars per contract basis. Dollar profits can be easily compared with alternative investments. From Equations (2) and (3), percentage returns for calls and puts can be expressed in dollars per contract as, $r_{c,K}/100 * c_{K,t} * 400$ and $r_{p,K}/100 * p_{K,t} * 400$, respectively.

Using these equations, percentage and dollar returns can be computed as follows, assuming that an at-the-money call with strike price $K = 65$ sells for \$2.08 a cwt and that at the expiration the underlying futures price is of \$67.37 a cwt. Then, according to Equation (2), the percentage return is 13.9% and the dollar returns is \$115.65 (= 0.139 * 2.08 * 400) per contract. It is worth noting that returns are computed at the option's expiration date, when only the intrinsic value is reflected in the premiums (i.e., at expiration, there is no time value). Holding positions until expiration has the advantage of eliminating any persistent bias that premiums could possibly reflect

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[2] Trading strategies with 90- and 120-day options were also simulated but not reported. Results from those strategies do not differ substantially from the ones reported here and are available on request.

[3] The bid-ask spread cost is also referred to as execution cost, liquidity cost, or skid error. There also other costs such as clearing, exchange, and floor brokerage fees; these however are a very small percentage of total trading costs (Wang, Yau, and Baptiste, 1997).

[4] Recently, Shah, Brorsen, and Anderson (2009) estimate for the first time the liquidity costs for an agricultural option market. Analyzing the wheat options contract traded at the Kansas City Board of Trade, the authors show that options liquidity costs are two to three times higher than the typical liquidity costs for the underlying futures.

because at expiration, only the intrinsic value remains. If trading positions were exited any time, prior expiration premiums could reflect any persistent biases influencing the test of market efficiency. A similar approach has been recently used in other studies of options market efficiency (e.g., Brittain, Garcia, and Irwin, 2009).

Options market efficiency tests are implemented by testing whether expected returns equal zero. That expected options returns are not statistically different from zero would imply that the equality in Equation (1) holds and that the options market is efficient (Fama, 1970). Returns are presented and analyzed grouped into five moneyness categories, which are defined by the ratio $k = K/Ft = 0.94, 0.97, 1.00, 1.03, 1.06$. The grouping into moneyness allows assessing whether the computed statistics vary across moneyness (e.g., Bollen and Whaley, 2004; Coval and Shumway, 2001). A sixth return category is created by pooling returns across moneyness categories. The pooled returns describe gains/losses of an investor trading all the considered options in a single portfolio.

To test whether expected options returns are statistically different from zero, bootstrapped confidence intervals are constructed. Bootstrapping uses the sample data to obtain a description of the sampling properties of empirical estimators when asymmetries in the return distribution might limit the reliability of the usual *t*-statistic. Bootstrapped confidence intervals are not affected by asymmetries in the distribution of returns. Given a sample of reasonable size and a consistent estimator, the asymptotic distribution of the estimator can be approximated by drawing observations from the data a given number of times. Then, from each of the bootstrapped samples, the estimator is computed (Greene, 1997). Because the mean is a consistent estimator, observations are drawn, with replacement, from each of the return vectors for calls and puts in each moneyness category and for straddles and strangles. Then, the mean return is computed from the bootstrapped vectors. This process is repeated 2000 times. Next, the 2.5% and 97.5% percentiles for the distribution of the mean return are computed. These percentiles are computed for puts and calls in each moneyness category and for straddles and strangles and they indicate the range within which the true mean return lie with 95% confidence.

Returns to buying and holding call and put options during the period 1985–2005 are presented in Table 2. Returns, presented by moneyness, are from the buyer's perspective; thus, if a buyer and a seller face similar transaction costs, a positive return indicates a profit to the

Table 2. Returns for Hog Futures Options Across Moneyness Categories, February 1, 1985 to December 31, 2005

	Calls by Moneyness						Puts by Moneyness					
	0.94	0.97	1.00	1.03	1.06	Pooled	0.94	0.97	1.00	1.03	1.06	Pooled
Mean return (%)	13.8	3.6	20.8	15.5	16.9	15.4	42.1	7.2	15.8	4.2	–18.3	14.8
Mean return ($/contract)	149	–11	89	51	5	51	–8	–25	31	35	–249	–22
Standard deviation (%)	90.3	104.7	159.3	218.4	313.1	210.3	682.2	301.5	224.5	142.3	90.5	391.5
Skewness	0.9	0.8	1.3	2.2	3.4	3.4	6.7	5.0	3.6	2.1	1.6	9.5
n	55	80	147	157	130	569	136	135	141	79	60	551

Note: Moneyness is defined by $k = K/F_t$. Thus, 0.94 and 0.97 indicates in-the-money calls and out-the-money puts; 1.03 and 1.06 indicates out-the-money calls and in-the-money puts; 1.00 indicates at-the-money calls and puts. Per contract returns are computed as $r_{c,K}/100 * c_{K,t} * 400$ and $r_{p,K}/100 * p_{K,t} * 400$ for calls and puts, respectively. For hog options, contract size is 40,000 pounds; thus, a contract equals 400 cwt. Confidence intervals for the mean returns were bootstrapped using 2000 repetitions. All confidence intervals for the mean returns presented in the table included zero. The number of observations is denoted by *n*. Pooled refers to the statistics computed by pooling across moneyness categories and weighting by observations.

