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FORECASTING PRICE MOVEMENT OF NOVEMBER SOYBEAN FUTURES UTILIZING DISCRIMINANT ANALYSIS

A Thesis

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ABSTRACT

The importance of soybeans to producers, processors, exporters and ultimately consumers has been increasing rapidly, pushing soybeans from a botanical curiosity in the 1920's to the second most important cash crop produced in the United States.

Prices play an important role in the industry. Producers, exporters, processors and other businesses related to soybeans and soybean products require accurate and timely information on soybean prices to promote efficient business flow and to allow for long-term planning. This benefits the consumer by providing a steady supply of products at stable prices.

The objectives of this study were:

1. to determine if recent price changes from close to close of November soybean futures can be used to indicate a weak market in the short run and, if so,

2. to determine if the indication of a weak market in the short run also indicates a good time to forward contract for harvest delivery.

Three models with different cutoff criteria of -$1.00, -$.90 and -$.80 were developed on 1973/1974 through 1981/1982 data. Contract years 1982/1983 and 1983/1984 were preserved to test the models. The independent variables were the changes in the 20 previous daily closes. If the closes decreased in price greater than the cutoff criteria over the next 30 days, then that observation was classified as a sell signal. To avoid placing a hedge on an observation

misclassified as a sell signal, a hedge was not placed until five sell signals occurred in a row. Once a hedge had been placed, the success of the three models was analyzed based upon the resulting profit (or loss) per bushel from the time the hedge was placed until the date the hedge was lifted.

For comparative purposes, two possible dates were used for lifting the hedge. The first date was at the time of harvest (assumed to be October 15) and the second was the last day of the contract. Thus it was found, that if the producer hedged using the -$.80 criterion and placed a hedge after five predicted sell signals occurred in succession and lifted the hedge on the last day of the contract's life, his profits per bushel could increase by 53.33¢ per bushel over lifting the hedge at the time of harvest (72.33¢-19¢). Furthermore, if the producer hedged after five predicted sell signals occurred in succession and lifted the hedge on the last day of the contract's life, his profits per bushel could increase 3.16¢ per bushel over the same trading procedure, but using the -$1.00 criterion.

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CHAPTER I

INTRODUCTION

Soybeans were first introduced to the United States in the late 1800's, but were merely a botanical curiosity and not considered to be of any agricultural importance until the 1920's. In 1925, the United States Department of Agriculture first included soybeans in agricultural statistics. In 1947 the Chicago Board of Trade started to trade soybean futures. Soybean oil and soybean meal futures were first introduced in 1950 and 1951, respectively.[1] Since then, the cultivation and use of soybeans have increased, especially during the Post-War War II era. For example, in 1925 the soybean harvest equalled 132,653 metric tons (4,875,000 bushels), while the 1982 harvest was estimated to be 61,958,530 metric tons (2,276,976,000 bushels).[2]

Today, the United States is the world's leading producer and exporter of soybeans, producing 61,958,530 metric tons in 1982/1983 (a metric ton equals approximately 2,205 pounds or 36.75 bushels) from 28,864,800 hectares planted. Brazil is the United States closest

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[1]James P. Houck, Mary E. Ryan and Abraham Subotnik, Soybeans and Their Products. University of Minnesota, Minneapolis, Minnesota, 1972, pp. 54.

[2]American Soybean Association, Soya Bluebook '83, St. Louis, Missouri, 1983, pp. 182.

competitor in worldwide soybean production; they produced 14,600,000 metric tons for the same time period from 8,300,000 hectares planted, while worldwide production equalled 94,843,000 metric tons. The United States clearly dominates world production of soybeans.[3]

While the demand for soybeans has been increasing since World War II, increasing production of soybeans in the United States has helped to meet this increased demand. For example, United States exports for 1982/1983 totalled 25,474,898 metric tons.[4] Soybean exports of this magnitude can help satisfy the demands of areas throughout the world which have low soybean production and high soybean demand.

Soybean production increased in the United States for several reasons. First, increased world demand for protein fats and oils caused soybean production to increase during and after World War II. This increase in demand for protein fats and oils arose from the quickly expanding economies in all parts of the world. As the affluence of these economies increased, so did the desire for a higher standard of living which created a desire for more protein in their diets. Secondly, increased livestock population caused a corresponding increased use of soybean meal for animal feed. Most, if not all, of the increase of soybean meal was used for expansion of the broiler industry. During this time period, United States broiler

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[3]American Soybean Association, pp. 182.

