Price Risk Management in White Corn Production

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Abstract: White corn garners a premium over commodity corn, but suffers from additional price risk and yield drag. Using a simple bootstrap procedure, this research considers whether white corn premiums compensate for yield drag and evaluates the relative merits of various pre-harvest marketing alternatives including contracts, cross hedges, and cash sales.

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White corn production in the United States has grown to 650,000 acres and continues an upward trend based the popularity of snack foods and increased trade with Mexico (Illinois Specialty Farm Products Fact Sheet).

Producers have been encouraged by higher premiums to supply more high quality white corn (Keeneth), but these premiums need not ensure profitability. First, the yield of white corn is usually less than that of yellow corn, and whether the white corn premium can offset revenue losses due to this "yield drag" is uncertain. A second concern is revenue variability due to white corn price fluctuations. Forward contracts establish white corn prices to a certain extent, but the net price received for these contracts is typically based on a formula that fixes the white corn premium and then adds it to a Chicago Board of Trade futures price. The futures price is not determined until after contract singing, usually just prior to harvest. As a result, a volatile component of the pricing formula is left to fluctuate. In addition, a recent survey suggests that only 60% of Indiana producers grow white corn under contract, the remainder rely on cash marketing (Pederson). It is hypothesized that these non-contract producers, or "wildcatters," face at least as much, if not more price volatility than contract producers.

The objectives of this study are three fold. The first objective establishes whether historical white corn premiums are sufficient to overcome white corn's yield drag. Second, the study examines the viability of cross hedging white corn price risk with No. 2 yellow corn futures contracts. Even if cross-hedging is viable, the gains from hedging may not be sufficient to justify it as a risk management procedure. Therefore, a third objective evaluates the merits of several price risk management strategies (e.g. cross hedging cash sales with futures contracts, combining forward contracts with futures contracts) and ranks these alternatives by mean, variance, and 5% Value-at-Risk. These research objectives are useful to white corn producers who market their corn, as well as toagribusiness managers who purchase white corn using any one of several marketing instruments. To the authors' knowledge, no previous studies have addressed these objectives in white corn production, although numerous studies exist that address risk management in yellow corn.

Tomek and Peterson provide an extensive literature review of risk management in agricultural markets finding many studies that examine hedging effectiveness, optimal marketing portfolios, and the performance of marketing strategies. The current study falls in the last category; its objectives are more concerned with the relative merits of white corn marketing strategies rather than optimal market positions. In this area of the literature, Wisner, Blue and Baldwin (1998) simulated returns to corn and soybean marketing alternatives for model farms in Iowa and Ohio. The statistically best performing alternatives reduced the net revenue coefficient of variation and increased mean returns relative to a cash sale at harvest. An increase in mean returns is contrary to the efficient market hypothesis (Fama, 1991), which the authors attribute to a pre-harvest price bias created by differences in perceived and probable yields as well as the costs associated with information acquisition and use.

In contrast to the previous study, Zulauf and Irwin found little empirical evidence that a price bias exists in pre-harvest futures markets, but suggest producers can benefit when using hedging strategies in conjunction with storage decisions. Zulauf et al. (2001) support this conclusion in an empirical study that examined cash flow risk for Ohio corn farms. Even though pre-harvest marketing netted greater returns than cash sales at harvest, the returns were not statistically significant and modest when viewed as a percentage change from the benchmark. Collins, Pritchett and Patrick investigate the impact that marketing alternatives and crop insurance products have on revenues for a corn and soybean farm in central Indiana using an historical, non parametric (i.e. bootstrap) procedure as is done in the current study. Results suggest that a combination of group insurance coverage and forward pricing may slightly increase mean revenues and significantly reduce downside risk.

As with the previously mentioned research, the current study evaluates returns to various marketing strategies, but model farm is set southwestern Indiana. The study's contribution is its emphasis on white corn revenues, examination of white corn premiums, and the evaluation of local cash contract marketing alternatives and futures cross hedges. Indeed, cross hedges with yellow corn futures contracts are one marketing alternative to be addressed in the current study, and its returns will be compared against a benchmark of a cash sale at harvest.

Empirical cross hedging studies for white corn do not exist, but research has considered cross hedges of other crops with yellow corn futures contracts. As an example, Witt, Schroeder and Hayenga evaluate sorghum and barley cross hedges while investigating three different analytical methods of determining the optimal hedge ratio. The authors find a price level linear regression is a suitable method for determining optimal cross hedge ratios for anticipatory (pre-harvest) market positions. Graff et al examine cross hedges of many agricultural commodities with futures contracts, and in particular, cross hedges of milo (sorghum) with corn futures contracts for several locations in Kansas. The authors use a price level linear regression suggesting a high R^2 and low root mean squared percentage error indicate an effective cross hedge.