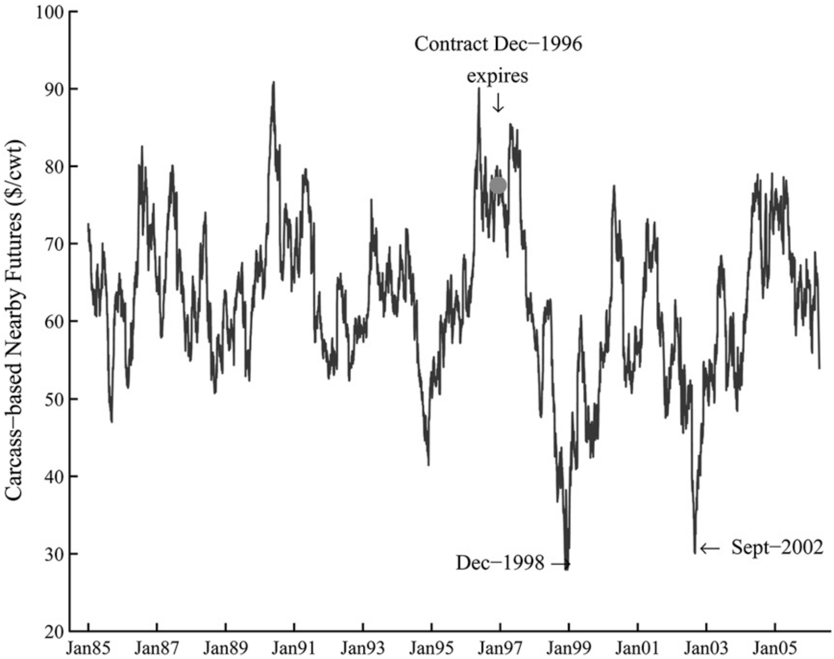

Figure 1. Carcass-Based Nearby Hog Futures Prices, February 1, 1985 to December 31, 2005

buyer and a loss to the seller, and vice versa, for a negative return. Figure 1 plots the nearby hog futures price throughout the sample period. No strong trends were present during the sample period; the linear trend has a slope of $\$-0.0008$/day. However, a rapid expansion of hog production facilities caused major drops in futures prices in December 1998 and September 2002.

In general, hog option returns are highly variable and characterized by several extreme returns along the sample period. For instance, at-the-money puts expire worthless 59% of the time but provide returns as large as 912.7% and 1504.4% (Figure 2). Therefore, the holder of one these puts loses the premium most of the time but obtains large positive returns on occasions. The distributions of hog option returns vary across moneyness. The largest standard deviations are for out-of-the-money options. Hog option standard deviations range from 682.2% to 90.3% (Table 2). The skewness of the return distribution increases when the option is further out-the-money.

Option returns appear profitable for buyers, on average, across moneyness categories. For instance, an investor buying and holding a hog call with $k = 0.94$ for 30 days would have gained on average 13.8 cents on the dollar (Table 2). Across moneyness categories, percentage returns are positive in 11 of 12 cases. Considering the positive cases, monthly profits for the holder of the options range from 3.6% to 20.8% for calls and from 4.2% to 42.1% for puts. Per contract returns for hog options are, in general, small in absolute value ranging from \$–249 for puts with $k = 1.06$ to \$149 for calls with $k = 0.94$ (Table 2).[5]

Although hog options appear profitable for buyers, none of the returns is statistically significant, because all 95% confidence intervals for the mean include the zero return. Also, returns are, in general, small in absolute value

[5] Note that although computations of contract returns do not change the sign of the return for individual options, they do change their magnitudes. As a consequence, some expected returns may have different signs when expressed in percentage than when expressed in dollar terms. For instance, consider that four options are purchased three at a premium of \$1 and one at a premium of \$10. Assume that the three options purchased by \$1 expire out-the-money and that the option purchased at \$10 expires in-the-money being worth \$15. In this example, the average percentage return from these four options is –62.5% (= [–100 – 100 – 100 + 50]/4), but the contract return is \$200 (= [–400 – 400 – 400 + 2000]/4).