[4]American Soybean Association, pp. 195.

consumption increased from 21.9 lb/capita in 1953 to 52.1 lb/capita in 1973.[5] The remainder of the world also experienced an increase in broiler consumption. The worldwide increase in broiler consumption has been the major cause of increased consumption of soybean meal for livestock feed.[6] Thirdly, the United States' farm policies encouraged removal of substantial acreage from the production of traditional crops, such as cotton, corn and wheat, which were considered surplus since the end of World War II. This land was available in sufficient quantities necessary to meet the increased demand due to the increased usage of soybean oil in margarine, shortening, salad oils and other foodstuffs. Finally, the technical progress in producing, processing and utilization of soybeans in new products has greatly increased the production and demand for soybeans. Recent technology has also become very efficient in such areas as production and processing of broilers, causing the relative cost to consumers to decrease, thereby increasing demand for broilers and soybean meal.[8]

Despite the rapid increase in soybean production and utilization, soybean stocks did not carry over in large quantities to the next

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[5]Tennessee Valley Authority, Soybeans: Production, Marketing and Use, 198 , p. 6.

[6]Tennessee Valley Authority, p. 7.

[7]Tennessee Valley Authority, p. 7.

[8]Tennessee Valley Authority, p. 7.

harvest year until the 1960's. This increasing demand for soybeans coupled with changing harvest expectations, caused soybean prices to be especially volatile. The volatile prices of soybeans instigated an interest in soybean futures on the part of the processor and exporter in an attempt to reduce the risk on their inventory.

It is generally agreed that futures trading aids in smoothing out price volatibility due to short harvests, bumper crops or shifts in government programs.[9] Futures trading in agricultural commodities promotes a systematic distribution of the commodity into consumption channels throughout the marketing year.

Often times producers face the prospect of an adverse price change of their product. This is especially true in the agricultural industry during the harvest season when there is an abundance of the crop to sell. If the producer can fully or partially protect himself from this price risk, then the producer's income can become more nearly stable and profit levels can increase both in the short and long run. It is also important to note that the producer can fully protect himself by cash contracting, but he can also go bankrupt if prices fall. Producers typically operate on high debt capital, thus even a mild downward price movement at the time his crop is sold on the cash market, could cause the producer to have difficulty making payments or even lose his assets to creditors. Some type of protection against this type of price risk is not only desirable, but it is also practical.

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[9]Houck, pp. 54.

The producer can utilize the futures market as a tool to reduce the chance of absorbing the full impact of a decline in prices at the time his commodity is for sale. The producer can cash contract or use the futures market to place a hedge. Hedging is defined as

> A means of protection against inventory loss due to adverse price changes by simultaneously offsetting the purchase or sale of cash grain by counter-balancing the sale or purchase of an equivalent amount of futures.[10]

By hedging, the producer has partially protected himself from price risk. However, some risk is still present; it is called basis risk. The basis is the difference between a cash price of a particular commodity at a specific location and the futures contract of that commodity. Usually, basis risk has been much less than price risk; and since local cash prices and futures prices tend to move together, the opportunity exists for the producer to utilize the futures market to hedge. In order for the hedge to be "perfect," the futures prices and the local cash prices must have the same differential when the hedge is lifted as when it was placed. Hedging on the futures market as protection against price risk is commonly used by processors but used little by producers. In fact, only a small fraction of producers use the futures market to hedge. It seems that producers have a basic mistrust of futures markets, have difficulty distinguishing between hedging and speculating and are discouraged from hedging because of margin calls.[11]

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[10]Gerald Gold, Modern Commodity Futures Trading, Commodity Research Bureau, Inc., New York, New York, 1975, pp. 105.

[11]Tennessee Valley Authority, pp. 145.

But producers have benefitted indirectly from the futures market. Whenever a producer sells or contracts his product to a local elevator or processor, the firm usually hedges the actual commodity by selling futures. Thus the producer can expect a contract price that parallels the futures market price (for example, the Chicago Board of Trade futures price minus the expected local basis minus elevator fee) for some particular time. By forward contracting (either by placing a hedge on the futures market or by contracting with an elevator for future delivery), the producer has a better idea of his cash flow situation early in the production process since he has established a price for his product.[12] In addition, if the producer hedges, the basis risk is no longer with the producer, but with the writer of the contract. All that is necessary for the producer to cash contract is to agree with another party on a specific price, quality and quantity. Cash forward contracting or forward contracting refers to the same type of transaction as cash contracting except the delivery date is not immediate but some agreed upon time in the future. The Disadvantage of cash forward contracts is that producers must deliver even if the cash price rises above the forward contract price at the time of delivery. This means that at the time the producer forward contracts he is willing to forego the potential profits of a high price at delivery time for reduced price risk at the start of the production process.

