OPTIMAL HEDGING STRATEGIES FOR EARLY-PLANTED SOYBEANS IN THE SOUTH

James H. Sayle
Department of Agricultural Economics
Mississippi State University
Mississippi State MS 39762
email: jhs49@msstate.edu

Dr. John Anderson
Department of Agricultural Economics
Mississippi State University
Mississippi State MS 39762
email: anderson@msstate.edu

Dr. Keith Coble
Department of Agricultural Economics
Mississippi State University
Mississippi State MS 39762
email: coble@msstate.edu

Dr. Darren Hudson
Department of Agricultural Economics
Mississippi State University
Mississippi State MS 39762
email: hudson@msstate.edu

June 1, 2006

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach CA, July 23-26, 2006.

Optimal Hedging Strategies for Early-Planted Soybeans in the South

James Sayle, Dr. John Anderson, Dr. Keith Coble, and Dr. Darren Hudson

Abstract

Soybean production in the South has evolved over recent years from conventional soybean production systems (CSPS) in which soybeans are planted after May 1st to early soybean production systems (ESPS) in which soybeans are planted as early as mid-March. The shift was aided by the advent of herbicide-tolerant genetically modified soybeans and a shift toward minimum or no-till seedbed preparation. The ESPS provide an advantage over the CSPS by allowing the crop to surpass critical growth stages before encountering significant environmental, pest, or disease pressure. The CSPS harvest date only allows for hedging on the November contract, but the ESPS harvest date is generally before September, allowing the producer to hedge on the September contract. Little research has been completed to study the optimal hedge ratios of ESPS. The model presented in this paper will be used to determine the optimal hedge ratios for ESPS and CSPS while accounting for production risk and transaction cost.

Keywords

Conventional soybean production system, early soybean production system, hedge ratios, production risk, transactions cost.

Introduction

Soybean production practices in the southern United States have evolved over recent years to accommodate earlier planting and harvesting. Traditionally soybean production has included tillage and the use of numerous herbicides to control weeds. The introduction of genetically modified (GM) soybeans revolutionized soybean production. Herbicide-tolerant GM varieties allow the producer to utilize one chemical (*Glysophate)* to control weed pests. *Glysophate* is a non-selective herbicide that allows the producer to manage all weeds in the crop without damaging the crop. It does not need to be incorporated into the soil, which reduces possible erosion, and it is not as toxic to wildlife as other commonly used herbicides. The producer can eliminate any pre-planting tillage required to incorporate chemicals, which allows for reduced or no-till seedbeds. The reduction in tillage makes the seedbed more firm allowing earlier planting than in tilled fields.

The availability of earlier planting gives Southern soybean producers several advantages. Soil moisture is typically better in the early spring than closer to the summer months allowing for better planting conditions. The seasonal precipitation in the spring reduces the amount of irrigation required, reducing costs. The most significant benefit from early planting is that the soybean crop surpasses critical growth stages before harmful environmental or pest conditions arise. Dry summer conditions in the South can significantly reduce soybean yields especially on non-irrigated cropland. ESPS are much farther along than CSPS when the driest conditions occur. Typically insect and disease pressure reaches treatment levels at certain times of the year. The ESPS are less susceptible to yield reducing damage than CSPS since the ESPS are farther along in growth stages than CSPS. Heatherly describes the effects of late maturing soybeans very well. “Planting late maturing cultivars results in later reproductive development and increases the risk of detrimental late-season effects on grain yield from insect pests and drought, and also provides opportunity for late-season foliar and seed disease development”(Heatherly). The discovery of Asian Soybean Rust (ASR) has increased the attractiveness of ESPS. The ESPS are more likely to be past critical growth stages, when the crop is most susceptible to damage, when the conditions are most favorable for ASR. The ESPS are less susceptible to yield-reducing damage during the crop year than CSPS. The ESPS yields should be equal to or higher and less variable than CSPS yields. The less volatile ESPS yields could promote higher hedge ratios on the September contract than CSPS hedge ratios on the November contract.

One issue that has not yet been investigated is how earlier planted soybeans could affect soybean marketing strategies. Soybean production in the South has historically been dominated by CSPS, but the advent of GM soybeans and conservation tillage practices has brought on increased ESPS. The CSPS in the south limit the harvest date to no earlier than late September. Soybean producers have historically priced their crop (either through forward contracting or hedging) on the CBOT’s November soybean contract. However, with ESPS soybeans are now being harvested in August. Soybean producers in the South now have the opportunity to price their crops on the September contract rather than the November contract. Little research has been done to investigate how the optimal pricing strategies may differ between the November (new crop) and September (old crop) contracts. The September contact could be more favorable to hedge on due to it’s containing the old crop versus the November contract which contains the new crop. Crop surpluses are depleted throughout the year reaching their lowest point prior to the new crop being harvested. The lower surpluses generally create higher prices due to low supplies. Once the harvest is completed surpluses are high creating downward pressure on prices.