The current study uses a price level, linear regression of local white corn cash prices on yellow corn futures prices to determine if sufficient correlation exists to create an effective pre-harvest cross hedge. The study then evaluates the cross hedge as one marketing alternative among a set of alternatives using a non-parametric, historical simulation of a white corn production enterprise in southern Indiana. Marketing alternatives are evaluated according to the moments of their respective net revenue distributions, and while it may be the case that cross hedges are deemed effective by simple linear regression, hedging costs, premium risk, and yield risk may render it ineffectual as a risk management tool.

Analytical Framework

Two decision periods exist in the analytical framework: a spring decision period and a harvest delivery period in the fall. In the spring, producers may choose to initiate a particular marketing strategy given that harvest prices and yields are unknown. In the second period, yields and harvest prices are realized and the crop is delivered to the contractor or sold in the cash market. Proceeds from the harvest cash sale, from positions taken in the futures market, or contract fulfillment are received at time of delivery. Four different marketing options are available to producers: a simple harvest cash sale, hedging a portion of the crop using yellow corn futures contracts (i.e. cross-hedging), signing a contract in the spring for a portion of the crop selling the remainder at harvest, and using a combination of a contract and cross-hedging.[1] The following subsections outline net returns from each marketing alternative and associated revenue risk. Net return equations used in the next subsection are the basis of the subsequent empirical procedure.

Harvest Cash Sale Net Returns

Proceeds from a harvest cash sale depend on the harvest price, white corn yield, the scale of operation and production costs:

$$(1) \quad \tilde{\pi} = \tilde{p}_1 \, \tilde{y} \, q - c(q)$$

where $\tilde{p}_1$ is the stochastic price for white corn and the subscript 1 indicates the harvest delivery period. The stochastic yield, $\tilde{y}$, is multiplied by a scale variable q to arrive at total white corn production. Costs of white corn production, $c(q)$, are the same regardless of the marketing method.

As noted by Li, purchasers quote white corn cash prices $(\tilde{p}_1)$ as a premium added to the daily Chicago Board of Trade settlement price for No 2. yellow corn futures contracts:

$$(2) \quad \tilde{p}_1 = \tilde{f}_1 + \tilde{b}_1$$

with $\tilde{f}_1$ as the stochastic futures price realized at harvest delivery and $\tilde{b}_1$ is the stochastic premium received at harvest. Similarly, local prices of yellow corn are determined as the sum of the yellow corn futures price and the local basis. Thus, one can treat the premium found in equation 2 as a basis, and its stochastic nature as basis risk. Therefore, equation (1) computes white corn net returns as a result of a harvest cash sale, which can be compared to the net returns from yellow corn cash sales. If white corn net returns exceed those of yellow corn, then the harvest premium has compensated for yield drag.

Net Returns of Cross-Hedging

Cross-hedging white corn cash positions with yellow corn futures contracts are an opportunity to manage white corn price risk. When cross-hedging, producers sell yellow corn futures contracts in the spring period, and offset the positions during the harvest period. A producer's net revenues while cross-hedging may be written as:

$$(3) \quad \tilde{\pi} \;=\; \tilde{p}_1 \tilde{y} q \;+\; \left(f_0 - \tilde{f}_1\right) h \;-\; c(q)$$

where f_0 is the delivery month's futures settlement price at the time the cross-hedge is initiated, a price known to the producer. The difference $f_0 - \tilde{f}_1$ represents the per unit returns to the cross hedge, and h is the quantity of yellow corn futures bushels used in the cross hedge.[2]

Equation 3 is a familiar representation of a producer's net returns when hedging in the presence of futures price risk, basis risk and yield risk. The ability of the cross hedge to mitigate revenue risk depends importantly on the relationship between white corn yields and the yellow corn futures price, as well as the relationship between white corn yields and white corn premiums. If the white corn yields were known with certainty (i.e. $\tilde{y} = y$), a full hedge $(h = y\,q)$ reduces (3) to:

$$(3a) \quad \tilde{\pi} \;=\; \left(f_0 + \tilde{b}_1\right) y\, q \;-\; c(q)$$

in which the only stochastic variable is the white corn premium b_1. Thus, cross hedges are tools for mitigating futures price risk, but leave premium risk unchecked.

Net Returns for White Corn Contracts

Producers may also sign cash contracts in the spring with local purchasers for the harvest delivery of their crop. As reported by Li, these contracts set the white corn premium in the spring (b_0), but allow the futures price to be determined at or a short time before delivery[3]. Net returns to contracting are written as:

$$(4)\quad \tilde{\pi} \;=\; \tilde{p}_1(\tilde{y}\,q - w) \;+\; \left(\tilde{f}_1 + b_0\right)w \;-\; c(q)$$

where $\left(\tilde{f}_1 + b_0\right)$ is the contract price per unit for the contract quantity w. The term $\tilde{p}_1\,(\tilde{y}\,q - w)$ is the revenue generated by white corn quantities in excess of the contract amount; should the contracted amount be less than actual production $(y\,q < w)$, producers still need to satisfy the contractual obligation by either purchasing the difference at the existing market price p_1, or by a simple cash settlement equal to the value of the shortfall. If the contracted amount is exactly equal to the actual production $(y\,q = w)$ equation (4) is reduced to:

$$(4a)\quad \tilde{\pi} \;=\; \left(\tilde{f}_1 + b_0\right)y\,q \;-\; c(q)$$

with the premium risk eliminated and the futures price serving as the only stochastic element.