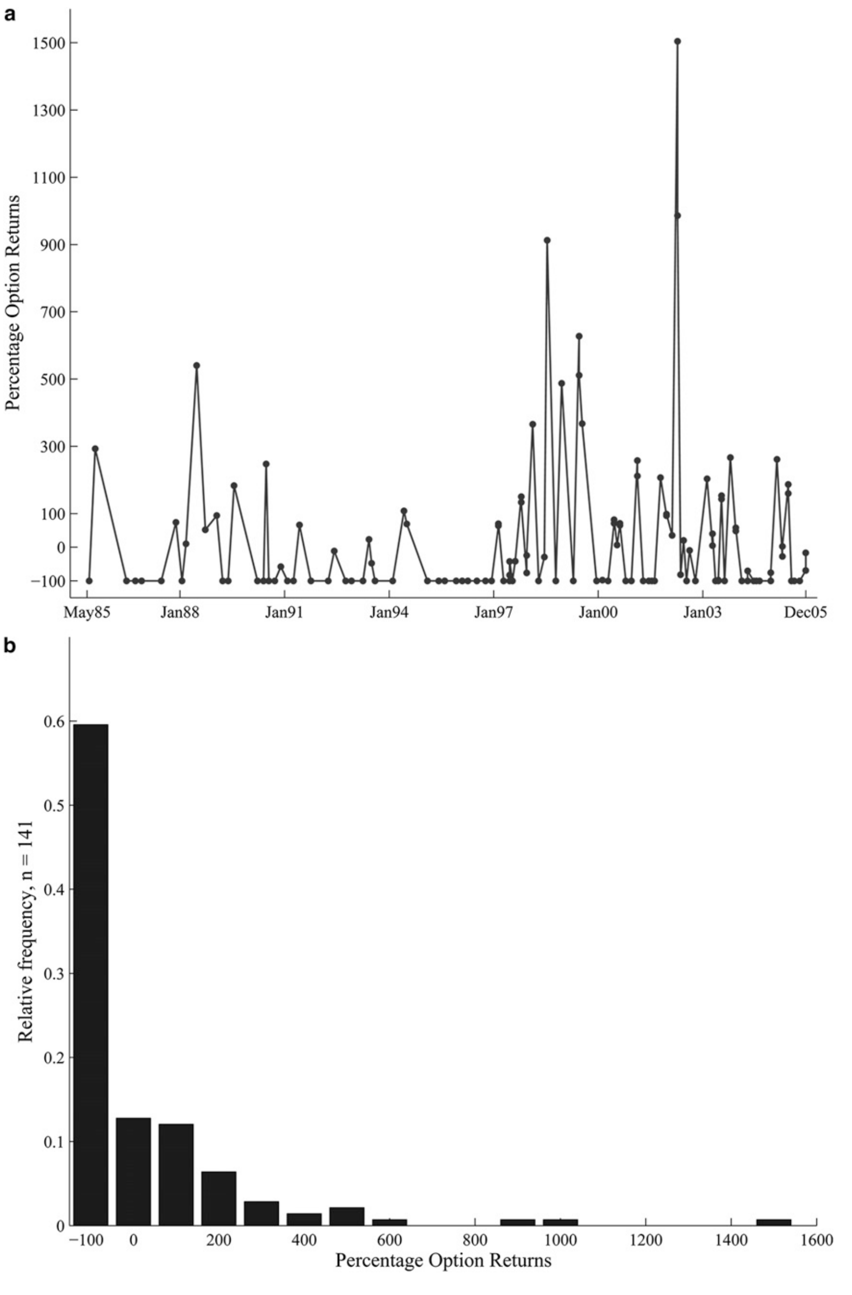

Figure 2. Percentage Returns and Histogram of Returns for At-the-Money Live and Lean Hog Puts, May 15, 1985 to December 31, 2005

indicating that profits to either buyers or sellers of these options are not economically meaningful (Table 2).

Trading returns discussed thus far do not include transaction costs. However, results presented cannot be changed by the inclusion of such costs. Including brokers' commissions and bid-ask spreads would only drive mean returns closer to zero supporting the efficiency of the hog option market. These results indicate that when analyzing the whole sample period, hog options appear efficiently priced and that it is unlikely that market participants can obtain systematic profits by trading these options.

The lean hog futures suffered a major drop on December 16, 1998, when it reached the minimum for the sample period of $27.95/cwt. This low price might potentially drive option returns and bias conclusions of this study. Therefore, options returns were recomputed excluding from the analysis the observations corresponding to the December 1998 option contract. No significant differences were found in historical returns when results were recalculated without the December 1998 contract. The next section explores possible differences in option returns during the live and the lean hog contracts.

Live/Lean Hogs Comparison

The periods corresponding to both contracts are characterized by different behavior of hog futures prices. During the live hog period, the carcass-based mean futures price was $64.3/cwt, whereas during the lean hogs period, the mean futures price was $59.6/cwt. Futures prices do not exhibit strong trends in any of the periods because the linear trend coefficients are $–0.00001/cwt and $0.00160/cwt during the live and the lean hog periods, respectively. However, futures prices were more volatile during the lean hogs than during the live hog period. In annualized terms, the average realized volatility of the futures price was of 27.3% during 1985–1996 and of 36.6% during 1997–2005. Also, the futures price shows significant drops, followed by swift recoveries, during the lean hogs period (Figure 1).