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[12]Tennessee Valley Authority, pp. 146.

Despite this shortcoming, cash forward contracting offers advantages to the producer. First, if the farmer is a small scale producer and his yield is less than the standard futures contract (5,000 bushels, Chicago Board of Trade), the producer can still protect his crop against adverse price movements by cash forward contracting. Also, the producer does not have to worry about paying commissions or margin calls and the exact price is guaranteed, i.e., no basis risk. The individual soybean producer utilizes cash forward contracting much more than hedging directly with the Chicago Board of Trade.

1. PROBLEM

Soybean producers have to make a decision each year as to whether or not to forward contract. In the past, the common approach was to market their soybeans on the cash market where the price is established at the time of the sale (which is the time of delivery for cash contracts). This marketing approach is appealing to the producer because it does not require much marketing skill or a contractual obligation. As noted before, if the producer does forward contract, there is a possibility that increased profits due to exceptionally high cash prices at the time of delivery will be foregone. On the other hand if the producer does not forward contract he is forced to accept the cash price at the time of sale even if the price is very low. A downward price movement prior to the time of sale could be large enough to seriously impair the producer's

financial standing. This decision to forward contract or not would be simple if the producer knew at what price to forward contract. In the long run and in the short run, a tool such as forward contracting could be used to increase the producer's profit levels and keep his income more nearly stable than if he had not protected himself against price risk.[13]

2. OBJECTIVES

The objectives of this study are to: (1) determine if recent price changes from close to close of November soybean futures can be used to indicate a weak market in the short run and, if so, (2) to determine if the indication of a weak market in the short run also indicates a good time to forward contract for harvest delivery.

These objectives will be accomplished by using past November soybean futures to determine when to sell a forward contract, and when to stay out of the market, or "handsoff." The wording "handsoff" will be used throughout as indicating no market action is taken. This study is not concerned with determining when to buy a contract, since the producer needs to know only when to sell a contract.

3. REVIEW OF RELATED STUDIES

This study will employ a statistical technique called discriminant analysis which was first introduced by Fischer in 1936. In the past,

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[13]Chicago Board of Trade, Introduction to Hedging, Board of Trade of the City of Chicago, 1984, p. 3.

discriminant analysis has been used primarily in sociology, psychology, and anthropology. Discriminant analysis is particularly useful when attempting to classify an observation as belonging to one of two or more groups.

Unfortunately, little research has been done with discriminant analysis to forecast the price of a particular commodity. However, there are some studies employing discriminant analysis to analyze "good" and "bad" agricultural loans.

Bauer and Jordon conducted a study in 1971 of Production Credit Association (PCA) loans in Tennessee. Using stepwise regression they found eight important characteristics of borrowers. These eight characteristics were: (1) equity; (2) reasonable farm value; (3) all liabilities; (4) married or single; (5) percent family expense is of total expense; (6) current ratio; (7) number of dependents; and (8) percent change in income. These eight characteristics were then used in the discriminant function. The discriminant function correctly identified 85 percent of the sample loans included in the study.

McManus and Scudi conducted a study on section 502 Housing Loan Program of the Farmers Home Administration in Fentress, Grundy and Haywood counties (Tennessee) in 1979. The samples were analyzed by: (1) tabular analysis; (2) stepwise regression; and (3) discriminant analysis. Stepwise regression found the strongest predictive variable to be income or wealth related. After the best predictive variables were identified, they were then used in three different discriminant

functions (one model for each county). The discriminant analysis for Fentress, Grundy and Haywood counties correctly classified 81 percent, 79 percent and 81 percent of the loan application samples, respectively.[14]

A third study by Dunn and Frey in 1976 analyzed Illinois PCA loans and found four important borrower characteristics in its discriminant analysis. They were: (1) total liabilities to total assets ratio; (2) amount of credit life insurance; (3) ratio of amount of the note to net cash farm income; and (4) the number of acres owned. The discriminant function correctly classified 75 percent of the sample loans tested.

