Are Corn and Soybean Options Too Expensive?

by

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Abstract

A growing body of recent evidence suggests that premiums for financial options might be too high. For agricultural options, market participants often make similar claims, however there is very limited scientific literature to prove or disprove such claims. This research investigates the efficiency of corn and soybean options markets by directly computing trading returns. Time effects on market efficiency are also investigated. When the sample period is considered as a whole, risk adjusted returns indicate that no profits can be made by taking either side of the corn or soybean options markets. However, when time effects are analyzed, corn calls appear to have provided excess returns during the 1998–2005 period. This result do not appear to be driven by movements in the underlying futures, since similar differences were not found for corn puts. Based on the evidence presented here, corn puts and soybean options would constitute fairly-well priced insurance tools. Further research should investigate the causes of corn call returns.

Keywords: corn, soybeans, options markets, mispricing, trading returns, market efficiency

1 Introduction

A growing body of recent evidence suggests that premiums for financial options might be too high. Several authors have studied options on the S&P500 futures concluding that excess returns of about 100% can be made by selling options through simple trading schemes (Bollen and Whaley, 2004; Bakshi and Kapadia, 2003; Bondarenko, 2003; Ait-Sahalia et al., 2001; Coval and Shumway, 2001). The education section of the exchange-traded funds (ETF) center of Yahoo Finance (2006) advises not to use options on ETF's routinely because their price is usually too expensive. The center suggests that puts should be used in an opportunistic way.

For agricultural options, market participants often make similar claims. For instance, market advisory services recommend that clients do not use options outright. Richard Brock of Brock Report argues that, "We don't use outright puts or outright calls. Normally, the premiums are too high and they don't work." (Williams, 2003, pg. 14). The Chicago Board of Trade (CBOT 2004, pg. 1) itself warns: "When evaluating price risk management strategies, some producers may shy away from options because they feel the option premiums are too costly". Despite these claims, there exists very limited scientific literature about the efficiency of agricultural options. Only two recent studies have investigated this issue. Szakmary et al. (2003) and Egelkraut (2004) found mixed results using almost identical research methods. Both studies concluded that the corn options market was efficient. For the soybeans options market, Szakmary et al. (2003) found that while implied volatility (IV) was not an unbiased predictor of realized volatility (RV), historical volatility (HV) contained no further information beyond that already present in IV. However, Egelkraut (2004) found that immediate historical volatility could be helpful in predicting future realized volatility.

If option premiums are too high, farmers that hedge the value of their crops or grain processors who hedge input purchases may lose substantial amounts of money when using options. It is the equivalent of buying expensive insurance, and if this insurance is expensive enough, the cost can offset (or more than offset) the benefits of reducing risks. Option mispricing may persist in equilibrium because margin requirements of short positions impose limits to arbitrage (Shleifer and Vishny, 1997; Liu and Longstaff, 2004). When margin calls are large enough, investors may not have the funds to meet them, and be forced to liquidate their positions at a loss.

In the literature, there are two basic approaches to testing options market efficiency. The first approach computes returns to different trading schemes using historical option prices. Returns are computed using a riskless trading strategy or raw returns are adjusted for risk using a theoretical model. In general, the efficient market hypothesis (EMH) requires that expected risk-adjusted returns equal zero. The second approach is based on the prediction that IV should be an unbiased predictor of subsequent RV under market efficiency, otherwise the options market may not correctly price options. The IV can be obtained by inverting a given pricing model and solving for the standard deviation. Usually, the forecasting ability of IV is also tested relative to alternative volatility forecasts, such as historical volatility.

Implied volatility tests of options market efficiency have two important limitations. First, estimation of implied volatility requires specification of a theoretical model. Thus, researchers need to commit to a given pricing model. Both of the aforementioned studies used Black's (1976) formula for European futures options. Second, the IV approach does not allow direct testing of the efficient market hypothesis because trading returns are not computed. Consequently, the effect of transaction costs cannot be quantified. These costs are known to have a substantial impact on net trading returns (Lence, 1996) and to change over time (Park, 2005). Therefore, mis-specification of the theoretical pricing model and the omission of transaction costs may bias the results of efficiency tests in previous studies. By comparison, the simulated trading approach is model-free and allows direct testing of the efficient market hypothesis because returns can be computed and tested statistically.

The objective of this study is to test the efficiency of the corn and soybean options markets by directly computing trading returns. Corn and soybeans are the main crops in Midwestern US and these options are commonly used by farmers and grain processors as hedging instruments.

2 Data and Methods

Daily settlement prices for American futures options for corn and soybeans are used to implement this study. Option and futures futures data come from the CBOT. Short-run interest rate is proxy by the 3-month Treasury Bill rate. The interest rate series is from the Federal Reserve Bank. The dataset covers the period 1/2/1991 to 12/31/2005.

Option contracts at the CBOT are of two types, "standard" and "serial". A standard option contracts exercises on the underlying futures in each corresponding contract month. Serial option contracts are listed in months where there is no futures contract, and exercise into the nearby futures (*i.e.*, an August option contract exercises into the September futures). In this way, there is an option contract available for each month of the year. While most of the option theory is developed for European-type options, this study is not affected by differences in pricing between American and European options because no theoretical pricing model will be used.

Daily settlement option prices are used since these do not suffer from nonsynchronous/stale trading, and are less likely to have rounding errors or to violate basic non-arbitrage restrictions than closing prices. This is because settlement prices are scrutinized at two different levels of control at the close of each trading day. First, prices are proposed by the settlement committee members. In proposing settlement prices committee members exert a mutual control over each other, since they are immersed in a conflict of interests. Settlement prices are used by the Clearing Corporation to compute the margin requirements. These margins determine the amount of money traders must maintain on deposit, and in some situations margins calls might drive traders into bankruptcy. Secondly, prices are checked with computer software, operated by an exchange member, which checks basic non-arbitrage restrictions. Because of this double scrutiny, settlement prices are a good approximation for the middle point of the closing bid/ask spread of the trading session, and reflect prices at which options could have been actually traded.

The dataset is also filtered according to minimum volume traded, strike price convexity and minimum option premium. The analysis uses options that, for any given day, have been traded above an established minimum volume. Prices of lightly traded options contain little to no information as they do not come from an agreement between buyers and sellers that actively negotiate the fair market value of the asset. Similar filters are regularly applied in studies of options markets (Coval and Shumway, 2001; Egelkraut, 2004). There is no established criterion to set the minimum volume figure. This depends on the specific market being analyzed, and on the time period under study. A practical rule used here is to analyze how the results change as this minimum volume is varied.

Strike price convexity constitutes a basic non-arbitrage relationship. It says that options prices must be convex functions of their strike prices, K, and that the slope of these functions should be less than 1 in absolute value. In practice sometimes option settlement prices do violate non-arbitrage relationships due to institutional issues, human errors, etc. However, those prices do not come from a true negotiation process, and can be seen as outliers that can potentially bias the analysis, thus those observations are excluded. Similar filtering criteria has been used by Jackwerth (2000).

Options whose price is less than three times the minimum tick size are also excluded from the analysis[1]. Options with such low prices are usually very illiquid and their trading normally constitutes block trades to liquidate positions. Furthermore, few of these observations have the potential to heavily bias the computations toward extremely high returns. Bondarenko (2003) have also applied similar filtering to his dataset.

Forward options prices are computed to express them in equivalent time-value of money as the underlying futures price. For this, put prices $p^s(\cdot)$ are converted to forward

[1]The tick size for corn and soybean options is 1/8¢. Thus, options whose price is lower than \$0.00375 are excluded.

prices as $p(\cdot) = e^{r_f(T-t)/365}p^s(\cdot)$, where t is the date when the option is bought, T is the expiration date. Thus, the holding period is equal to $T - t$. r_f is the risk-free interest rate . Call forward prices are computed in similar way.

2.1 Historical Returns

The EMH is checked here using returns to three trading strategies. Once returns to these strategies are computed, the test for the EMH can be implemented as

$$E(r_{j,T} \mid \Phi_t) = 0. \tag{1}$$

Equation (1) says that conditional on the information set Φ available at time t the expected profits of trading security j should be zero (Fama, 1970). In this case, r_j are the returns to trading the j asset, where j can be a put or call. Finally, Φ_t is the information set formed by historical prices.