Expected hog option returns differ substantially by contract period. During the live hogs contract era, calls are profitable for buyers and puts are profitable for sellers, whereas during the lean hogs contract era, calls are profitable for sellers and puts are profitable for buyers (Table 3). Differences in the movements of the hog futures during the live and the lean contract periods are likely the main driver of the contrasting option returns. During the live hog period, the hog futures experienced two major price increases with peaks in May 29, 1990, and in May 20, 1996. In contrast, during the lean hog period, two major price drops occurred in December 16, 1998, and in September 3, 2002, when the futures descended to $27.95/cwt and to $30.05/cwt, respectively.

During the live hog period, upward price movements cause more positive returns for calls than what downward movements cause for puts. The f_{sign} statistic, shown in Table 3, indicates the percentage of observations having the same sign as the mean return. For instance, during the live hog period, 55% of the at-the-money call returns are positive, whereas only 25% of the at-the-money put returns are positive. In contrast, during the lean hog period, downward price movements cause more positive returns for puts than what upward movements cause for calls. During this period, 33% of the at-the-money call returns are positive but 37% of the at-the-money put returns are positive. Also, put returns, during the lean hog contract, are in general larger than call returns for the same period. Inspection of the return distributions indicate that 9% of the at-the-money put returns are larger than 300%, whereas only 4% of the at-the-money call returns exceed 300%.

Hog options absolute value returns tend to be larger during the live hog than during the lean hog period. For instance, eight percentage returns and 11 contract returns are closer to zero during the lean hog period than during the live hog period. Also, all but one statistically significant returns occur during the live hogs period. Results show that 16 of the 24 returns computed for live hogs are statistically significant. In contrast, only one of the 24 returns computed for lean hogs is statistically significant.[6]

For options having statistically significant dollar returns, the maximum transaction costs (i.e., commissions plus bid-ask spread) that can

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[6] To investigate differences between the live hogs and the lean hogs periods thoroughly, significant option returns are adjusted for risk to assess whether they are indicative of inefficiency or whether they are consistent with some theoretical model of returns and risks (i.e., option mispricing is caused by a risk premium that has the role of attracting speculators to the short side of the market). The risk adjustment of returns is done using the Sharpe ratio (SR) and the capital asset pricing model (CAPM). Results indicate that all option categories having significant percentage returns also exhibit SRs that are significantly different from zero. Similarly, the CAPM is rejected for six of the seven option categories yielding statistically significant percentage returns (Table 3). These results are not presented but are available on request.

Table 3. Returns for Hog Options during the Live and the Lean Hog Periods, February 1, 1985 to December 31, 2005

	Calls by Moneyness						Puts by Moneyness					
	0.94	0.97	1.00	1.03	1.06	Pooled	0.94	0.97	1.00	1.03	1.06	Pooled
Live hog period: 1985–1996												
Mean return (%)	38.6*	43.3*	63.0*	49.5	94.2	61.3*	–84.5*	–41.5	–34.5	–25.2	–34.7*	–45.5*
Mean return ($/contract)	497*	348*	294*	153	81	240*	–111*	–135*	–193*	–173	–398*	–188*
Maximum trans. costs ($/contract)	93	22	61	—	—	143	69	1	8	—	82	103
f_{sign} (%)	65	62	55	33	28	45	98	91	75	66	68	81
n	23	29	53	51	47	203	44	43	48	35	28	198
Lean hog period: 1997–2005												
Mean return (%)	–4.0	–19.0	–3.0	–0.9	–26.8	–10.1	102.6	30.0	41.8	27.6	–3.9	48.7*
Mean return ($/contract)	–102	–215	–26	2	–38	–53	41	26	146	201	–119	70
f_{sign} (%)	63	65	67	77	89	74	13	24	37	43	53	29
n	32	51	94	106	83	366	92	92	93	44	32	353

Note: Moneyness is defined by $k = K/F_t$. Thus, 0.94 and 0.97 indicates in-the-money calls and out-the-money puts; 1.03 and 1.06 indicates out-the-money calls and in-the-money puts; 1.00 indicates at-the-money calls and puts. Per contract returns are computed as $r_{c,K}/100 * c_{K,t} * 400$ and $r_{p,K}/100 * p_{K,t} * 400$ for calls and puts, respectively. Maximum trans. costs is the maximum commission costs that can be applied while maintaining average returns significant at 5% level. Asterisks (*) indicate that the bootstrapped 95% confidence interval for the mean return, constructed using 2000 repetitions, does not include zero. The f_{sign} statistic indicates the percentage of observations having the same sign as the mean. The number of observations is denoted by n. Pooled refers to the statistics computed by pooling across moneyness categories and weighting by observations.

be applied and still maintain those returns statistically significant at 5% level are computed (Table 3). Thus, if for the purchase of at-the-money calls total transaction cost of $61 per contract were subtracted, the remaining returns would still be statistically different from zero. However, if total transaction costs of $62 per contract were subtracted, then the remaining returns would not be statistically different from zero at a 5% level. Maximum transaction costs range from $1 to $143, and four option categories have maximum transaction costs higher than $80 per contract. The computed costs suggest that some option categories yielded statistically significant after-transaction costs profits during the live hog period. For the case of pooled returns, transaction costs of more than $100 per contract, much larger than realistic levels, are needed to eliminate the significant profits found.