Returns to a Combination Strategy

In an effort to mitigate both futures price risk and premium risk, producers might choose to use a white corn contract in conjunction with a cross hedge. Returns to this combination are expressed as:

$$(5)\quad \tilde{\pi} \;=\; \tilde{p}_1\,(\tilde{y}\,q - w) \;+\; \left(f_o - \tilde{f}_1\right)h \;+\; \left(f_1 + b_0\right)w \;-\; c\,(q)\quad .$$

Assuming that the cross hedged quantity and the contracted quantity are the same (i.e. $h = w$)[4] and using the white corn cash price equation (2), equation (5) is simplified to:

$$(5a)\quad \tilde{\pi} \;=\; \tilde{p}_1\,\tilde{y}\,q \;+\; \left\{\left(f_0 - \tilde{f}_1\right) + \left(b_0 - \tilde{b}_1\right)\right\}w \;-\; c\,(q)$$

where the term $\left(f_0 - \tilde{f}_1\right)$ is the per unit return to hedging, while the term $\left(b_0 - \tilde{b}_1\right)$ represents the difference between white corn premiums quoted in the spring and stochastic premiums in the Fall. In the special case in which actual production equals the contracted amount, $(5a)$ is reduced to:

$$(5c) \quad \pi = (f_0 + b_0)w - c(q)$$

As illustrated by $(5c)$, the combination of a white corn contract and cross hedge mitigates both futures price risk and premium risk in the spring decision period. Of course, yield risk remains with this, as well as all, marketing alternatives, and has not been represented in the special case (equation 5c).

Equations (1), (3), (4) and (5) demonstrate white corn production profits using various marketing alternatives. In sum, a harvest cash sale bears yield risk, futures price risk and premium risk (equation 1). Cross-hedging mitigates futures price risk, but premium risk and yield risk remain unchecked (equation 3). Use of white corn contracts mitigates premium risk leaving yield risk and futures price risk (equation 4), while the combination strategy represents a means of addressing both futures price and premium risk (equation 5). The objective of this research is to compare the relative merits of each marketing alternative, so equations (1), (3), (4) and (5) will be used to compute each alternative's historical net return distribution using a bootstrap simulation procedure. Alternatives may then be compared according to several criteria including mean/variance efficiency, stochastic dominance and Value at Risk. In addition, a net return distribution for No. 2 yellow corn is simulated in order to determine if white corn premiums have historically compensated for the yield drag associated with white corn production.[5]

Bootstrap Procedure and Data

The representative white corn enterprise is located in Warrick County, Indiana, and is comprised of 1,000 acres.[6] A bootstrap simulation procedure is used to generate the net return for each marketing alternative based on equations (1), (3), (4) and (5). The specific marketing alternatives are listed in Table 1, and these alternatives represent three different contract amounts (33%, 66%, 100% of expected production) as well as two different initiation dates (March 15th, May 15th). Table 1 lists 20 different marketing alternatives in total including benchmarks of a white corn and yellow corn cash sale at harvest. Stochastic variables in the model include an historical year generator, white corn yields, and yellow corn yields.

A model iteration begins when an historical year is chosen at random from the set 1986 - 2000. Once the year is selected, that year's white corn yield and yellow corn yield are randomly generated using a process described below. The historical year's white corn cash price, yellow corn cash price, and yellow corn futures prices are then drawn from a data set. Net returns for each marketing alternative are computed, and the model is iterated one thousand times. Each iteration's net return is collected to form a net return distribution

Raw data for white corn and yellow corn yields are taken from plot trials in Warrick County, Indiana during the years 1986-2000[7]. The Warrick County corn trials are organized by the Purdue University Cooperative Extension Service for the comparison of commercial corn hybrids, which are planted by a local farming operation. In any given year, roughly 50 white corn hybrids and 100 yellow corn hybrids are planted and harvested. For the purpose of random variable generation, the mean yield of each year is computed and the individual hybrid's yields are subtracted from the mean. The remainder is an error that is then converted to a percent error. Each percent error is assigned an equal probability, and these errors form an empirical distribution.

Once the historical year is chosen during a model iteration, that year's mean white corn and yellow corn yields are selected from the data. Next, one of the percent errors is drawn from the distribution and added to the mean. The sum becomes the iteration's yield.