The general trading strategy used will be to buy the option a given number of days prior to expiration and hold them until expiration. Then, at expiration, a new set of option contracts having the same amount of time left to expiration are purchased and held until they expire, and so on. Trading strategies with holding periods of one, three and four months will be tested.

These trading strategies involve taking long positions. For the case of put (call) options, long positions earn (lose) money when the underlying futures price decreases. On the contrary, long put (call) positions lose (make) money when the price of the underlying futures increases. Note that when long positions make money, short positions lose money. Therefore, determining that long positions consistently make money would indicate that short positions consistently lose money, and vice versa. This would indicate that the equality in (1) does not hold. Ignoring transaction costs, and being the settlement price at the middle point of the bid/ask spread, the profits of the buyer of the option are equal to the losses of the seller of the option and vice versa. In other words, the pay off functions for longs and shorts are reverse images of one another.

In general, the decision maker modeled in this paper can be any rational risk-averse profit maximizer investor. However, some strategies, in particular the one with four months holding period, can represent more closely hedging strategies for agricultural producers. These strategies will have a much smaller number of observations, but they can provide an approximation to the economics of hedging schemes with longer horizons using the commodity options included here.

Potentially, an infinite number of trading strategies exist, and it is not possible to simulate them all. However, the strategies chosen here have several advantages and collectively allow testing different aspect of market efficiency. For instance, the one-month holding strategy maximizes the number of non-overlapping return observations. This strategy may be appropriate for a short term portfolio investor. The three- and four-month holding strategies represent situations that can be used by grain producers. Since these strategies only involve trading once, they minimize the effects of transaction costs and/or bid-ask spreads.

The returns to a put, $r_{p,K}$, and to a call, $r_{c,K}$, with strike price K can be computed as

$$r_{p,K} = \frac{\max(K - v_T, 0)}{p_{K,t}} - 1 \tag{2}$$

$$r_{c,K} = \frac{\max(v_T - K, 0)}{c_{K,t}} - 1 \tag{3}$$

where $p_{K,t}$ and $c_{K,t}$ are respectively the price of the put and the call with strike price K at time t, v_T is the price of the underlying futures at expiration. Note that these returns are in excess of the risk-free rate, since options and futures contract prices were converted into forward prices.

Transaction costs are an important determinant of net trading profits. Options markets trading costs can be broadly divided into two categories, brokerage commissions and bid-ask spread. The latter is also referred to as execution costs, liquidity costs, or skid error[2]. Brokerage commissions are readily available from brokerage service providers; however data on bid-ask spread is not usually available and must be estimated. There exist a large body of literature analyzing the bid-ask spread in futures and in stock options markets. However, we are not aware of any scientific estimate of bid-ask spread for commodity options markets. In this study, the approach used is to compute the trading returns excluding all trading cost (brokerage fees and bid/ask spread) from the analysis. Then, if risk-adjusted profits are found, it will be analyzed which level of transaction costs is needed to eliminate those profits.

In order to compute descriptive statistics on the time-series of returns, options will be classified according to their level of moneyness at time t, $k = K/v_t$. The moneyness or leverage is a measure of the ability of the option to magnify gains and losses, and it varies directly with the relationship K/v_t. Options with different moneyness level have different behavior. For instance, the sensitivity of the option price to changes in the price of the underlying futures, (the option's delta and gamma) and to changes in its volatility (the option's vega) changes with the moneyness ratio (see Hull (1999), chapter 14). Thus, to compute descriptive statistics on the time-series of returns, options will be classified according to their level of moneyness at time t, $k = K/v_t$. Jackwerth (2000) and Bondarenko (2003) have used similar classifications to study option returns. According to this definition puts are classified as out-the-money (OTM) if $k < 1$, at-the-money (ATM) if $k = 1$ and in-the-money (ITM) if $k > 1$. Similarly, calls are out-the-money if $k > 1$, at-the-money if $k = 1$ and in-the-money (ITM) if $k < 1$.

Practically these definitions say that OTM options have no value if they are exercised immediately. For instance, for an out-the-money put $max(K - v_T, 0) = 0$ when $K < v_T$. Conversely, ITM puts have some positive value if exercised immediately, since $K > v_T$, and thus $max(K - v_T, 0) > 0$. Finally, ATM puts are the ones where $K = v_T$. The opposite is true for call options.

Five moneyness categories will be defined, $k = 0.94,\ 0.97,\ 1.00,\ 1.03,\ 1.06$. Extending these categories further down or further up would include in the analysis options

[2] There also other costs such as clearing, exchange and floor brokerage fees, these however are very small totaling approximately \$2 per contract (Wang et al., 1997).

with non-desirable characteristics as explained above (*i.e.*, illiquid options with potentially nonsynchronous prices). Return observations will be classified in one of the five moneyness categories as follows, return observations whose k is $0.925 \leq k < 0.955$ will be assigned to the 0.94 category, return observations whose k is $0.955 \leq k < 0.985$ will be assigned to the 0.97 category and so on. Therefore, each trading strategy will yield five different types of returns, one for each k-category $\{r_{0.94}, \ldots, r_{1.06}\}$.

In order to test the statistical significance of average options returns, 95% confidence intervals for the mean will be constructed using the technique of bootstrapping. This technique is used to obtain a description of the sampling properties of empirical estimators using the sample data. Given a sample of reasonable size, n, and a consistent estimator, the asymptotic distribution of the estimator can be approximated by drawing m observations, with replacement, from the sample vector B times. Where m can be smaller, equal or larger than n. Then, from each of the B samples the estimator is computed (Greene, 1997). In this study, m observations are drawn from each return vector of size n, 2,000 times, being $m = n$. Then, the mean return is computed from each of the 2,000 bootstrapped return vectors and a 95% confidence interval for the mean is computed. Bootstrapped confidence intervals are not affected by asymmetries in the distribution of returns.

2.2 Risk Adjustment

Computed returns need to be adjusted for risk, given that probably large absolute-value returns are just a reflection of a higher risk of those returns. For instance, empirical returns can be, after adjusting for risk, consistent with theoretical returns predicted by some asset pricing model, such as the capital asset pricing model (CAPM). For instance, say that put returns are negative on average. Then risk adjustments will be used to judge whether such low returns are consequence of put mispricing or whether they are consequence of a theory-predicted risk premium that has the role of attracting speculators to the short side of the market[3].

In this paper, two basic methods to adjust returns for risk will be used, the Sharpe ratio (SR) and the CAPM. SR indicates whether returns are due to a superior investment strategy or are caused by holding asset with higher risk levels. In an efficient market different assets should have similar SR's, as their returns are function of their intrinsic risk. The SR is defined as

$$SR = \frac{E\left[r_j\right]}{Std\left[r_j\right]} \tag{4}$$

The SR is known to be affected by skewness in the distribution of returns. For instance, it is possible that extreme positive returns would increase the denominator proportionally more than the numerator yielding a low ratio despite the fact that those upside variations may be attractive to the investor (Bernardo and Ledoit, 2000; Goetzmann et al., 2002).

[3] Actually, this last possibility is predicted under the normal backwardation theory proposed by Keynes. However, the predictions of the theory are in qualitative terms, saying nothing about how much is a normal risk-premium.

Another model to adjust returns for risk is the CAPM. This model has been widely used in studies of futures markets in general, and in studies of option markets in particular. CAPM basically says that the expected return on any asset can be expressed as the sum of the risk-free rate plus a compensation for the risk involved in holding the asset. That compensation is the risk premium which depends not on the asset own variance, but on the covariance of the asset rate of return with that of the market portfolio. CAPM can be written as

$$E\left[r_j^{CAPM}\right] = r + \beta_j \; E\left[r_m - r\right] \qquad \text{where} \qquad \beta_j = \frac{Cov(r_j, r_m)}{Var(r_m)}, \tag{5}$$

where $E\left[r_j^{CAPM}\right]$ is the expected asset return predicted by CAPM, r is the risk-free interest rate , r_m is the return to the market portfolio, $Cov(\cdot)$ and $Var(\cdot)$ are the covariance and variance operators, respectively. r_m is in theory a value-weighted index of all assets in the economy. The expression for β_j in (5) indicates the responsiveness of the j security to movements in the market. Intuitively, this says how much the returns of security j will change given a 1% change in the market return, r_m.