This study is only applicable for regions that are capable of utilizing ESPS. The southern region of soybean production can loosely be defined as all soybean production south of the boot heel of Missouri. This region typically has a more temperate growing season and warmer temperatures in the spring, than the more northern regions of soybean production in the United States. The differences and benefits of ESPS versus CSPS are most apparent in the south.

Previous research has estimated hedge ratios using the well documented minimum variance hedge ratio method. The minimum variance hedge ratio makes certain assumptions that will be relaxed in this research. Production risk is not accounted for in standard minimum variance hedge ratios. Production risk is a key variable influencing the outcome of a hedge and could influence a producer’s optimal hedging strategy. If the producer has less production risk then a less variable yield can be assumed. When the yield is less variable then the producer can hedge a larger portion of the expected crop. The most basic benefit of hedging is reducing price risk. The more expected yield the producer can hedge the less price risk he will have to assume. ESPS should involve less production risk since the crop passes critical growth stages earlier than CSPS. In this study utility maximizing hedge ratios will be estimated to capture the impact of production risk on the optimal strategy.

The objectives of this study are to determine the differences in optimal soybean marketing strategies between ESPS and CSPS. Hedging on the September contract may be a possibility for producers using ESPS, but the effectiveness of this strategy has not been investigated. The use of ESPS is hypothesized to result in less variable yields promoting higher hedge ratios, ceteris paribus, using either the September contract or the November contract. The study also hypothesizes that ESPS yields will be equal to or higher than CSPS yields due to more favorable growing season conditions. Soybean producers in the South will benefit from this research by having a better understanding of soybean marketing strategies focusing on the differences between ESPS and CSPS. This research will not focus on general prices, but on specific net price received and risk mitigation.

Literature Review

Hedging crops is an attractive way for producers to manage their price risk in production agriculture. Kahl sums up traditional literature on commodity futures markets by defining a hedge as, “A futures market position which is equal but opposite to the individual’s cash market position” (Kahl, 603). This equal but opposite relationship protects the producer from adverse price changes, assuming that cash and futures prices are fairly closely correlated. Hedge ratio estimation is a topic that numerous researchers have studied. The various authors utilize a multitude of assumptions and methods in their research. Myers and Thompson generally disagree with the simple regression method of obtaining a slope coefficient from spot price levels on futures price levels, except under certain restrictive assumptions. They develop a generalized approach to relax some of the more restrictive assumptions of other models, their method does not account for production risk. Viswanath offers a further refinement of Myers and Thompson’s generalized model that accounts for the possibility of spot-futures convergence and the dependence of the hedge ratio on hedge duration and the time left to maturity” (Viswanath, 44). Cecchetti disagreed with fundamental assumptions that are made in much of the previous literature noting specifically the assumed objective of risk minimization rather than utility maximization.

Lapan, Moschini, and Hanson modify previous hedge ratio estimation models by incorporating futures market contract options and expected utility framework. Their paper integrates production and marketing decisions by modeling the simultaneous choice of production and hedging levels using the general expected utility model. The sub-optimal nature of a hedging strategy based on the risk minimizing hedge ratio has also been used by Lence.

Soybean production has generally been hedged on the November contract due to the harvest date, but with earlier planting and earlier maturing varieties, hedging on a September contract has become a viable option. The different planting dates change the production risk as described previously. Estimating optimal hedge ratios between two fundamentally different crop production systems with out accounting for production risk would remove valuable information regarding the hedge ratios. Similar to Lapan, Moschini, and Hanson, this paper will use the expected utility framework to consider the impact of production risk on the optimal hedging strategy. This approach is consistent with the recommendations of Davis and Patrick, who advocate an investigation of price and production risk interactions in order to calculate the risk management decisions of producers. Davis and Patrick's paper calls for an analysis of this type, "The interrelationship between price risk and production risk needs to be explored in order to better understand how producers make risk management decisions" (Davis & Patrick, 15).