Cash price data are gathered from the *Grain and Feed Market News* published by USDA's Agricultural Marketing Service. The data are simple averages of monthly closing bid prices by country elevators in Kentucky[8]. It is assumed that all of the cash grain is marketed in November.

Chicago Board of Trade (CBOT) December corn prices are collected at three selected dates for each year over the 1986-2000 time period. The dates include an early spring futures contract price (March 15), a later spring futures contract price (May 15), and a harvest time futures price (November 15)[9]. Applicable commission and brokerage service fees were assumed to reflect current conditions. A 7.5% margin requirement was assumed for a producer's hedging account. For most brokerage services, margin accounts do not collect interest, thereby the producer must sacrifice interest for the period of time the hedge was active. The annual interest rate charged to margin accounts was assumed to be 9% in this model.

When hedging with futures contracts, a producer does not know the quantity that will be produced in the upcoming fall, but on March 15 he/she must decide how many contracts to enter. Cross hedges and cash contracts are assumed to be 33%, 66%, or

100% of expected production. For modeling purposes, the expected yield is a moving average of the previous three years' production levels. If total production exceeds the contracted amount, the remainder is sold on the cash market; if grain is over-contracted (production is less than the contracted amount), then additional bushels are purchased at harvest prices to fulfill the contract.

White corn contract bid prices were unavailable for this study. In order to approximate the premiums, the current year's premium quoted in the spring (either March 15th or May 15th) is the moving average of the fall premiums for the previous three years. Under this assumption, white corn buyers naively set spring premiums equal to past history without the benefit of price forecasts, and there is no advantage to contracting on March 15th vs. May 15th. A sensitivity analysis in the results section explores the ramifications of this assumption.

Net revenues are calculated for the 20 marketing alternatives using the procedure and data described above. Each iteration's net revenue is collected, and 1000 model iterations result in a distribution of net revenues that may be compared using several criteria. The next section reports the results of the comparison, first comparing white corn cash sales to yellow corn cash sales, and then a comparison of marketing alternatives versus the white corn cash sale benchmark.

Results

White Corn Yield Drag and Premiums

An objective is to determine whether white corn premiums have historically compensated for lesser yields relative to traditional yellow corn production. To this end, net returns from a harvest cash sale of yellow corn are subtracted from white corn net returns in each model iteration. A negative difference indicates yellow corn is more profitable than white corn, a positive difference indicates the opposite. Each iteration's difference is collected, and the collection is sorted to form the cumulative distribution function found in Figure 1.

Values of the net return difference in Figure 1 range from -$156.92 per acre to $255.84 per acre with a mean of $37.23 per acre. Negative net return differences occur 25% of the time; that is, yellow corn net returns exceed white corn net returns in 25% of the bootstrap simulations. Consequently, the white corn premium compensates for yield drag in 75% of model simulations.

White Corn Price Level Regression

A simple price level regression of the white corn cash price on the yellow corn futures contract price for the harvest date is used to determine if the sufficient correlation exists to warrant cross hedging:

$$(6)\quad \underset{}{WC_t} = \underset{(1.09)}{-0.54} + \underset{(0.48)}{1.46}\, FC_t \,.$$

In equation (6), *WC* is the white corn cash price, and *FC* the futures price. Standard errors appear in parenthesis below regression coefficients. The R^2 for equation (6) is 0.53 indicating some correlation exists between the variables, while the root mean squared percent error percent (RMSPE) is 0.41. The RMSPE is a measure of dispersion that the actual cash price has around the expected futures price; thus we conclude that using equation (6) means the actual cash price will be within 41% of the futures price 68% percent of the time. Regression results suggest some correlation exists between the white corn cash price and yellow corn futures price, but sufficient variation exists such that cross hedging may actually be more risky relative to other marketing alternatives whose results are described in the next section

Comparing White Corn Marketing Alternatives

The final objective is to compare marketing alternatives found in Table 1 according to mean, variance and 5% Value-at-Risk. Strategies will be compared to each of these criteria in turn, and full results are enumerated in Table 2.

A desirable marketing alternative decreases risk and increases net returns relative to the benchmark. A risk-return tradeoff is expected however; that is, if a strategy transfers white corn price risk to another party (i.e. the futures market or a local purchaser via cash contract) then the other party should receive compensation and net returns to the producer will fall. Thus, marketing alternatives that reduce risk should suffer from lower net returns relative to the harvest benchmark.

The mean and standard deviation of net returns distributions are used as the measure of risk and return for the marketing alternatives considered in the current study and are summarized in Figure 2. The origin of the scatter plot in Figure 2 is the mean net return and standard deviation of the benchmark, of a harvest cash sale of white corn ($231.28 per acre and $95.03 per acre respectively). The mean and standard deviation of other marketing alternatives are plotted with respect to the benchmark, and each marketing alternative's code is found next to that point. A list of codes is provided in Table 2.