Comparing the live and the lean hog periods indicates that expected returns are closer to zero during the lean hog than during the live hog contract. Furthermore, the patterns in the sign of the returns evidence the influence of futures price movements on option returns. Live options returns are consistent with futures price increases causing a larger effect than futures price decreases. The opposite holds true for lean options returns.

Lean hog option returns closer to zero than live hog options returns can be consequence of a better contract design that improved the efficiency of the market. A superior contract can provide a more accurate reflection of business practices yielding a more efficient market. However, other market conditions may also contribute to reducing the average level of observed returns. For instance, economic theory suggests that marginal revenue should equal marginal costs. Therefore, a decreasing level of trading cost (i.e., marginal cost) through time might cause no-transaction cost returns (i.e., marginal revenue) to decrease as well to maintain the equality. Other factors such as increasing trading volume, the growing use of electronic trading, and a trader's improved knowledge of the market might contribute to gradually reduce the level of average returns. The next sections analyze option returns through straddle and strangle strategies.

Straddle and Strangle Returns

This section investigates simulated option returns to buying straddles and strangles formed by purchasing of an equal number of calls and puts with the same time to expiration and the same or different strike prices. Straddles have been used in several studies of options market efficiency (e.g., McKenzie, Thomsen, and Phelan, 2007; Simon, 2001), but strangles have not. The advantage of using both straddles and strangles is that this allows assessing the pricing ability of options with a range of moneyness, whereas straddles provide information for at-the-money options only. Also, the simulations of long straddle and strangle strategies complement the strategy of buying and holding puts and calls individually. Testing options market efficiency based on call and put returns implicitly assumes that the underlying futures is efficient and free of persistent price trends. Although this assumption may hold in the long run, future price trends can occur during specific time periods distorting efficiency tests based on individual option returns (Brittain, Garcia, and Irwin, 2009). For instance, during periods of increasing futures prices, calls (puts) will yield positive (negative) returns, and vice versa, for periods of decreasing futures. However, straddle and strangles are nondirectional trades and their payoff functions are symmetric above and below the call and put strike prices. Figure 3 shows the payoff functions for straddle, strangle, and out-the-money strangle strategies as a function of the futures price movements during the holding period, $T - t$. The payoff functions show that straddle and strangle profits are identical given a 3% increase in futures ($F_T/F_t = 1.03$) or a 3% decrease in the futures ($F_T/F_t = 0.97$). The figure also indicates that a 3% (6%) movement in the futures price is needed for one of the options in the strangle (out-the-money strangle) strategy to expire in-the-money. Although the described strategies profit from substantial price movements, losses occur if the futures remains at similar levels (i.e., $F_T/F_t \approx 1$).

Straddle and strangle also profit from volatility increases. If volatility increases once the position has been established, the value of both calls and puts will rise and the position can be sold at a profit. On the contrary, losses occur if volatility decreases. Because of the symmetric payoff function and the sensitivity to volatility changes, straddles and strangles remove the influence of the underlying futures movements and highlight the ability of the options to price the market risks. Under this framework, options market efficiency should be assessed analyzing both individual options returns and straddle and strangle returns. For instance, significant returns of individual calls or puts combined with insignificant straddle or strangle returns would indicate that option returns are caused primarily by movements of the futures price but that, in aggregate, the options are not mispriced. On the contrary, significant straddle and/or strangle returns would indicate that options are mispriced relative to risk in the market.[7] The described approach has been used recently to test cattle options market efficiency by Brittain, Garcia, and Irwin (2009). Long straddles are formed by purchasing one nearest-to-the-money call and one nearest-to-the-money put. Additionally, strangles and

[7] It is worth noting that straddle and strangle strategies have a limited downside risk because the maximum possible losses are the sum of the premiums paid to purchase the options. Also, initially straddle positions constitute delta-neutral strategies given that, by the put–call parity, call and put deltas are equal and of opposite sign. In this study, however, the strategies are simulated as buy-and-hold and not rebalanced through the holding period. Therefore, the delta of the straddle position, formed by the sum of the call and the put deltas, can become positive or negative as one of the options moves into the money given the movements of the futures price.