Boone and Kyle conducted a study in 1968 analyzing soybean futures prices. However, multiple regression was utilized in this study instead of discriminant analysis. The basic objectives of this study were to predict the direction of change of the November contract price from the prior year's contract price and to predict the November futures price for the current year. The predictions were based on information available at the time soybeans would be planted each year. The variables considered were those with an acceptable r^2 value and were theoretically sound. Five models were developed using combinations of eight independent variables. These eight variables were: (1) March estimates of production; (2) meal price; (3) exports; (4) oil prices; (5) April 1 stocks of soybeans; (6) projected total supply; (7) soybean

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[14]Morgan, J. C. Scudi, A Discriminant Analysis of Farmers Home Administration of Housing Loans, The University of Tennessee, Knoxville, Tennessee, 1979, p. 7.

equivalents of meal and oil; and (8) index numbers of prices received by farmers for livestock. Each of the five equations predicted approximately as well as the others. R^2 ranged from .65 to .68. The standard error of the estimate ranged from 20.07 to 20.98 cents/bushel.

CHAPTER II

THEORETICAL FRAMEWORK

1. DATA

Contract years 1973/1974 through 1981/1982 were used for the discriminatory classification. The years 1982/1983 and 1983/1984 were preserved to test the model for accuracy in prediction. The data used are past November soybean closes.

A handsoff signal and a sell signal were defined. A sell signal was defined as a price decline greater than the cutoff criterion over a given time period, and a forward contract should be sold. Three separate discriminant analysis were run; one used an .80¢ decline as the cutoff criterion, one a .90¢ decline and a third at a $1.00 decline. A handsoff signal was defined as any change other than a decrease in price greater than the cutoff criterion, and no position should be taken. The cutoff criteria of .80¢, .90¢ and $1.00 were subjectively chosen based on the actual number of sell signals defined for each year. The number of sells defined by a cutoff criterion greater than $1.00 decreased to only 1-3 sell signals per contract year, which was deemed too small to be of practical value. On the other hand, the number of sell signals defined by a cutoff criterion less than .80¢ greatly increased, but so did the number of handsoff signals misclassified as sell signals.

Each observation uses 51 consecutive daily closes. If the oldest of these closes is called number 1 and the most recent number 51,

the first 21 of the closes are used to construct the explanatory variables consisting of 20 first differences. The remaining 30 closes are then used to classify the observations. If prices decrease more than .80¢ from the close of the day 22 anytime within a 30 day period, then that observation is placed in the sell group; otherwise, it is placed in the handsoff group. The next observation moved everything forward one day. The same routine was used for the .90¢ cutoff criterion and for the $1.00 cutoff criterion.

The total number of sell signals and handsoff signals manually classified for 1973/1974 through 1981/1982 equalled 2,596. Table 1 gives the numbers of sell signals and handsoff signals by contract year for each different cutoff criterion.

Once all of the data have been classified manually as either sell or handsoff, the discriminant analysis was utilized to reclassify data according to a set of independent variables. The set of independent variables was defined as the 20 preceding first differences of November soybean futures for each time period.[15] It is important to note, that, although a sell signal may be accurately classified by discriminant analysis, the price decrease which exceeded the cutoff criterion, and qualified that observation as a sell, may come early in the observation time period, whereby the thirtieth day in the

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[15]The first model used the daily closes as the independent variable set. This model had high correlation among the independent variables with correlation coefficients ranging between .97 to .99. Once the first differences were calculated, the correlation coefficients ranged between .01 to .26, thus the problem of correlation among the independent variables was remedied.

TABLE 1. The Number of Sell and Handsoff Signals for 1973/1974--1981/1982

Year	Total Observations	.80¢ Sell	.80¢ Handsoff	.90¢ Sell	.90¢ Handsoff	$1.00 Sell	$1.00 Handsoff
1974	302	61	241	56	246	45	257
1975	287	101	186	69	218	49	238
1976	287	25	262	18	269	17	270
1977	280	41	239	38	242	35	245
1978	273	0	273	0	273	0	273
1979	282	27	255	14	268	5	277
1980	289	9	280	2	287	1	288
1981	301	58	243	30	271	8	293
1982	295	4	291	0	295	0	295
9 yrs.	2,596	326	2,270	227	2,369	160	2,436

observation time period could have a price change much less than the cutoff criterion or it could have a positive change.

The first 51 closes of each contract year could not be classified since the computer package used (SAS) does not have the capability to look forward at the data set, only backwards. The model uses the first 20 days of this 51 day period as explanatory variables and the next 30 days are used for classification.