Data and Methods

Soybean yield data for this study were collected from soybean research trials conducted in Washington County, Mississippi by USDA-ARS. The data set spans a period from 1976 to 2003, but this study will only use the data from 1994 to 2003. The data earlier than 1994 is not representative of current yields and production practices in the Mid-South region. A total of 172 field experiments on or in close proximity to the Delta Research and Extension Center in Stoneville, MS are included in the data set. These field experiments include irrigated and non-irrigated experimental plots on Sharkey clay soil. The data set includes relevant observations of irrigated and non-irrigated yield measurements as well as planting date. The price data for this study can be divided in two sets. One set will focus on ESPS and includes the mid-April and end of August price on the September and November soybean futures contract as well as the August cash soybean price received by farmers. The set relating to CSPS will include the mid-May and ending October soybean price on the November soybean contract as well as the October cash soybean price received by farmers. Futures price data were collected from the CBOT. Cash prices were obtained from NASS. The marketing year average price (MYA) was also obtained from NASS and is the same for both systems. The MYA price is used in the calculation of counter-cyclical payments. Loan deficiency payments (LDPs) and Counter-Cyclical Payments (CCPs) are included in the calculation of returns for conceptual completeness. Table 1 (included in "Tables") contains the descriptive statistics of the data used for this research.

The first step in this research is to generate correlated random variables to simulate returns for each production system. This simulation is complicated by the fact that both prices and yields must be simulated. Phoon et al. describes a procedure for simulating correlated random variables with different marginal distributions. To begin this procedure a rank correlation matrix P_s is calculated. An Eigen decomposition of P_s is then done to result in Eigen values ε and Eigen vectors $\hat{\varepsilon}$. Correlated standard normal deviates ($\hat{Z}$) are generated using:

1) $$\hat{Z} = \sqrt{\varepsilon} Z \hat{\varepsilon}$$

where Z is a vector of independent standard normal deviates. These correlated standard normal deviates are converted to correlated uniform deviates on the (0,1) interval by a transformation on the standard normal CDF. The uniform deviates are used as probabilities in an inverse transformation on each of the marginal distributions for the variables being simulated. In this study, prices are assumed to be log normally distributed and yields are assumed to have a Beta distribution. Parameters for these distributions are derived from the historic data (1994-2003). A detailed description of this procedure is available in Phoon et al.

A set of 5,000 beginning futures prices, ending futures prices, harvest time cash prices, MYA prices, irrigated yield, and non-irrigated yields are simulated. These simulated prices and yields are used to calculate net returns. Net returns include crop returns, government payments, and hedging returns. The returns are then converted to utility values using a Constant Relative Risk Aversion (CRRA) utility function used by Anderson, Coble, and Miller.

2) $$E(U)_r = \sum_{i=1}^{n} \omega_i \frac{W_i^{1-r}}{1-r}, r \neq 1$$

or

3) $E(U)_r = \sum_{i=1}^{n} \omega_i \ln(W_i), r = 1$

where $W_i = W_0 + NR_i$, r is a risk aversion coefficient, and ω_i is the weight associated with each observation i. Simulated ending wealth is represented by W_i, and initial wealth is represented by W_0. NR_i represents total net returns and includes returns from crop production, hedging returns, counter-cyclical payments and loan deficiency payments.

Utility outcomes for each of 5,000 prices and yields are summed and converted to certainty equivalents (CE) by inverting equation 2 or 3 to obtain the following equations:

4) $CE = e^{(\overline{U})} - W_0, r = 1$

or

5) $CE = \left[\overline{U}(1 - r)\right]^{\left(\frac{1}{1-r}\right)} - W_0, r \neq 1,$

where $\overline{U}$ is the level of utility associated with a given hedge ratio. A grid search in 1% increments is then used to find the hedge ratio that maximizes the CE.

Results

The results collected from the model are presented in Table 2. The table consists of three different hedging strategies. The strategies are CS Nov, ES Nov, and ES Sept, which are defined as CSPS hedged against the November contract, ESPS hedged against the November contract, and ESPS hedged against the September Contract, respectively. The results are divided into irrigated and non-irrigated results. Table 2 displays the optimal hedging ratio for the given strategy and the CE for that strategy. All results are for a relative risk aversion coefficient of 1, reflecting slight risk aversion.

The hedge ratio is an instrument, which at its most basic levels accounts for the level of expected yield as well as the associated price risk. The optimal hedge ratio defines the percentage of total production that should be hedged to produce the highest level of producer utility. The optimal hedge ratio is influenced by a number of factors including the level of correlation between the cash and futures prices, yield variability, and the correlation between prices and yields.

The CE measures the amount of compensation that would be required for decision maker to sell a risky outcome. In this study the risky outcome is the uncertain total revenue. In comparing the revenue outcomes associated with alternative hedge ratios, a higher CE implies higher and/or less variable returns.

The results are somewhat counter intuitive. One would expect the higher and less volatile ESPS yields to produce a higher hedge ratio. However, basis variability is greater under the ESPS system, using either the September or the November contract. The results show a diminishing hedge ratio for the ESPS. Irrigation should also produce a less volatile yield, but the results show lower hedge ratios for the irrigated soybeans.