Using Figure 2, there are six strategies that generate net greater returns than the benchmark, and at the same time reduce the standard deviation of returns. These alternatives include all of the options positions (O100, O66, O33), and the contract alternatives (CE100, CE66, CE33). The mean net return of each of these alternatives, an indeed all of the strategies, is statistically different than that of the benchmark at the 95% confidence level.

Contracts (CE100, CE66, CE33) tend to reduce risk by locking in white corn cash premiums earlier rather than waiting until harvest. Notably, the contract alternatives increase net returns and reduce their standard deviation relative to the cash sale at harvest, even when a contract is signed for an amount equal to one hundred percent of expected production.[10]

It is more difficult to explain the performance of option alternatives. Options have the advantage of fixing a price floor at the nearest at-the-money strike price, but allow the producer to take advantage of price increases unlike futures hedges. The cost of the option is its premium, and the option premium varies according to its intrinsic value and time value. The volatility of the market influences the option's time value, increased volatility leads to greater time value and larger option premiums. Thus, while an option can set a price floor and allow traders to capture gains from price increases, option premiums tend to reduce overall net returns in the face of greater volatility. Interestingly, white corn prices are much more volatile than yellow corn futures prices, but the yellow corn option price does not reflect white corn's price volatility. As a result, the yellow corn options are relatively cheap for the cross-hedge, and this may explain why the option alternatives perform well in the bootstrap simulation.

Unlike the previously mentioned alternatives in the upper left quadrant of Figure 2, there are strategies that decrease returns and increase risk, and these are plotted in the lower right-hand quadrant. All of the futures hedging strategies fall into this category

(WHE100, WHE66, WHE33 and WHL100, WHL66, WHL33), suggesting that fixing the futures price does not sufficiently reduce overall revenue volatility, and that the opportunity cost of the cross-hedges (an inability to take advantage of higher prices) outweighs its benefits. In addition, a contract and cross hedge combination alternative for 100% of expected production (CML100, CME100) also tends to reduce returns and increase risk relative to the benchmark.

As mentioned previously, a risk-return tradeoff is hypothesized so that alternatives that decrease the variability of returns will also decrease mean net returns. The tradeoff is true for the alternatives that appear in the lower left quadrant of Figure 2. All of these alternatives are contract-cross hedge combinations (CML 33, CML 66, CME 33,CME 66) with the exception of the yellow corn harvest cash sale (YC).

Figure 2 provides a broad illustration of the risk and returns that marketing alternatives have relative to the cash sale at harvest benchmark. However, producers are often concerned with the likelihood that they may face a year with poor net returns. This concern is addressed when the simulated net return distributions are evaluated using Value-at-Risk in the next section.

5% Value-at-Risk Analysis

Value-at-Risk (VaR) analysis can be used to evaluate the downside risk potential of various marketing alternatives. VaR is a financial measure that focuses specifically on the lower tail of a distribution of net returns. Increasingly popular in the finance literature, researchers have recently used VaR for agricultural applications[11]. The top ten marketing alternatives, as ranked by 5% VaR, are shown in Figure 3.

In Figure 3, the light cross-hatched bars are the 5% VaR level of the marketing alternative expressed as a percentage of the benchmark. The mean net returns of each alternative are the darker bar found directly below an alternative's VaR bar. Those alternatives with the greatest 5% VaR levels are found at the bottom of the chart.

As illustrated by Figure 3, seven strategies have higher 5% VaR levels than the benchmark, three of which are options alternatives, three are contract alternatives, and one is a combination of a futures cross-hedge and contract. Options strategies perform the best in terms of 5% VaR, with the Options Hedge 100 alternative having a 5% VaR that is 143% of the benchmark strategy. More specifically, the options strategy has a 5% VaR of $118.80 per acre (see Table 2) meaning there is a 5% chance this alternative will lose $118.80 per acre in any given simulation. Stated differently, this strategy has a 95% chance of netting more than $188.80 per acre. The benchmark strategy has a 5% VaR of only $83.09, a difference of nearly $50 per acre. Producers would generally favor the option strategy over the white corn cash sale at harvest especially given the options strategies do not reduce, but rather improve, mean net returns. In a similar vein, the contract strategy is preferred to the cash sale at harvest if the focus is downside risk; the contracts fix white corn premiums, a volatile component of white corn prices. Recalling that the white corn premium is assumed, a sensitivity analysis is performed. Reducing the premiums by a standard deviation does not change the 5% VaR ranking of contract alternatives relative to the benchmark, but does reduce its mean net returns as discussed in endnote 11.

Conclusions and Caveats

White corn production may generate additional revenues for producers beyond commodity corn production, but additional risks should be recognized. The current study examines two sources of risk in white corn revenues relative to commodity corn (i.e., premium risks and yield drag), and examines the relative merits of marketing alternatives that might be used to overcome these risks.