The model in equation (5) is not free of criticisms. Stein (1986) argues that some of the assumptions of CAPM are not consistent with futures markets. In particular, CAPM assumes that all investors hold the market portfolio. However, in futures markets the open interest (number of outstanding contracts) is equally divided between long and short positions, thus traders that are short can not be holding the same portfolio as traders that are long. Also, CAPM assumes that the quantity of all assets being traded is fixed, but in futures markets the number of outstanding futures contracts (the open interest) varies from day to day and is endogenously determined.

In spite of these criticisms, Dusak (1973) argues that the capital asset pricing model is remarkably robust even when some of its assumptions may not hold. Several studies have shown that the model provides an appropriate description of the relation between risks and returns (Black et al., 1972; Fama and MacBeth, 1972; Miller and Scholes, 1972). Furthermore, the CAPM model has been recently used in a series of studies on option returns (Bondarenko, 2003; Coval and Shumway, 2001). Despite the controversy described, CAPM will be used here to determine whether options returns are consistent with the theory underlying this model. Also, its inclusion here will allow comparing results with those of other studies.

Further discussion has arisen regarding the appropriate market index to use in the CAPM specification. In the model the term r_m represents the returns to the market portfolio, which in theory is a value-weighted index of all assets in the economy. Since this variable is not observable, Dusak (1973) used the Standard and Poor Index of 500 Common Stocks (S&P500). However, Carter et al. (1983) criticized the use of this index alone as it does not directly include agricultural commodities. The authors note that agricultural commodities are indirectly included in the S&P500 through the publicly traded firms that are in the S&P index and hold these commodities in their inventories. These authors suggested using an equally weighted combination of the S&P500 and the Dow Jones commodity futures. They argued that this scheme would provide a better representation of the importance of commodities in the economy.

Later Marcus (1984) argued that Carter et al. (1983) overestimated the importance of agricultural commodities in the economy. Marcus (1984) comparing the value of agricultural farm assets to the value of the household sector net wealth and the gross farm income with the national income concludes that the appropriate weight for the commodities in a market index should be roughly one-tenth. The author notes that the estimated β's are an increasing function of the weight of the commodities in the index. This is because the greater the participation of commodities in the market index, the higher the correlation of any single commodity return with the index return.

In this research, returns to the Commodity Research Bureau (CRB) index futures will be used as proxy for the market return in the CAPM. The CRB index tracks the price movements of a wide range of commodities, and it is used here to proxy changes in the value of the portfolio of a decision maker investing in commodity markets. The CRB index futures, designed by Reuters, is traded at the New York Board of Trade. It includes 17 contracts of the following types of commodities energy, grains, industrials, livestock, precious metals and softs. The grain and energy categories each represent 17.6% of the value of the index.

In order to test the observed returns against CAPM, the Jensen's alpha will be computed as

$$\alpha_{i,j} = r_{i,j} - E\left[r_j^{CAPM}\right], \tag{6}$$

where $r_{i,j}$ is the ith return for the jth asset (*i.e.*, it can be defined as $r_j \equiv r_{p,K}$ or $r_j \equiv r_{c,K}$) and $E\left[r_j^{CAPM}\right]$ is the expected returns for the jth asset predicted by CAPM. The Jensen's alpha is a risk-adjusted measure of the returns that the asset is earning above (or below) the returns predicted by CAPM — the excess return. Therefore, if observed returns are consistent with CAPM, the average α should not be different from zero. To test this hypothesis the modified t test proposed by Johnson (1978) will be used. This modified test allows for the possibility that the excess returns α_i are drawn from an asymmetric distribution[4]. If returns come from a symmetric distribution with zero skewness (*i.e.*, $U = 0$) the statistic collapses to the usual t-statistic. Johnson's test statistic is

$$t_J = \frac{\overline{\alpha} + \frac{U}{6\sigma^2 n} + \overline{\alpha}^2 \frac{U}{3\sigma^4}}{\sqrt{\frac{\sigma^2}{n}}} \quad \longrightarrow \quad t_{n-1} \tag{7}$$

where $\overline{\alpha}$ is the mean, σ is the standard deviation, U is the skewness of the distribution of α_i and t_{n-1} is a Student t distribution with $n-1$ degrees of freedom.

The trading strategies with three- and four-month holding period will produce overlapping returns. It is well know that overlapping can bias statistical inference because returns are not independent, rather the time series is autocorrelated. When returns are correlated, the OLS estimator is still unbiased, but it is inefficient. In order to correct the standard errors of the t-statistics computed from the overlapping returns, the Newey-West autocorrelation consistent covariance estimator will be used. This procedure corrects for a general structure of autocorrelation yielding standard errors that are more efficient than the ones obtained from the traditional variance-covariance matrix.

[4] This test has been used in similar studies of options returns (Bollen and Whaley, 2004).

The Newey-West estimator is widely used to correct for non-spherical disturbances, and is described in Greene (1997).

2.3 Time Effects Analysis

In order to test for time effects in the trading returns, time series will be split in two subperiods. Subperiod one will cover from 1991 to 1997, and subperiod two will cover from 1998 to 2005. Then, the same analysis will be done separately for each subperiod. While the number of observations within each subperiod will be smaller, this analysis will help assessing the existence of structural changes in the series of returns.

3 Results

This section presents historic returns to buying and holding corn and soybeans options during three different holding periods. Figure 1 presents nearby future prices for corn and soybeans. No strong trends in futures prices were observed during the period analyzed. For instance, corn prices show a trend of $-\$0.00009$/day, and soybean prices trended down at a rate of \$0.00004/day. Extremely high futures prices occurred in June 1996 and in March 2004 for corn and soybeans, respectively. Average trading volume for corn and soybean options with different times to maturity is shown in tables 1 and 2, respectively. For both commodities, there is an increase in trading volume as the times to maturity decreases, although the increase is more pronounced for soybeans. The heaviest trading occurs normally in options with k close to 1. Trading is higher for OTM options than for ITM options. Also for corn and soybeans, OTM calls are more heavily traded than OTM puts. This feature contrasts with the findings of Bondarenko (2003) who found that OTM puts on the S&P500 futures were traded more actively than OTM calls on the index.

3.1 Options Returns

Tables 1 and 2 show several statistics of the historic returns for corn and soybean options with different k-categories, r_K. These returns are obtained including in the analysis options with a minimum daily trading volume of five contracts. Simulations done for corn puts indicate that the same qualitative results can be obtained by setting the minimum volume at ten and at fifteen contracts. According to this, a minimum volume of five contracts is considered to ensure a price that is informative of the option market value. Tables 1 and 2 also indicate when a 95% confidence interval for the mean return, constructed using a bootstrap of 2,000 repetitions, does not include the zero return.

In general, the skewness of option returns distributions increases as the option is more OTM (tables 1 and 2). For instance, ATM corn calls expire worthless 73% of the times (figure 2), while ITM soybean puts expire worthless 23% of the times (figure 3). Consequently, the buyer of an ATM or OTM option usually loses the premium, but obtains a large gain on some occasions.

Table 1 indicates that an investor buying and holding a corn call with $k = 0.94$ for 30 days would have lost an average of 5¢ on the dollar. Similarly, an investor would have gained on average 18¢ on the dollar when buying and holding 90 days ITM soybean puts with $k = 1.06$ (table 2). Some of the returns in tables 1 and 2 appear fairly large in absolute value, which would suggest option mispricing. For instance, the expected return for ATM corn calls with a 30-day holding period is -40.20%. Similarly, the average return for soybean puts with 120-day holding period and $k = 0.94$ is -40.53%. However, aside for three cases, most of the expected returns include zero in the 95% confidence interval. This indicates that investors can not rule out, with 95% confidence, a zero return when trading these options. In other words, it is not possible to rule out that the true mean of the return distribution is zero for most of the options.