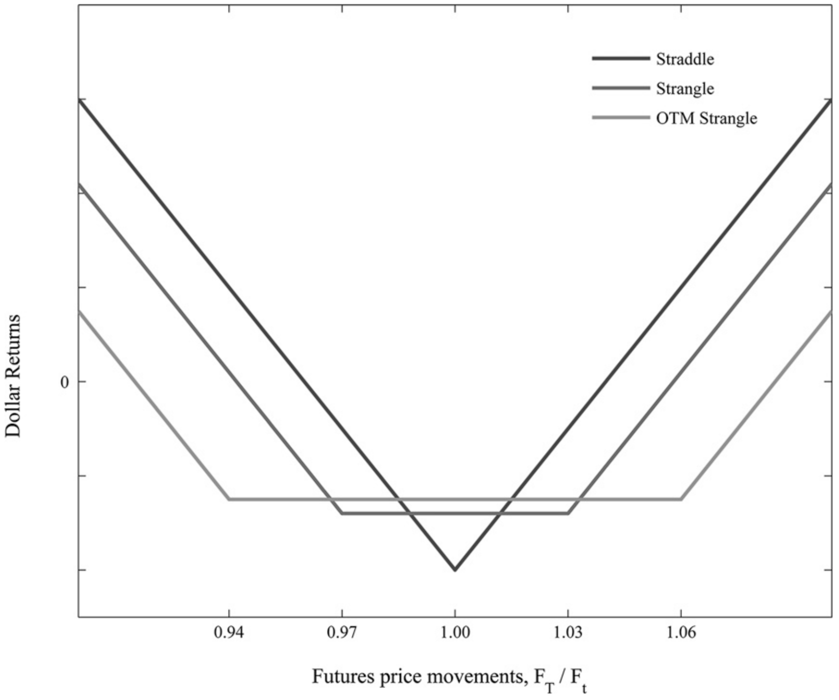

Figure 3. Payoff Functions for Straddle, Strangle, and Out-the-Money Strangle Strategies as a Function of the Futures Price Changes, F_T/F_t

out-of-the-money strangles are simulated. Strangles are formed by purchasing calls with moneyness $k = 1.03$ and puts with moneyness $k = 0.97$, and out-of-the-money strangles are formed by purchasing calls with moneyness $k = 1.06$ and puts with moneyness $k = 0.94$. Similar to call and put strategies, straddle and strangle positions are exited, and returns are realized, on the options expiration date.

Returns to long straddle and strangle positions are computed in percentage terms as:

$$(4) \qquad r_k = \left(\frac{c_{K1,T} + p_{K2,T}}{c_{K1,t} + p_{K2,t}} - 1 \right) * 100.$$

Similarly, straddles and strangle returns are expressed in dollars per contract as:

$$(5) \qquad r_k = (c_{K1,T} + p_{K2,T} - c_{K1,t} - p_{K2,t}) * 400.$$

where $c_{K1,T} = \max(F_T - K, 0)$ and $p_{K1,T} = \max(K - F_T, 0)$ are, respectively, the premiums for calls and puts at expiration. The purchase price of calls and puts at time t is denoted $c_{K1,t}$ and $p_{K2,t}$, respectively. For straddles $K_1 = K_2$, whereas for strangles and out-of-the-money strangles $K_1 > K_2$.

Because straddle and strangle strategies profit from volatility increases, it might be wise to buy straddles or strangles when the trader expects an increase in volatility. To test whether any mispricing in option premiums may be exploited, different entry rules that increase the possibilities of profitable trades are simulated. First, straddles and strangles are initiated with options having 1 month to expiration regardless of volatility levels. Second, straddles and strangles are initiated with options having 1 month to expiration on days when the 30-day moving average of realized futures volatility is below average. This strategy would profit from a mean-reverting volatility behavior. Indeed, inspection of the realized volatility and of IV patterns through the sample indicates cycles around a long-term mean. Realized volatility is computed as the standard deviation of the continuously compounded daily returns calculated as the log of the ratio of the futures price at t and at $t - 1$. Realized volatilities are annualized by multiplying this volatility by the square root of 252, which is the typical number of trading days per year. Third, straddles and strangles are

Table 4. Returns for Straddle, Strangle, and Out-the-Money Strangle with Three Trading Decision Rules, February 1, 1985 to December 31, 2005

	No Volatility Rules Buy and Hold Systematically		Realized Volatility Is Below the 30-Day MA		IV Is Below the Sample Mean	
	Percent	$/Contract	Percent	$/Contract	Percent	$/Contract
Straddle						
Mean return	10.4	68.6	7.9	23.3	20.4*	186.2
n	141	141	95	95	80	80
Strangle						
Mean return	18.5	–1.1	29.3	12.6	46.8	181.8
n	125	125	78	78	74	74
Out-the-money strangle						
Mean return	54.6	47.2	79.9	78.6	119.2	236.8
n	92	92	60	60	53	53