A bootstrap simulation procedure is used to determine the net revenue difference between harvest cash sales of white corn and yellow corn. Computing the difference is one method for determining if the additional premium paid to white corn overcomes its yield drag relative to yellow corn varieties. In 75% of the simulations, the net revenue generated by white corn was higher than that of yellow corn suggesting that premiums generally overcome the loss in yield drag.

The same bootstrap procedure computes the net returns to various marketing alternatives including futures cross-hedges, cash forward contracts, combinations of futures cross-hedges and contracts, and options cross-hedges. Options cross-hedges outperform the benchmark and all other alternatives in terms of mean net returns and 5% Value-at-Risk. Perhaps the options strategies perform well because the premium paid for options does not fully reflect the risk of white corn production, as well as the fact that option strategies tend to set price floors but allow for upside potential. This matter can be addressed in future research, perhaps by computing hypothetical premiums for white corn options and comparing them to historical values of yellow corn options. Cross-hedges using yellow corn futures contracts consistently perform poorly in terms of mean net returns and 5% VaR relative to the benchmark. Poor performance may be largely due to insufficient correlation between white corn cash prices and yellow corn futures prices, the volatility of white corn premiums, and the opportunity cost of futures contract cross-hedges.

The current study is a beginning point; further research may address some of this study's limitations. A weakness of the current study is its use of a bootstrap simulation procedure to approximate the historical correlations between white corn yields, white corn prices and yellow corn yields. Obviously, results of this study are most relevant to past history, and are reliable to the extent that future relationships between prices and yields is similar to the past. The bootstrap procedure is used primarily due to the expense and difficulty of acquiring data for a structural econometric model that might be used to generate relevant price data. It is unknown how or if a structural model would improve the accuracy of the results given a reliance on historical data.

In addition, the current study's use of local yields limit how conclusions might be generalized to other areas such as the western Corn Belt. The use of southwest Indiana data does, however, give an more accurate portrayal of farm level risk, which would be lost if an aggregate model were used. The model is particularly relevant to white corn production in the eastern Corn Belt, which is a major white corn production area.

An interesting research extension might consider storage returns of post harvest marketing alternatives. In post harvest period, yellow corn futures prices tend to increase overt time to compensate for storage costs, and there is less variability in futures prices. At the same time, the white corn market becomes focused on international production, especially South African production, and white corn prices may be more volatile.

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[1] Analysis of another alternative, hedging with options, is found in Li (2001). Additionally, analysis is focused primarily on pre-harvest hedging; Li has also examined post-harvest strategies.

[2] Equation (3) omits explicit consideration of hedging costs such as brokerage fees and the opportunity cost of margin deposits. However these costs may be considered a reduction in the per unit return to hedging, and the costs are included in the empirical procedure.

[3] White corn forward contracts are very similar to basis contracts used to market yellow corn.

[4] A naïve assumption but is useful in the empirical analysis when comparing various market alternatives (explain this better). An optimal approach would maximize (5) within in an expected utility framework choosing both the quantity hedged and the quantity contracted. However, the purpose of this research is not to select an optimal hedging portfolio, but rather to demonstrate the potential risk reduction effects of various marketing alternatives.

[5] The net return for yellow corn is calculated using equation (1), with $\tilde{p}_1$ as the yellow corn cash price, (this cash price is the sum of the yellow corn futures price and the local yellow corn basis $(\tilde{f}_1 + \tilde{b}_1)$, and y is the yellow corn yield. The scale of production q is held constant for both yellow corn and white corn, but yellow corn costs of production $c(q)$ replace white corn costs of production.

[6] Warrick County is located in southwest Indiana, a region of the state in which white corn production is prevalent. Southwest Indiana has many barge locations along the Ohio River that allow access to international and domestic markets as well as local white corn processors.

[7] Weather problems prevented harvest in 1997, so this year is omitted from the dataset and from model iterations. Specifically, rain at planting eliminated corn stands and the plot committee does not have the ability to replant.

[8] Kentucky cash price bids are the nearest geographic substitute for southwestern Indiana cash price bids. Southwestern Indiana cash price bids are not publicly available, but are closely tied to the Kentucky prices that also include elevator bids along the Ohio River.

[9] If the March 15th futures price did not occur on a Wednesday, then the closest Wednesday settlement price was selected.

[10] Recall that option premiums were unavailable for the current study, so contract premiums were set as the moving average of the previous three years. To determine the limitations of these assumptions, a sensitivity analysis was performed in which premiums were reduced by a standard deviation, or $0.22 per bushel. The change reduced the mean net returns of the contract alternatives, but did not influence the standard deviation of net returns. All of the contract alternatives are shifted into the lower-left hand quadrant of

Figure 2, with the larger contract amounts (i.e. 100% of expected production) shifter further than the smaller contracted amounts.