Given the results presented, it is unlike that investors would be able to make profits by taking either side of the corn and soybeans options market. While some of the mean returns appear large in absolute value, it is not possible to rule out that the true expected return is zero, for most options. Furthermore, these returns have not been adjusted for risk. Some of the options may seem to provide large returns, but they also have large standard deviations. Thus, at this point a risk adjustment is needed to assess whether these returns are consistent with the options risk characteristics.

3.2 Risk Adjustment

This section examines the relationship between corn and soybean options returns and risk by using the Sharpe ratio and the CAPM. The SR's presented in tables 3 and 4 provide a simple way to examine the risk return characteristics of corn and soybean options. The SR is interpreted as the return per unit of risk. Thus if options markets were inefficient, SR's should be large in absolute value indicating that one side of the market is obtaining excess returns over the risk level of the options returns. In this study, SR's are small in absolute value for both crops and for both types of options. This suggests that no profits can be made given that mean options returns only reflects the cost of bearing the risk inherent on those returns. This results support options market efficiency.

Tables 3 and 4 present the results of the risk adjustment using the CAPM. Overall, observed returns appear to be consistent with those predicted by CAPM. For both crops, the CAPM model is rejected in only two cases. At-the-money corn calls with 30-day holding period exhibit the largest difference between the observed mean return and the expected return predicted by CAPM, $E\left[r_j^{CAPM}\right]$ (Panel A, table 3). However, for all other cases the excess returns, α's, are not statistically significant at a 0.05 level, supporting CAPM.

Results obtained in this section indicate that no profit can be made by trading these options using any of the strategies tested here. Observed historical returns are too variable to constitute attractive investment opportunities. The two models used to adjust the returns for risk consistently indicate that corn and soybean options do not yield excess returns given their risk levels. It is worth noting that these conclusions can not be changed by the inclusion of transaction costs or bid-ask spreads. This is because options are assumed to be traded only once, at the beginning of each holding period. At the end of which, options either expire worthless or are exercised with a small commission for the exercise. Note that returns would be driven closer to zero by introducing transaction costs and/or bid-ask spread, supporting further the efficiency of these markets.

To better assess the economic significance of the returns presented, dollar returns on a per contract basis are also presented in table 5. Extreme per contract returns occur for the 90-day holding horizon in soybeans, and are −\$381 for calls and \$1,168 for puts. Almost all dollar returns per contract are small enough in absolute value to not have economic significance. Any potential profit from these returns would be greatly reduced or eliminated by the introduction of transaction and execution costs faced by market participants that trade through commercial brokers. For example, consider that a typical bid/ask spread for these options is two ticks, one tick to open the position and one tick to close it. Also, consider a brokerage fee of \$50/contract, and a \$2/contract commission for exercising the option at expiration. Then, it would cost \$58.25/contract to set up the trading strategies employed here. Because options are traded only once, half of the bid/ask spread is paid. Subtracting the \$58.25 transaction costs from the average per contract return in table 5, it can be seen that the remaining returns are in general too low to be economically significant.

For the two markets analyzed here, results suggest that no gross mispricing exist for corn and soybean options. These results agree with those of Szakmary et al. (2003) and Egelkraut (2004) regarding the corn options market, but contrast with those of Egelkraut (2004) regarding soybean options. Egelkraut (2004) found that immediate historical volatility could be helpful in predicting future realized volatility, thus suggesting market inefficiency. Furthermore, these results are substantially different to those analyzing stock options markets (e.g., Coval and Shumway 2001; Bondarenko 2003; Bollen and Whaley 2004). Probably this is because corn and soybean options are written on futures on a single asset, as opposed to options on index futures such as options on the S&P500 futures. Bollen and Whaley (2004) compared simulated trading strategies for options on twenty individual stocks with options on the S&P500 futures. The authors found positive excess returns, ranging from 6.9% to 2.0%, to a strategy of selling options on the index. But performing the same strategy on options on individual stocks produced excess returns that were not statistically different from zero for all levels of moneyness (Table VIII of Bollen and Whaley (2004)). The authors conclude that option mispricing is due to a buying pressure that market makers are not able to arbitrage away in order to bring index prices back into alignment. Intuitively, this explanation says that many more people buy puts on the S&P500 futures to hedge their portfolios (*i.e.*, the S&P500 includes 500 assets) than the people that buy options to hedge corn or soybeans (the underlying futures consists of a single asset: corn or soybeans). According to this, it is reasonable that the mispricing of corn and soybeans options may be either small or nonexistent.

3.3 Time Effect Analysis

Tables 6 through 9 present option returns and risk adjustment for the two subperiods, separately. Mean options returns differ substantially from one subperiod to the next. For instance, the spike in corn futures prices in June 96 causes expected call returns to be positive, and expected put returns to be negative from 1991 to 1997. During the second subperiod, corn futures prices decreased causing negative average call returns and positive average put returns, in general (tables 6 and 7). For the first subperiod, soybean call returns tend to be negative. Soybean put returns tend to be positive for the shortest holding horizon, and negative for the 90- and 120-day holding horizons (table 8). During the second subperiod, soybean futures prices spiked to $10.52/bu. in March 2004. Such movement causes, average call returns to be positive, and average put returns to be negative, in general (table 9). For corn, six confidence intervals for the mean return on calls, and one confidence interval for the mean return on puts do not include zero. All of these confidence intervals correspond to the second subperiod (table 7). For soybeans, only two confidence intervals for put mean returns during the first subperiod do not include zero (table 8).

Corn calls present the largest differences in efficiency from one subperiod to the next. Sharpe ratios for corn calls are larger in absolute value during the second subperiod than during the first (table 6 and 7). Also, CAPM performs better for corn calls during the first subperiod. For this crop, CAPM is rejected eight times for calls during the period 1998–2005 (table 7). Corn put differences during the first and second subperiods are not so evident. Absolute value SR's from one subperiod are not consistently larger than the ones for the other subperiod, and CAPM is rejected only two times during the second subperiod (table 9). Soybean options present similar levels of efficiency during the two subperiods. Absolute value SR's from one subperiod do not consistently dominate those for the other subperiod, although put SR's tend to be larger, in absolute value, during the first subperiod (tables 8 and 9). For soybeans, CAPM performs similarly through time. For soybean puts, predicted returns from CAPM are statistically different from empirical returns in three cases during the period 1991–1997. For calls, predicted and observed returns differ statistically in only one case during the period 1998–2005.

Results of time effects in options efficiency suggest that corn calls yielded returns that differ substantially between the two subperiods analyzed. During the period 1998–2005, average returns of corn calls appear to favor the seller, and to be statistically different from zero. For this subperiod, several call returns appear inconsistent with their risk level according to CAPM. This result suggests that excess returns could potentially be made by selling corn calls from 1998 to 2005. Large differences in expected returns and risk adjusted measures between subperiods were not found for corn puts, thus call results do not seem to be consequence of movements in the underlying futures.

The effect of movements in the underlying futures on options returns can be controlled for more formally by computing returns to hedged portfolios of options and futures. These portfolios are rebalanced periodically to make their value insensitive to small variations in the futures price. This type of strategy is widely used in studies of options returns (e.g., Coval and Shumway 2001; Bollen and Whaley 2004). Further research will compute returns to riskless trading strategies to control for the effect of futures price movements. Finally, in splitting the sample into two separate subperiods the number of observations is greatly reduced. Consequently, the power of the statistical tests used here decreases as well. This should be considered when interpreting the results.

4 Concluding Comments

This research is unique in studying the efficiency of agricultural options markets by directly computing and risk adjusting trading returns. The efficiency of the markets for corn and soybean options has been analyzed using a low cost trading strategy. Returns have been adjusted for risk using the Sharpe ratio and the CAPM. When the sample period is considered as a whole, risk adjusted returns indicate that no profits can be made by taking either side of the corn or soybean options markets. However, when the sample period is split in two halves, corn calls appear to have provided excess returns during the 1998–2005 period. These results do not appear to be driven by movements in the underlying futures, since similar differences were not found for corn puts. Results indicates that soybean options would constitute fairly-well priced insurance tools. Failure to find profitable trading strategies is not sufficient to conclude that markets are efficient. However, based on the evidence presented here, corn puts and soybean options would constitute fairly-well priced insurance tools. Further research should investigate the causes of corn call returns.