Note: Asterisks (*) indicate that the bootstrapped 95% confidence interval for the mean return, constructed using 2000 repetitions, does not include zero.

initiated with options having 1 month to expiration on days when the at-the-money implied volatility is below the sample average implied volatility. Similar to the realized volatility decision rule, this strategy will generate profits when IV increases once the position has been established. The goal of the IV decision rule is to enter the straddle and strangle trades when IV is relatively low.[8] Implied volatilities are computed using the Black's future options pricing model for the nearest-to-the-money call and the nearest-to-the-money put with approximately 30 calendar days to expiration. At-the-money IVs are constructed by averaging the IVs of calls and puts. In all cases, simulated straddle and strangle positions are held until the options' expiration date. Similar trading decision rules have been used in previous option research studies (e.g., Simon, 2001).

Simulations results are analyzed for the whole sample period and, in the next section, separately for the live and for the lean hog periods. Results for the whole sample are shown in Table 4. Results show that returns to buying straddles and strangles systematically are not economically important and not statistically significant. When volatility is not used to trigger the trading positions, percentage returns range from 10.4% to 54.6% and contract returns range from $–1.1 to $68.6. When the trigger to initiate the positions is a below-average 30-day moving average-realized volatility, dollar gains are positive but small. The largest returns are obtained when the criterion to enter the straddles and strangles is a below-average IV. In this case, returns increase with respect to the other rules, and returns for out-the-money strangles are the largest. However, although some percentage returns appear large, neither percentage nor dollar returns are statistically significant with the only exception of percentage returns for straddles under the IV trading rule.

Straddle and Strangle Returns for Live and Lean Hogs

Straddle and strangle returns split into live and lean hog periods are presented in Table 5. Straddle and strangle returns tend to be small and nonsignificant for both live and the lean hog periods. When volatility is not used as a trading rule, straddles and strangles generate small dollar gains to option buyers with live period straddles yielding the largest contract return of $98.9. Straddle and strangle returns do not change substantially when realized volatility is used to determine when to enter the market. In this case, the trading strategies generate small gains on a per contract basis during both periods. The largest dollar returns

[8] Straddles and strangles were also initiated when realized volatility and IV were below their 40th and 30th percentiles. Such strategies did not produce statistically significant profits.

Table 5. Returns for Straddle, Strangle, and Out-the-Money Strangle with Three Trading Decision Rules for the Live and the Lean Hog Periods

	No Volatility Rules Buy and Hold Systematically		Realized Volatility Is Below the 30-Day MA		IV Is Below the Sample Mean	
	Percent	$/Contract	Percent	$/Contract	Percent	$/Contract
Straddle						
Live mean	12.6	98.9	3.5	16.9	16.5	160.6
n	47	47	28	28	28	28
Lean mean	9.5	54.4	9.7	26.1	22.6	199.9
n	92	92	67	67	52	52
Strangle						
Live mean	9.6	69.9	12.4	25.9	20.5	144.3
n	27	27	16	16	15	15
Lean mean	23.8	–11.8	33.6	9.2	53.5	191.3
n	92	92	62	62	59	59
Out-the-money strangle						
Live mean	–12.3	–76.0				
n	15	15			[a]	
Lean mean	67.6	71.2				
n	77	77				

Note: Live mean and lean mean are the average return from February 1, 1985 to December 31, 1996, and from January 1, 1997 to December 31, 2005, respectively. Asterisks (*) indicate that the bootstrapped 95% confidence interval for the mean return, constructed using 2000 repetitions, does not include the zero.

[a] The number of live hog options meeting the trading decision rules was too small to allow for a meaningful comparison of the options market efficiency in both periods.

are achieved when IV is used to trigger trading. Implied volatility-based trading generates dollar returns ranging from $144.3 to $199.9. However, in any case are the returns statistically significant, indicating that these option combinations do not yield consistent speculative gains during either period.

Straddle and strangle returns are at odds with individual calls and puts returns during the live hog period. During this period, individual calls and puts in some moneyness categories yield significant excess returns. However, when calls and puts are combined into straddles and strangles, absolute value returns are fairly small. Straddles and strangles remove the influence of future price changes and highlight the accuracy with which options price the market risk. Under this framework, results suggest that significant live returns are caused primarily by futures price movements but that live options price the market risk correctly, because straddle and strangle returns are not significant. Next, the effects of several market conditions on option returns are described.