[11] For a review of VaR applications in agriculture see Manfredo and Leuthold (1999).

Table 1. Marketing alternatives used in bootstrap simulation.

Marketing Alternative	**Quantity Hedged (% of expected production)**	**Quantity Contracted (% of expected production)**	**Initiation Date**
Benchmarks[a]	N/A	N/A	N/A
Cross Hedge Early	33%, 66%, 100%	N/A	March 15th
Cross Hedge Late	33%, 66%, 100%	N/A	May 15th
Options Hedge Early	33%, 66%, 100%	N/A	March 15th
Contract Early	N/A	33%, 66%, 100%	March 15th
Contract Late	N/A	33%, 66%, 100%	May 15th
Combination Early	33%, 66%, 100%	33%, 66%, 100%	March 15th
Combination Late	33%, 66%, 100%	33%, 66%, 100%	May 15th

[a]A cash sale at harvest for white corn and yellow corn, all production marketed Nov. 15th.

Figure 1. Difference in Net Returns - White Corn Minus Yellow Corn
Cumulative Distribution Function

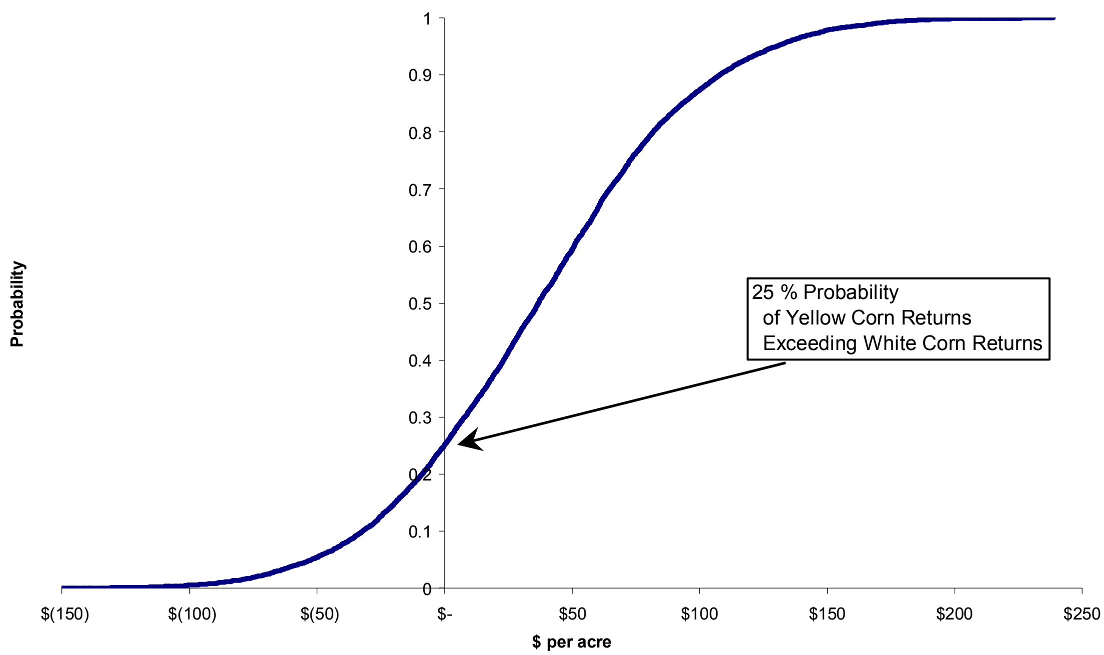

Table 2. Selected Summary Statistics of the Net Return Distributions for Various Marketing Alternatives.

Strategy Name	Code	Mean	St. Dev.	5% VaR	Mean % of WC	St. Dev. as % of WC	5% VaR as % of WC
Yellow Corn Cash Sales	YC	$ 194.06	$ 76.00	$ 82.07	84%	80%	99%
White Corn Cash Sales	WC	$ 231.29	$ 95.03	$ 83.09	100%	100%	100%
White Hedge 33% March	WHE33	$ 216.60	$ 100.60	$ 57.99	94%	106%	70%
White Hedge 66% March	WHE66	$ 201.87	$ 108.72	$ 35.38	87%	114%	43%
White Hedge 100% March	WHE100	$ 186.75	$ 119.14	$ 8.81	81%	125%	11%
White Hedge 33% June	WHL33	$ 218.43	$ 96.57	$ 67.42	94%	102%	81%
White Hedge 66% June	WHL66	$ 205.53	$ 101.01	$ 50.69	89%	106%	61%
White Hedge 100% June	WH100	$ 192.30	$ 108.18	$ 34.45	83%	114%	41%
Contract 33% March	CE33	$ 235.20	$ 83.47	$ 103.42	102%	88%	124%
Contract 66% March	CE66	$ 239.12	$ 78.39	$ 109.84	103%	82%	132%
Contract 100% March	CE100	$ 243.15	$ 81.21	$ 107.49	105%	85%	129%
Combination 33% March	CME33	$ 220.51	$ 88.55	$ 77.70	95%	93%	94%
Combination 66% March	CME66	$ 209.71	$ 89.86	$ 58.55	91%	95%	70%
Combination 100% March	CME100	$ 198.62	$ 98.93	$ 30.72	86%	104%	37%
Combination 33% June	CML33	$ 222.34	$ 85.28	$ 83.93	96%	90%	101%
Combination 66% June	CML66	$ 213.37	$ 85.79	$ 67.00	92%	90%	81%
Combination 100% June	CML100	$ 204.16	$ 96.79	$ 41.67	88%	102%	50%
Options Hedge 33%	O33	$ 236.36	$ 89.89	$ 95.41	102%	95%	115%
Options Hedge 66%	O66	$ 241.79	$ 85.46	$ 107.71	105%	90%	130%
Options Hedge 100%	O100	$ 246.91	$ 82.22	$ 118.80	107%	87%	143%