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Table 1: Descriptive statistics for returns to long corn options across five moneyness categories and with 30, 90 and 120 days holding periods.

	Calls					Puts				
k	0.94	0.97	1.00	1.03	1.06	0.94	0.97	1.00	1.03	1.06
Panel A: 30 days holding period										
Mean Return	-5.00	-15.40	$-40.20^{\dagger}$	-14.50	-21.80	-25.60	-12.50	0.60	5.80	6.60
Std Dev	86.10	114.50	134.70	259.50	280.20	256.10	161.30	110.60	85.50	65.00
Skewness	1.059	2.016	3.243	3.587	4.95	4.042	2.025	0.88	0.682	-0.053
Avg. Volume	282	453	646	747	621	557	600	529	212	211
n	46	80	120	97	88	70	109	114	66	45
Panel B: 90 days holding period										
Mean Return	-5.60	-16.60	-5.00	26.70	-16.70	4.10	23.20	20.50	11.20	17.00
Std Dev	123.00	131.10	162.90	234.40	212.10	196.20	140.90	138.40	116.00	90.60
Skewness	1.176	1.716	1.607	1.614	2.729	2.136	0.69	1.031	0.668	-0.091
Avg. Volume	155	269	694	662	655	435	561	620	268	184
n	34	50	59	44	57	53	49	54	45	29
Panel C: 120 days holding period										
Mean Return	-4.90	11.10	-12.60	-24.10	5.00	4.20	-13.50	6.00	16.70	7.70
Std Dev	128.10	154.70	172.50	177.20	238.30	167.40	128.80	119.30	99.80	98.70
Skewness	1.458	1.317	2.099	3.008	2.854	1.371	1.449	0.886	0.337	0.294
Avg. Volume	222	288	590	813	452	683	619	324	185	154
n	30	51	49	54	49	44	53	49	32	26

Returns are in percentage and over each respective holding period — not annualized; $k = K/v_t$; n is the number of observations. † Indicates that a 95% confidence interval for the mean constructed using 2,000 repetitions does not include the zero mean return.

Table 2: Descriptive statistics for returns to long soybeans options across five moneyness categories and with 30, 90 and 120 days holding periods.

	Calls					Puts				
k	0.94	0.97	1.00	1.03	1.06	0.94	0.97	1.00	1.03	1.06
Panel A: 30 days holding period										
Mean	3.32	7.94	-3.95	3.28	-32.72	-18.11	-11.00	$-21.97^{\dagger}$	0.76	-8.45
Std Dev	83.05	117.27	150.68	226.27	236.64	283.91	228.48	123.08	90.49	64.30
Skewness	0.738	1.194	1.751	2.701	4.831	4.315	4.647	1.788	0.854	0.227
Avg. Volume	228	303	570	743	598	582	644	467	177	124
n	59	80	166	136	116	123	150	159	94	48
Panel B: 90 days holding period										
Mean	2.62	19.66	7.94	15.95	-33.82	-0.52	-15.52	-15.79	-4.70	17.71
Std Dev	101.59	151.31	201.34	252.52	153.21	271.47	152.50	105.54	110.65	110.43
Skewness	0.662	2.342	3.234	4.724	2.620	5.756	2.560	0.897	1.300	0.468
Avg. Volume	94	108	442	426	392	355	323	318	149	148
n	43	63	71	77	76	71	83	68	49	21
Panel C: 120 days holding period										
Mean	11.25	11.58	9.01	-8.70	-22.81	$-40.53^{\dagger}$	-24.03	-23.01	-9.37	-9.20
Std Dev	102.55	144.00	169.15	191.89	186.13	126.90	140.36	113.95	90.97	79.95
Skewness	0.614	1.755	2.133	3.139	2.668	2.378	2.030	1.537	0.453	0.268
Avg. Volume	111	69	166	284	221	212	214	146	150	86
n	27	47	67	75	64	68	64	61	31	14

Returns are in percentage and over each respective holding period — not annualized; $k = K/v_t$; n is the number of observations. † Indicates that a 95% confidence interval for the mean return constructed using 2,000 repetitions does not include the zero mean return.

Table 3: Sharpe ratio, excess return and t-statistics for corn options returns across five moneyness categories and with 30, 90 and 120 days holding periods.

	Calls					Puts				
k	0.94	0.97	1.00	1.03	1.06	0.94	0.97	1.00	1.03	1.06
Panel A: 30 days holding period										
Sharpe Ratio	-0.057	-0.134	-0.299	-0.056	-0.078	-0.100	-0.077	0.005	0.068	0.101
α	-7.60	-19.90	-43.40*	-28.80	-20.70	-18.90	-8.20	3.50	8.00	8.80
t_J stat.	-0.531	-1.411	-3.009	-1.081	-0.686	-0.608	-0.516	0.351	0.810	0.890
Panel B: 90 days holding period										
Sharpe Ratio	-0.046	-0.127	-0.031	0.114	-0.079	0.021	0.165	0.148	0.096	0.188
α	-8.88	-21.84	-11.54	2.28	-22.91	27.66	26.49	21.51	27.68	14.78
t_{NW} stat.	-0.359	-0.941	-0.464	0.054	-0.657	1.070	1.352	1.171	1.575	1.030
Panel C: 120 days holding period										
Sharpe Ratio	-0.038	0.072	-0.073	-0.136	0.021	0.025	-0.105	0.050	0.168	0.078
α	-18.76	-2.87	-20.53	-31.76	-17.08	21.85	-3.17	11.64	26.14	8.17
t_{NW} stat.	-0.638	-0.109	-0.705	-1.059	-0.419	0.777	-0.170	0.657	1.670	0.447

In CAPM, CRB index is used as r_m. α is the average excess returns, which is computed as $\alpha_{i,j} = r_{i,j} - E[r_j]$ where $r_{i,j}$ is the ith return for the jth option and $E[r_j]$ is as defined in (5). Asterisk (*) indicate significance at 5% level. t_J and t_{NW} refers respectively to the modified t-statistic Johnson (1978) and to the t-statistic computed with standard errors corrected for autocorrelation through the Newey-West procedure. Both statistics test the null hypothesis $H_0 : \alpha = 0$.

Table 4: Sharpe ratio, excess return and t-statistics for soybean options returns across five moneyness categories and with 30, 90 and 120 days holding periods.

	Calls					Puts				
k	0.94	0.97	1.00	1.03	1.06	0.94	0.97	1.00	1.03	1.06
Panel A: 30 days holding period										
Sharpe Ratio	0.040	0.068	-0.026	0.015	-0.138	-0.064	-0.048	-0.178	0.008	-0.131
α	2.49	-1.14	-14.92	-4.65	-38.94	-17.67	-6.93	-18.36	0.77	-9.47
t_J stat.	0.261	-0.073	-1.248	-0.236	-1.731	-0.685	-0.365	-1.779	0.103	-0.957
Panel B: 90 days holding period										
Sharpe Ratio	0.026	0.130	0.039	0.063	-0.221	-0.002	-0.102	-0.150	-0.042	0.160
α	-5.96	9.55	-7.64	7.41	-33.35	5.11	-8.65	-4.85	-5.54	23.57
t_{NW} stat.	-0.036	0.474	-0.287	0.237	-1.783	0.153	-0.483	-0.369	-0.346	0.936
Panel C: 120 days holding period										
Sharpe Ratio	0.110	0.080	0.053	-0.045	-0.123	-0.319	-0.171	-0.202	-0.103	-0.115
α	0.49	-4.80	0.24	-21.19	-31.52	-32.98*	-14.77	-17.90	-3.34	-3.15
t_{NW} stat.	0.023	-0.213	0.010	-0.787	-1.315	-2.167	-0.788	-1.108	-0.182	-0.139

In CAPM, CRB index is used as r_m. α is the average excess returns, which is computed as $\alpha_{i,j} = r_{i,j} - E\left[r_j\right]$ where $r_{i,j}$ is the ith return for the jth option and $E\left[r_j\right]$ is as defined in (5). Asterisk (*) indicate significance at 5% level. t_J and t_{NW} refers respectively to the modified t-statistic Johnson (1978) and to the t-statistic computed with standard errors corrected for autocorrelation through the Newey-West procedure. Both statistics test the null hypothesis $H_0 : \alpha = 0$.