As each day passes, that day's close is added to the 30 days used for classification as the oldest of these 30 days is pushed into the 20 days used for the explanatory variables. The oldest of these 20 days is dropped. This process continues until there are not 30 days left in the life of the contract. The next observation starts with the fifty-first day of the next year's November soybean contract. This process is repeated throughout all years which resulted in a loss of 51 days per contract year, 21 days for the explanatory variables and 30 days for the observation time period, for 9 years equalling 459. This reduced the number of observations for classification by discriminant analysis from 2,596 to 2,137.

Once the models were developed on 1973/1974 through 1981/1982, they were then used for prediction on 1982/1983 and 1983/1984. The producer will only hedge after the models predict five sell signals in succession, thereby reducing the chances of hedging on an observation incorrectly predicted to be a sell signal. For comparative purposes, the producer will lift the hedge at the time of harvest, which was arbitrarily chosen as the middle of October for that contract year, and

on the last day of the contract, to determine which of these is the most profitable.

2. DISCRIMINANT ANALYSIS

Multiple discriminant analysis is a statistical technique which is used to classify data into one of two or more predetermined groups. The problem of discriminant analysis is to develop a classification rule from these sample observations which will classify new observations into one of these groups.[16]

The discriminant analysis utilized in this study is from SAS DISCRIM procedure.[17] This study assumes that the two populations (sell and handsoff) are multivariate normal, and the distribution of x, under the hypothesis that x_i is a handsoff signal, is $f_1(x)$. The distribution of x under the hypothesis that x_i is a sell signal, is $f_2(x)$.[18] The ratio of these distribution functions is the likelihood ratio. The classification rule will be based on the

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[16]J. Johnston, Econometric Methods, 2nd edition, McGraw Hill Book Co. of New York, New York, New York, 1960, p. 334.

[17]For details on SAS DISCRIM, see SAS User's Guide: Statistics, 1982 edition, SAS Institute, Cary, North Carolina, 1982, p. 318.

[18]John P. Van de Geer, Introduction to Multivariate Analysis for the Social Sciences, W. H. Freeman and Company, San Francisco, California, 1971, p. 260.

magnitude of the likelihood ratio relative to the ratio of the prior probabilities, i.e.,[19]

$$\frac{f_1(x)}{f_2(x)} \lessgtr \frac{p_2}{p_1} \qquad \text{Eq. 1}$$

Thus, when the likelihood ratio is greater than the ratio of the prior probabilities, that observation is classified into the hands-off group; when the likelihood ratio is less than the ratio of the prior probabilities, that observation is classified into the sell group. If the two ratios are equal, that observation could be assigned at random to either sell or handsoff. $f_1(x)$ is the formula for multivariate normal distribution, which is[20]

$$(2\pi)^{-\frac{n}{2}} |S_1|^{-1/2} \exp(-1/2(x_i - \bar{x}_1)'S_1^{-1}(x_i - \bar{x}_1)) \qquad \text{Eq. 2}$$

similarily, $f_2(x)$ is

$$(2\pi)^{-\frac{n}{2}} |S_2|^{-1/2} \exp(-1/2(x_i - \bar{x}_2)'S_2^{-1}(x_i - \bar{x}_2)) \qquad \text{Eq. 3}$$

where

S_1 = group$_1$ variance-covariance matrix

S_2 = group$_2$ variance-covariance matrix

n = the number of variables

x_i = observation$_i$

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[19]Johnston, p. 336.

[20]Van de Geer, p. 226.

p_1 = prior probability of group$_1$

p_2 = prior probability of group$_2$

$\bar{x}_1$ = mean of group$_1$

$\bar{x}_2$ = mean of group$_2$.

Logarithms are then taken from both sides of the inequality in Eq. 1, yielding.[21]

$$\tfrac{1}{2} \ln|S_2| - \tfrac{1}{2} \ln|S_1| - 1/2\ (x_i - \bar{x}_1)'\ S_1^{-1}\ (x_i - \bar{x}_1) +$$

$$1/2\ (x_i - \bar{x}_2)'\ S_2^{-1}(x_i - \bar{x}_2) \lessgtr \ln p_2 - \ln p_1 \qquad \text{Eq. 4}$$

On the occasions where S_1 and S_2 cannot be called different with a specified probability, the determinants of the variance-covariance matrices cancel out, and the pooled variance-covariance matrix is used instead of the within-group variance-covariance matrix.

To determine whether or not S_1 and S_2 are significantly different, the variance-covariance matrices are tested for homogeneity. In this particular example, the variance-covariance matrices for sell and handsoff are different with a probability of .9999. Therefore, the determinants of the variance-covariance matrices remain in the likelihood ratio and the within-group variance-covariance matrices are used instead of the pooled matrix. The discriminant analysis coefficients do not exist when the data cannot be pooled. Thus, this study will employ matrix multiplication on Eq. 4 above, for each iteration, test years 1982/1983 and 1983/1984.