Figure 2. Mean and Standard Deviation of White Corn Marketing Alternatives

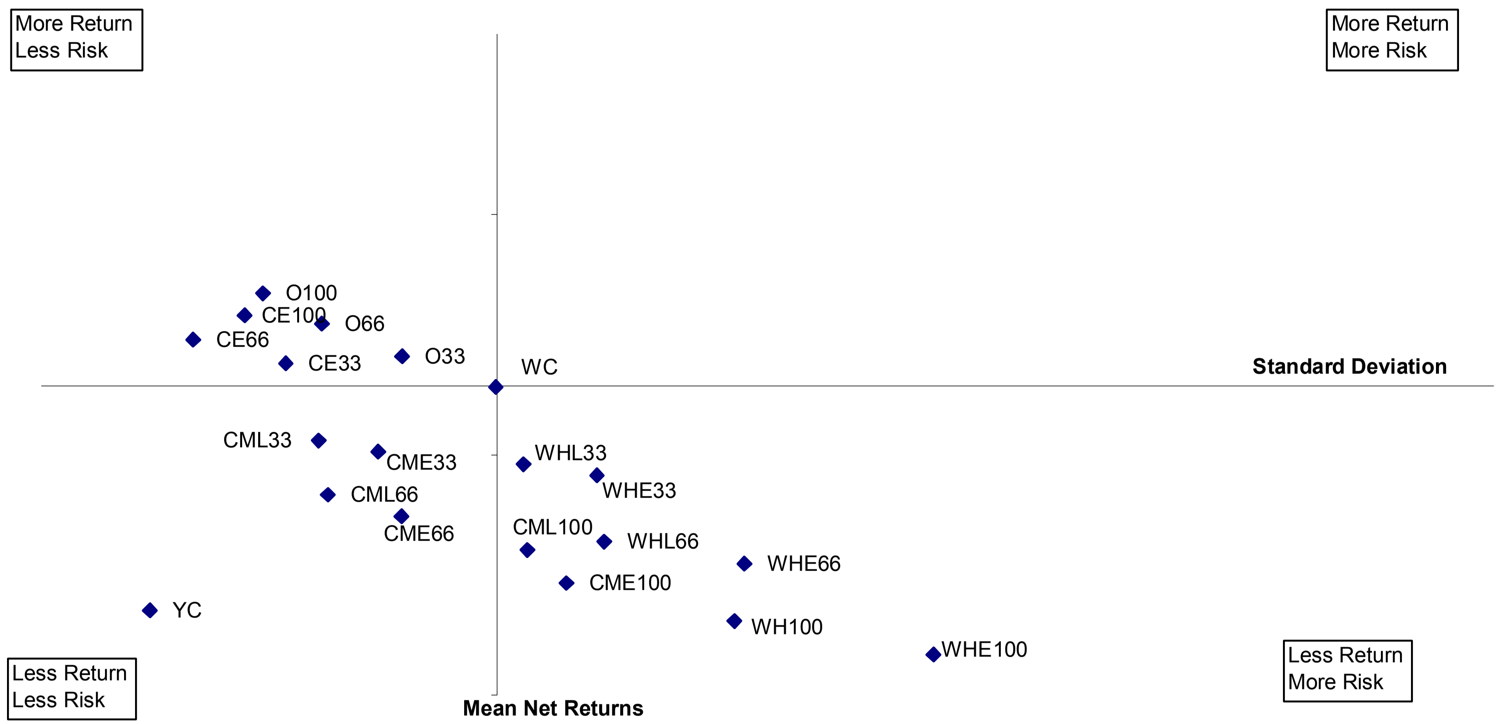

Figure 3. Mean Net Return and 5% VaR vs Benchmark
Top 10 Alternatives by 5% VaR Ranking