Table 5: Average returns, in dollar per contract, to long corn and soybean options across five moneyness categories and with 30, 90 and 120 days holding periods.

	Calls					Puts				
k	0.94	0.97	1.00	1.03	1.06	0.94	0.97	1.00	1.03	1.06
Panel A: Corn Options										
30 days	-53	-56	-143	-61	-45	-33	1	11	28	21
90 days	-93	-136	-22	99	-112	102	170	193	163	235
120 days	-61	94	-130	-165	-43	127	-21	73	225	159
Panel B: Soybean Options										
30 days	132	98	-68	-40	-182	-27	13	-9	124	-219
90 days	-86	193	-28	-30	-381	142	67	-71	129	1168
120 days	268	179	-8	-266	-359	-152	-76	-105	-212	-272

Puts and calls dollar returns per contract are computed as $r_{p,K} * p_{K,t} * 5,000$ and $r_{c,K} * c_{K,t} * 5,000$, respectively, where $r_{p,K}$ and $r_{c,K}$ are as in (2) and (3).

Table 6: Mean Return, Sharpe ratio, excess return, t-statistics and number of observations for long corn options from 1991 to 1997 across moneyness categories and holding periods.

	Calls					Puts				
k	0.94	0.97	1	1.03	1.06	0.94	0.97	1	1.03	1.06
Panel A: 30 days holding period										
Mean Return	16.50	13.19	22.69	56.59	25.75	-27.36	-17.28	-8.38	-10.79	-14.23
Sharpe Ratio	0.166	0.115	0.107	0.131	0.103	-0.082	-0.085	-0.084	-0.086	-0.089
α	12.97	12.82	37.49	60.58	59.60	-20.70	-25.78	-9.58	-23.96	-19.44
t_J stat.	0.646	0.498	0.872	0.781	0.754	-0.286	-0.716	-0.414	-1.021	-1.303
n	20	28	26	26	26	22	27	27	23	17
Panel B: 90 days holding period										
Mean Return	3.54	20.41	31.87	110.79	52.59	-14.86	-5.04	5.30	-24.25	6.04
Sharpe Ratio	0.027	0.086	0.122	0.255	0.233	-0.071	-0.063	-0.036	-0.061	-0.051
α	-3.64	14.11	20.85	64.06	51.97	-3.77	2.82	1.76	-8.85	2.33
t_{NW} stat.	-0.112	0.324	0.472	0.878	0.797	-0.104	0.118	0.064	-0.393	0.097
n	23	23	29	22	28	27	26	26	22	12
Panel C: 120 days holding period										
Mean Return	32.29	52.38	12.74	43.02	62.27	-35.06	-4.97	-17.57	12.07	-21.13
Sharpe Ratio	0.205	0.260	0.180	0.179	0.188	-0.304	-0.143	-0.147	-0.097	-0.115
α	9.58	34.51	-0.49	36.36	38.98	-15.74	3.28	-12.15	23.68	-37.08
t_{NW} stat.	0.182	0.847	-0.010	0.608	0.489	-0.635	0.120	-0.538	1.096	-1.135
n	15	26	27	24	22	21	29	27	11	9

† Indicates that a 95% confidence interval for the mean constructed using 2,000 repetitions does not include the zero mean return. In CAPM, CRB index is used as r_m. α is the average excess returns, which is computed as $\alpha_{i,j} = r_{i,j} - E[r_j]$ where $r_{i,j}$ is the ith return for the jth option and $E[r_j]$ is as defined in (5). Asterisk (*) indicate significance at 5% level. t_J and t_{NW} refers respectively to the modified t-statistic Johnson (1978) and to the t-statistic computed with standard errors corrected for autocorrelation through the Newey-West procedure. Both statistics test the null hypothesis $H_0 : \alpha = 0$.

Table 7: Mean Return, Sharpe ratio, excess return, t-statistics and number of observations for long corn options from 1998 to 2005 across moneyness categories and holding periods.

	Calls					Puts				
k	0.94	0.97	1	1.03	1.06	0.94	0.97	1	1.03	1.06
Panel A: 30 days holding period										
Mean Return	-21.45	-30.77†	-57.64†	-40.51	-41.71	-24.80	-10.88	3.34	14.75	19.17
Sharpe Ratio	-0.298	-0.319	-0.436	-0.307	-0.260	-0.115	-0.100	-0.080	-0.062	-0.046
α	-22.22	-34.81*	-60.90	-54.66*	-45.90	-21.76	-7.19	6.65	20.24	25.98*
t_J stat.	-1.188	-2.040	-1.754	-2.338	-1.663	-0.685	-0.406	0.576	1.819	2.157
n	26	52	94	71	62	48	82	87	43	28
Panel B: 90 days holding period										
Mean Return	-24.84	-48.10†	-40.72	-57.29	-83.60†	23.69	55.17	34.55	45.02†	24.82
Sharpe Ratio	-0.230	-0.359	-0.353	-0.380	-0.451	0.128	0.223	0.233	0.258	0.258
α	-24.46	-48.72*	-44.84*	-74.56*	-83.87*	61.31	52.21	37.14	68.64*	16.57
t_{NW} stat.	-0.694	-2.656	-2.190	-2.792	-6.972	1.623	1.714	1.535	2.947	0.932
n	11	27	30	22	29	26	23	28	23	17
Panel C: 120 days holding period										
Mean Return	-42.05†	-31.90	-43.72	-77.73†	-41.59	39.96	-23.86	34.82	19.16	23.00
Sharpe Ratio	-0.532	-0.333	-0.325	-0.409	-0.368	0.200	0.099	0.140	0.146	0.156
α	-53.82*	-47.09	-49.78	-81.47*	-63.11	59.96	-11.28	43.06	29.21	22.11
t_{NW} stat.	-2.758	-1.664	-1.823	-5.413	-2.009	1.288	-0.458	1.658	1.411	1.026
n	15	25	22	30	27	23	24	22	21	17

† Indicates that a 95% confidence interval for the mean constructed using 2,000 repetitions does not include the zero mean return. In CAPM, CRB index is used as r_m. α is the average excess returns, which is computed as $\alpha_{i,j} = r_{i,j} - E[r_j]$ where $r_{i,j}$ is the ith return for the jth option and $E[r_j]$ is as defined in (5). Asterisk (*) indicate significance at 5% level. t_J and t_{NW} refers respectively to the modified t-statistic Johnson (1978) and to the t-statistic computed with standard errors corrected for autocorrelation through the Newey-West procedure. Both statistics test the null hypothesis $H_0 : \alpha = 0$.

Table 8: Mean Return, Sharpe ratio, excess return, t-statistics and number of observations for long soybean options from 1991 to 1997 across moneyness categories and holding periods.