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[21]For details on SAS computational methods, see Appendix I, page

CHAPTER III

RESULTS

1. CONTRACT YEAR 1973/1974-1981/1982

After the problem of correlation among the independent variables was remedied, the new independent variable set of first differences was used for the discriminate analysis. Three models with different cutoff criteria of -$1.00, -$.90 and -$.80 were employed with arbitrarily set prior probabilities of 84 percent for handsoff and 16 percent for sell.

The prior probabilities were arbitrarily set based upon what a reasonable ratio was expected to exist between the number of handsoff signals and the number of sell signals for a given year. The prior probabilities used in this study had a ratio of 5.25 handsoff to 1 sell. In actuality, the -$1.00 model had a ratio of 13.84 handsoff to 1 sell (these are averages for 1973/1974-1981/1982). The -$.90 model had a ratio of 9.37 handsoff to 1 sell and the -$.80 had a ratio of 6.17 handsoff to 1 sell.

Table 2 lists the discriminant analysis classification summary for each of the three different models, for 1973/1974-1981/1982. The -$.80 model had more sells than either the -$1.00 or -$.90 models. This is to be expected since the -$.80 model is less restrictive than the other two models. Table 2 shows the number of sells and handsoff signals correctly classified, and the number of sells and handsoff

TABLE 2. Discriminant Analysis Classification Summary for Cutoff Criteria -$1.00, -.90¢ and .80¢ for Test Year 1973/1974 Through 1981/1982

	Actual Signal	Classified As: Hands Off	Classified As: Sell	Total
Cut off Criterion = $-1.00	Hands off	1,847	146	1,993
	Sell	65	79	144
	Total	1,912	225	2,137
Cut off Criterion = -.90¢	Hands off	1,747	184	1,931
	Sell	111	95	206
	Total	1,858	279	2,137
Cut off Criterion = -.80¢	Hands off	1,654	185	1,839
	Sell	174	124	298
	Total	1,828	309	2,137

signals misclassified. The -$.80 model correctly classified 124 out of 298 sells. The -$.90 model correctly classified 95 out of 206 sells. The -$1.00 model correctly classified 79 out of 144 sells. Although the number of sell signals correctly classified appear rather low compared with the total number of classified sell signals, favorable results depend upon how close a misclassified sell signal is to an actual sell signal; and if it is not close to an actual sell signal, whether or not the price decreased or increased within the observation time period. The -$.80 model classified 309 observations as sell signals, but 185 of these were misclassified; the -$.90 model classified 279 observations as sell signals, but 184 of these were misclassified; the -$1.00 model classified 225 sells, but 146 of these were misclassified.

For a model to be of any predictive value, the prices must decrease in each observation time period, such that a sufficient number of sell signals exist in each year. For the time period 1973/1974-1981/1982 the number of actual sell signals ranged from 144 for the -$1.00 model to 298 for the -$.80 model. This averages out to between 16 and 33.11 per year over the 9 year period. These averages are large enough to warrant using each model for prediction on contract year 1982/1983.

Additionally, the model must classify a sufficient number of sell signals for each year. The number of sell signals classified for the same time period ranged from 225 for the -$1.00 criterion to 309 for the -$.80 criterion. This averages out to between 25.00

and 34.44 classified sell signals per year over the 9 year period. Again, these averages are large enough that each criterion will be used for prediction on 1982/1983.

2. CONTRACT YEAR 1982/1983

Prediction on 1982/1983 involves using the means, variance-covariance matrices and the log of the determinants of the variance-covariance matrices calculated from 1973/1974 through 1981/1982. The within-group variance-covariance matrices will be used instead of the pooled matrix since the variance-covariance matrices were determined to be different with a probability of .9999, and the log of the determinants will remain in the classification rule

$$1/2\ \ln|S_2| - 1/2\ \ln|S_1| - 1/2(x_i - \bar{x}_1)'S_1^{-1}(x_i - \bar{x}_1)$$

$$+ 1/2(x_i - \bar{x}_2)'S_2^{-1}(x_i - \bar{x}_2) \lesssim \ln p_2 - \ln p_1 \qquad \text{Eq. 4}$$

Table 3 lists the prediction results for each of the three cutoff criteria for contract year 1982/1983. This year has a total of 396 observation time periods. There were 8 actual sells for the -$1.00 criterion; 13 sells for the -$.90 criterion; and 19 sells for the -$.80 criterion.