This result appears to be driven by the price/yield correlation found in the data. For example the correlation between non-irrigated yield and harvest time cash price in the ESPS system is fairly large and positive (0.486), while there is essentially no correlation between irrigated yield and price (p=-0.037). The positive correlation between non-irrigated yield and price increases the volatility of returns. A higher hedge ratio is called for to reduce that volatility. The CE's are drastically different for the two production systems in non-irrigated and irrigated results. The CE is a reflection of both the level and the variability of a given outcome. Since ESPS yields are both higher and more stable than CSPS yields, the CE associated with the ESPS is considerably higher than the CE associated with the CSPS. The higher hedge ratio associated with the CSPS indicates that the variability of CSPS returns can be more effectively managed than the variability of ESPS returns. However, the ESPS returns would still be preferred, as indicated by the larger CE.

Conclusions

The differences in ESPS and CSPS are based in fundamental production practices that result in benefits for the producer. The agronomic benefits of a lower likelihood of pest, climatic, and disease pressures provide the producer with a less variable yield in an ESPS. CSPS are still a viable production practice, but the likelihood of an outcome better than comparable ESPS is typically small. ESPS are proven in a majority of previous studies to produce equal or higher yields than comparable CSPS. The higher CEs associated with ESPS reflect the higher and less volatile yield of the early system as compared to the conventional system. This study derives optimal hedge ratios for mid-southern soybean producers, but in some cases the optimal hedge ratio is to not hedge at all. These hedge ratios reflect the optimal level of hedging at planting time. It is likely that at a later decision point, a higher level of hedging would be optimal due to the producer's better knowledge of the condition of the crop. This is a topic for further research. Results of this paper reveal the economic value of the production advantages of ESPS in the South. These results indicate that further adoption of ESPS is likely to occur in the South.

Bibliography

Anderson, John D, Keith Coble, and J. Corey Miller. “Using Private Risk Management Instruments to Manage Counter-Cyclical Payment Risks Under the New Farm Bill” Conference Paper. NCR-134. April, 2003.

Cecchetti, Stephen G; Cumby, Robert E; Figlewski, Stephen. “Estimation of the Optimal Futures Hedge.” *The Review of Economics and Statistics*. 1988. 623-630.

Davis, Todd D; George F. Patrick. “Forward Marketing Behavior of Soybean Producers.” AAEA Meeting. 2000.

Heatherly, Larry G. “Soybean Development in the Midsouthern USA Related to Date of planting and Maturity Classification.” USDA-ARS. April, 2005

Kahl, Kandice H. “Determination of the Recommended Hedging Ratio.” *American Agricultural Economics Association*. August, 1983. 603-605.

Lapan, Harvey; Moschini, Giancarlo; Hanson, Steven D. “Production, Hedging, and Speculative Decisions with options and Futures Markets.” *American Journal of Agricultural Economics*. February, 1991. 66-74.

Lence, Sergio H. “Relaxing the Assumptions of Minimum-Variance Hedging.” *Journal of Agriculture and Resource Economics*. 21:1. 1996. 39-55.

Myers, Robert J.; Thompson, Stanley R. “Generalized Optimal Hedge Ratio Estimation.” *American Journal of Agricultural Economics.* November, 1989. 858-868.

Phoon, Kok-Kwang; Ser-Tong Quek, Hongwei Huang. “Simulation of non-Gaussian processes using Fractile Correlation” *Probabilistic Engineering Mechanics*. 19. 2004. 287-292.

Viswanath, P.V. “Efficient Use of Information, Convergence Adjustments, and Regression Estimates of Hedge Ratios”. *The Journal of Futures Markets*. 13:1. 1993. 43-53.

Tables

Table 1. Descriptive Statistics

Title	Mean	Standard Deviation
ESPS yield (irr)	62.98	5.678
ESPS yield (non-irr)	35.68	7.348
CSPS yield (irr)	55.91	5.922
CSPS yield (non-irr)	26.33	10.250
April Price on September S Contract	588.50	117.059
August Price on September S Contract	573.57	107.979
August Cash Price	5.83	1.064
May Price on November S Contract	582.26	108.783
October Price on November S Contract	576.28	99.435
October Cash Price	5.79	1.021
Marketing Year Average Price	5.83	1.019

Table 2. Production System Hedge Ratios and Certainty Equivalents

	Non-Irrigated		Irrigated	
Strategy	Hedge Ratio	CE	Hedge Ratio	CE
CS Nov	72%	$47,646.13	60%	$172,100.10
ES Nov	57%	$89,271.67	0%	$207,494.18
ES Sept	47%	$87,547.89	0%	$206,476.09