	Calls					Puts				
k	0.94	0.97	1	1.03	1.06	0.94	0.97	1	1.03	1.06
Panel A: 30 days holding period										
Mean Return	-15.56	-14.82	-22.06	-9.86	-12.26	26.07	5.51	-32.57	16.35	0.88
Sharpe Ratio	-0.277	-0.140	-0.140	-0.037	-0.036	0.065	0.025	-0.295	0.176	0.017
α	-13.32	-17.66	-12.03	1.07	24.66	30.72	4.24	-33.50	12.51	-9.83
t_J stat.	-0.910	-0.797	-0.466	0.031	0.428	0.469	0.123	-1.472	0.853	-0.670
n	25	30	41	39	34	37	35	37	34	15
Panel B: 90 days holding period										
Mean Return	12.44	16.83	-14.91	-12.24	-36.52	$-63.16^{\dagger}$	-33.78	-16.38	-25.25	-16.97
Sharpe Ratio	0.132	0.149	-0.099	-0.085	-0.245	-0.607	-0.299	-0.157	-0.303	-0.223
α	4.76	15.70	-19.39	-3.28	-38.41	-62.61*	-34.97	-14.63	-40.35*	-19.33
t_{NW}	0.231	0.789	-0.657	-0.119	-1.516	-3.453	-1.827	-0.835	-2.141	-0.689
n	20	33	33	34	39	35	38	33	22	8
Panel C: 120 days holding period										
Mean Return	20.98	7.03	-0.51	-20.55	-24.75	-42.99	-41.19	$-55.90^{\dagger}$	-13.93	-22.93
Sharpe Ratio	0.209	0.054	-0.004	-0.131	-0.127	-0.333	-0.389	-0.819	-0.162	-0.262
α	10.44	-1.90	-5.69	-23.73	-31.02	-33.81	-37.21	-48.29*	-5.31	-22.64
t_{NW}	0.292	-0.067	-0.208	-0.762	-0.862	-1.313	-1.713	-3.384	-0.203	-0.536
n	11	23	36	33	35	30	31	26	12	6

† Indicates that a 95% confidence interval for the mean constructed using 2,000 repetitions does not include the zero mean return. In CAPM, CRB index is used as r_m. α is the average excess returns, which is computed as $\alpha_{i,j} = r_{i,j} - E\left[r_j\right]$ where $r_{i,j}$ is the ith return for the jth option and $E\left[r_j\right]$ is as defined in (5). Asterisk (*) indicate significance at 5% level. t_J and t_{NW} refers respectively to the modified t-statistic Johnson (1978) and to the t-statistic computed with standard errors corrected for autocorrelation through the Newey-West procedure. Both statistics test the null hypothesis $H_0 : \alpha = 0$.

Table 9: Mean Return, Sharpe ratio, excess return, t-statistics and number of observations for long soybean options from 1998 to 2005 across moneyness categories and holding periods.

	Calls					Puts				
k	0.94	0.97	1	1.03	1.06	0.94	0.97	1	1.03	1.06
Panel A: 30 days holding period										
Mean Return	17.20	21.59	1.99	8.57	-41.21	-37.11	-16.02	-18.75	-8.08	-12.68
Sharpe Ratio	0.178	0.176	0.013	0.041	-0.229	-0.172	-0.069	-0.148	-0.091	-0.182
α	9.88	10.59	-13.30	-4.00	-54.23*	-35.78	-9.66	-12.27	-3.23	-7.85
t_J stat.	0.622	0.632	-0.980	-0.183	-2.531	-1.496	-0.436	-1.027	-0.251	-0.594
n	34	50	125	97	82	86	115	122	60	33
Panel B: 90 days holding period										
Mean Return	-5.93	22.77	27.79	38.25	-30.98	60.38	-0.10	-15.24	12.05	39.04
Sharpe Ratio	-0.054	0.122	0.117	0.122	-0.194	0.168	-0.001	-0.141	0.094	0.312
α	-15.71	5.52	5.30	20.24	-28.52	72.84	13.43	5.77	17.40	50.38
t_{NW}	-0.613	0.150	0.124	0.394	-1.019	1.198	0.468	0.291	0.712	1.363
n	23	30	38	43	37	36	45	35	27	13
Panel C: 120 days holding period										
Mean Return	4.57	15.93	20.07	0.60	-20.46	-38.58	-7.92	1.43	-6.50	1.10
Sharpe Ratio	0.043	0.100	0.099	0.003	-0.115	-0.304	-0.048	0.011	-0.068	0.014
α	-6.37	-3.93	7.08	-18.92	-32.07	-30.89	6.74	6.22	-0.93	21.01
t_{NW}	-0.236	-0.110	0.167	-0.454	-1.041	-1.677	0.225	0.251	-0.036	0.778
n	16	24	31	42	29	38	33	35	19	8

† Indicates that a 95% confidence interval for the mean constructed using 2,000 repetitions does not include the zero mean return. In CAPM, CRB index is used as r_m. α is the average excess returns, which is computed as $\alpha_{i,j} = r_{i,j} - E[r_j]$ where $r_{i,j}$ is the ith return for the jth option and $E[r_j]$ is as defined in (5). Asterisk (*) indicate significance at 5% level. t_J and t_{NW} refers respectively to the modified t-statistic Johnson (1978) and to the t-statistic computed with standard errors corrected for autocorrelation through the Newey-West procedure. Both statistics test the null hypothesis $H_0 : \alpha = 0$.

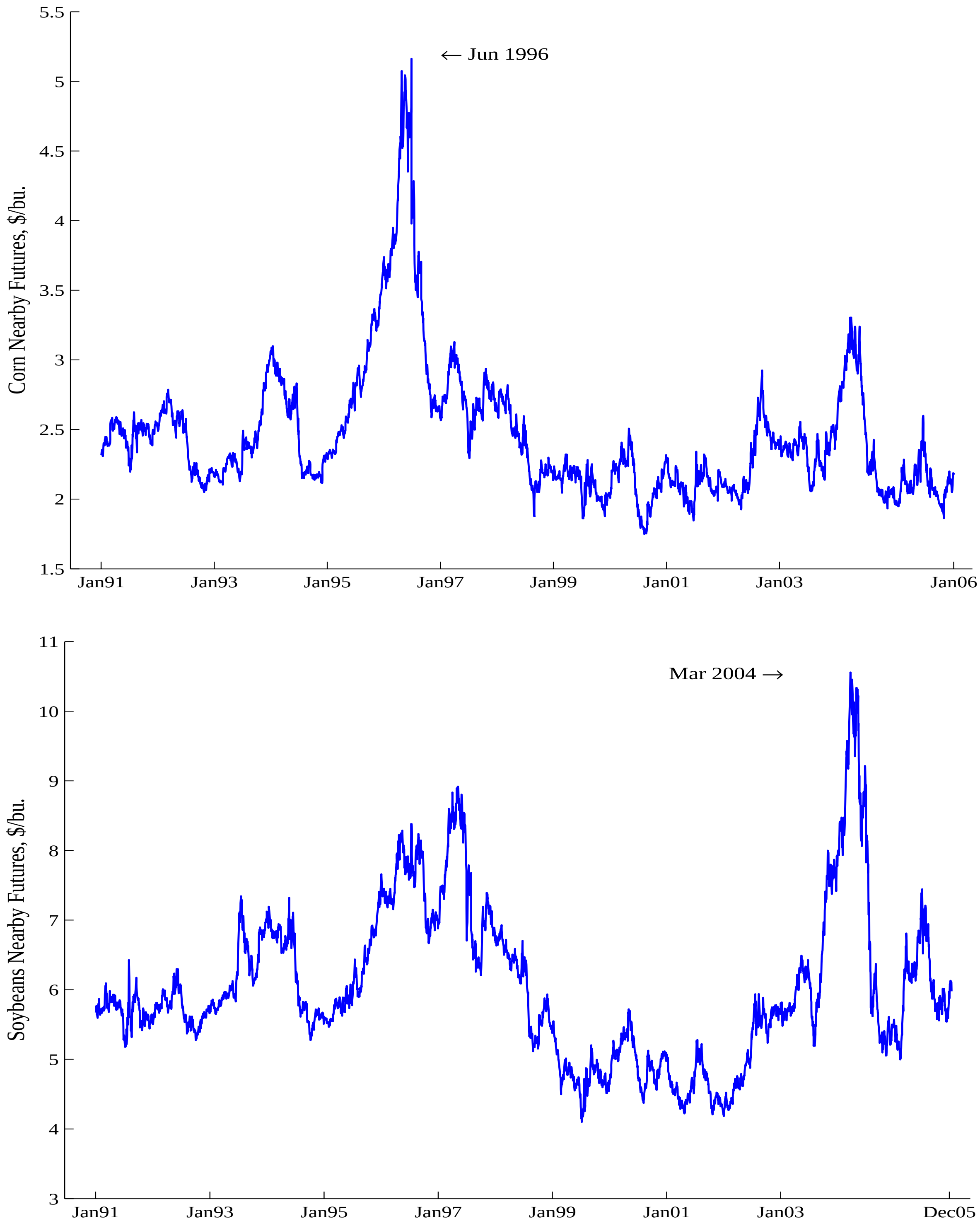

Figure 1: Corn and soybean nearby futures prices ($/bu.) from Jan 1991 to Dec 2005