The -$.80 criterion predicted 42 sell signals; 19 correctly classified sell signals and 23 misclassified handsoff signals. The -$.90 criterion predicted 49 sell signals; 13 correctly classified sell signals and 36 misclassified handsoff signals. The -$1.00 criterion predicted 38 sell signals; 7 correctly classified sell signals and

TABLE 3. Prediction Results for Cutoff Criteria -$1.00, -.90¢ and -.80¢ for Test Year 1982/1983

	Actual Signal	Predicted As: Hands Off	Predicted As: Sell	Total
Cut off Criterion = $-1.00	Hands off	267	31	298
	Sell	1	7	8
	Total	268	38	306
Cut off Criterion = -.90¢	Hands off	257	36	293
	Sell	0	13	13
	Total	257	49	306
Cut off Criterion = -.80¢	Hands off	264	23	287
	Sell	0	19	19
	Total	264	42	306

and 31 misclassified handsoff signals. The -$.80 criterion correctly classified the most sell signals and misclassified the least number of signals as sell signals. In this respect, the -$.80 criterion was superior to the others.

However, all cutoff criteria misclassified a large number of handsoff signals as sell signals relative to the total number of classified sell signals. The predictive success of any of these three criteria depends upon how close these incorrectly classified sell signals are to an actual sell signal. Since the criterion for predicting a sell signal is a decrease in price greater than each of the respective cutoff criterion over the observation time period, the producer would take a short position in the market and lift the hedge when his soybeans are harvested. The closer the handsoff signals misclassified as sell signals are to actual sell signals, the greater the probability that the producer will be able to forward contract at a higher price and subsequently higher profits. Thus another characteristic of the best predictive criterion would be the ability to minimize the difference between misclassified handsoff signals as sell signals and actual sell signals. Figures 1, 2, and 3 illustrate the range of price changes from the first day over the observation time period for each criterion and for each observation classified as a sell signal for 1982/1983. Included are the highest change, lowest change and the final change between the first day and the thirty-first day of the observation time period.