Time, Information, Moneyness, and Type of Contract Effects

To investigate the process of returns thoroughly, the effects of time, time of year, moneyness, type of contract, and the release of the Hogs and Pigs Report on call, put, straddle, and strangle returns are quantified using regression analysis.[9] The described effects can influence option returns given that market behavior might change over time as traders learn and liquidity

[9] The Hogs and Pigs Report, developed and released by the USDA, inform about U.S. pig production for major states and for the whole country, including inventory numbers by class, weight groups, value of hogs and pigs, farrowings, and farrowing intentions. The schedule for the release of the Hogs and Pigs Report during the sample period is the following: from February 1985 through December 1999 reports were issued four times a year (March, June, September, and December); from January 2001 through September 2003 reports were issued monthly; and after September 2003, the report schedule returned to its previous quarterly basis.

increases. In such a case, option returns would tend to zero over time. Furthermore, futures prices volatility varies throughout the year as information flows more or less often into the market, and it is also known that market participants follow closely the information contained in the Hogs and Pigs Report (e.g., Egelkraut and Garcia, 2006; Frank, Garcia, and Irwin, 2008). Also, options with different moneyness might have different demands to implement hedging or investment strategies. Therefore, it is possible that call and put returns are different for options with different level of moneyness. Finally, option returns might be different for the live hog and for the lean hog period. If any of these variables have a substantial effect, hog option returns would vary systematically.

The models are specified having returns as dependent variables and with variables for time (i.e., linear and quadratic time variables), quarter of the year, release of the Hogs and Pigs Report, moneyness level, and type of contract (i.e., live or lean contract) as independent regressors. With the exception of linear and quadratic time trends, the rest of the regressors are specified as dummy variables. Variations across moneyness do not apply to straddle and strangles; thus, moneyness variables were not included in models for these strategies.

For brevity, these results are not presented but are available from the authors on request. Results indicate that independent variables explain little of the return variability because coefficients of determination are low and estimated parameters are not statistically significant. Regression models also do not indicate much difference in results when they are estimated for call, put, straddle, or strangle returns. Results from the models indicate no significant linear or quadratic time trends in option returns and no differences in returns among quarters. The release of the Hogs and Pigs Report reduces the return of call and put options, probably because option sellers charge a higher price fearing the market moves against them as a consequence of the information contained in the report. However, the Hogs and Pigs Report announcement effect is not significant in any case. Regression results indicate that the pricing ability of the hog options market is stable through time and time of year and that it is not affected by the release of the Hogs and Pigs Report, moneyness level, or by the change from the live to the lean hog contract.

Conclusion

This article evaluates the efficiency of the hog options market and the effect of the hog contract redesign on efficiency. Empirical returns from different trading strategies were computed using a history of 21 years of futures and option prices. Also, the impact of the 1996 contract redesign has been assessed by analyzing separately option returns during the live hogs and during the lean hogs contracts. Analyzing the full sample, we find that observed option returns are highly variable and not statistically different from zero. Contract returns are small and do not appear to yield economically significant profits. These findings hold for the trading of calls, puts, straddles, and two types of strangles and indicate that the hog option market is efficient. Comparing live and lean hog option returns indicates that some option categories yielded significant risk-adjusted returns during the live hog period but not during the lean hog period. The combined analysis of call, put, straddle, and strangle trading indicates a stronger influence of futures price movements over live hog option returns than over lean hog option returns. Lower lean hog option returns can be a consequence of the new contract better representing common business practices so that the futures price provides a more accurate forecast of expected cash prices. However, other conditions such as decreasing transaction costs over time, increased trading volume, or the widespread use of electronic trading can also contribute to reduce average options returns during the latter period.

Our findings agree with those of McKenzie, Thomsen, and Phelan (2007) who concluded that the hog options market is efficient for an off-floor trader. Results of this study complement those of Egelkraut and Garcia (2006) and Szakmary et al. (2003) given that our findings indicate that any possible bias of the volatility forecast of hog options is not large enough to generate consistent speculative profits. Furthermore, our results are at odds with the hog producers' perceptions that hog option premiums are too high. However, it is not uncommon for agricultural producers to miscalibrate the actual futures price distribution (e.g., Eales et al., 1990; Kenyon, 2001). For instance, if producers expect a lower than actual price volatility, they will see option premiums as too high. Similarly, if the producer's subjective probability distribution is more skewed toward higher prices than the actual distribution, producers will see put options as too expensive. Misperceptions such as these have been proposed formally by Tversky and Kahneman (1974).

Several guidelines emerge. First, our findings show that option returns are not consistently favoring either buyers or sellers. Therefore, hog producers and processors can use hog options as a hedging tool confidently. Given that hog options are priced accurately, these contracts can be use alone or in combination with other options, futures, or forward contracts to manage price risk. Hedging strategies for any type of risk management need can be designed; thus, conclusions from this article should encourage market participants to search advice about the best use of hog options in their business operations. Also, the evidence found supports the notion that option premiums fully reflect all available information and that the hog options market is able to quickly correct any mispricing, as proposed by Fama (1970). Finally, recent changes in the market place deserve further research work. The growing use of electronic trading platforms is likely to have an impact on trading costs potentially modifying expected returns. The pervasive use of computers to organize and monitor trading activities makes readily available time-stamped transaction data sets. Such detailed information combined with modern economic theories can shed new light on the effects of modern production and trading technologies on market prices.

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