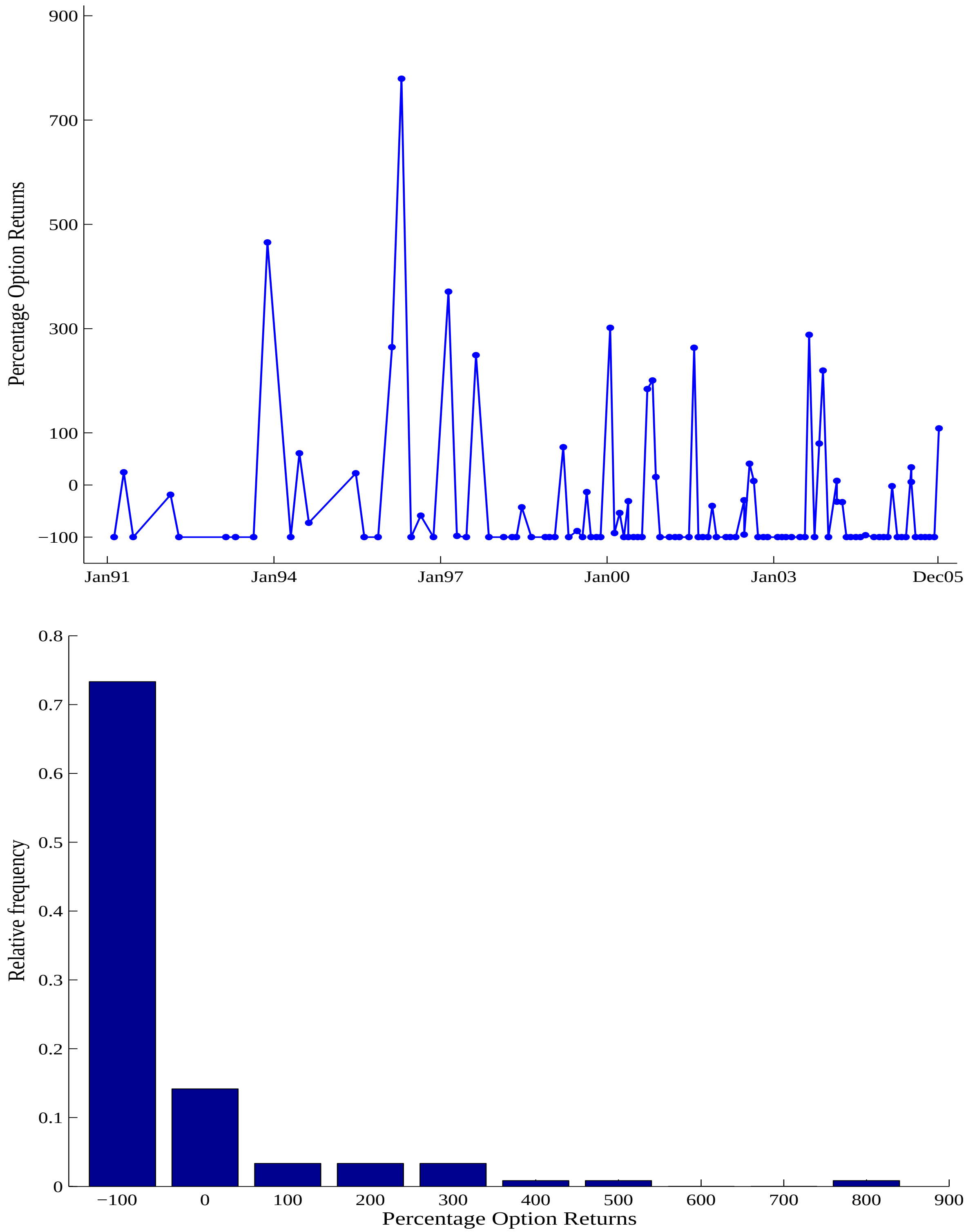

Figure 2: Percentage returns and histogram of returns for ATM corn calls with 30 day holding period from Jan–1991 to Dec–2005. 120 observations.

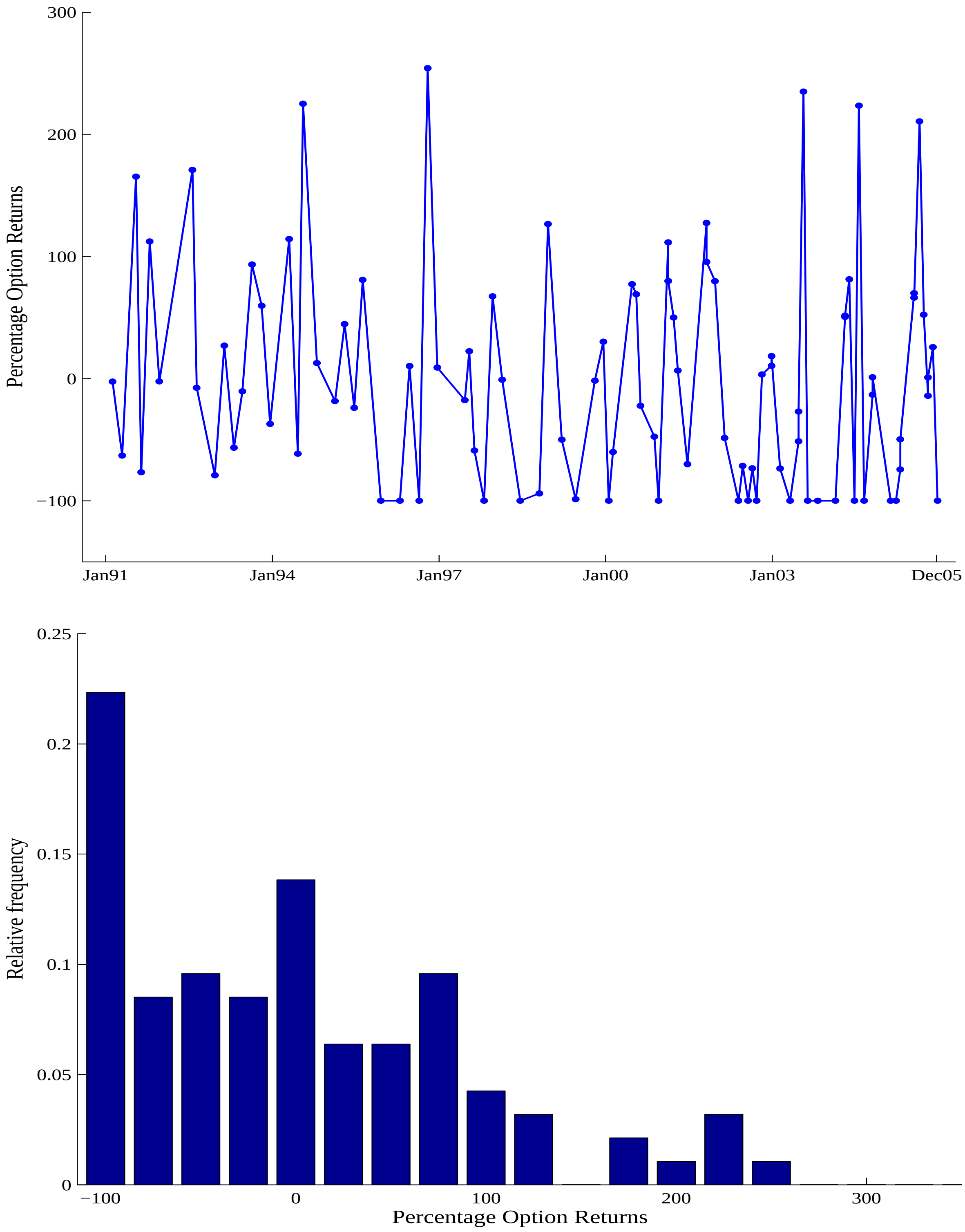

Figure 3: Percentage returns and histogram of returns for ITM soybean puts with 30 day holding period from Jan–1991 to Dec–2005. 94 observations.