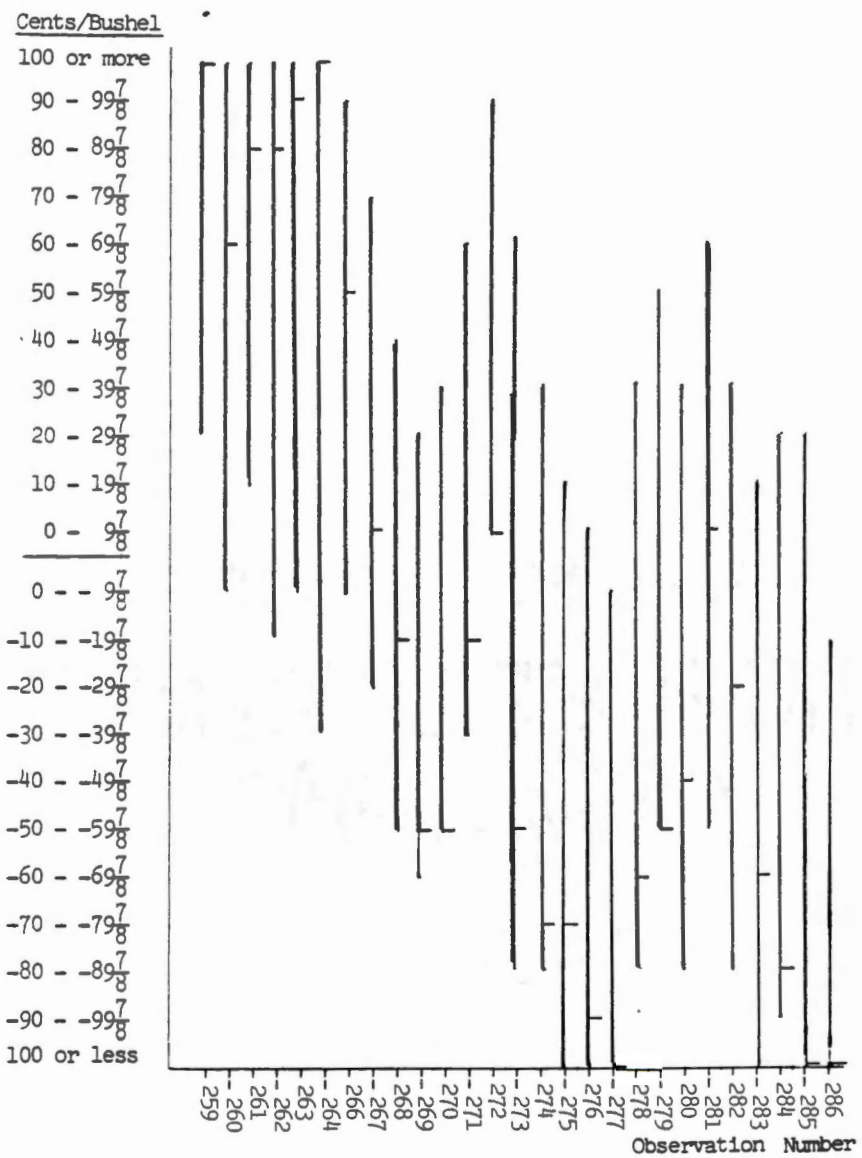

FIGURE 1. Range of Price Changes from the First Day of the Observation Time Period, Including the Price Change Between the First and Thirty-First Day, for the -$1.00 Model, Test Year 1982/1983.

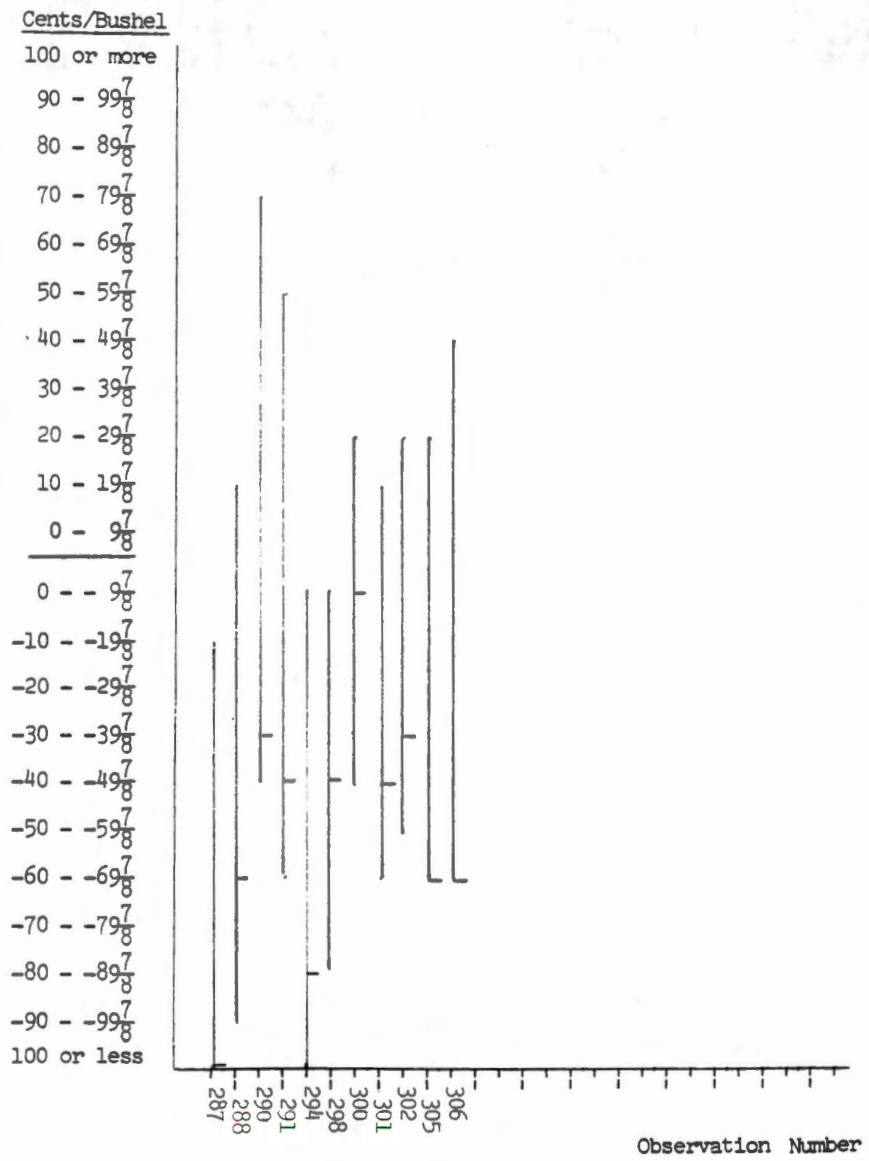

FIGURE 1 (Continued)

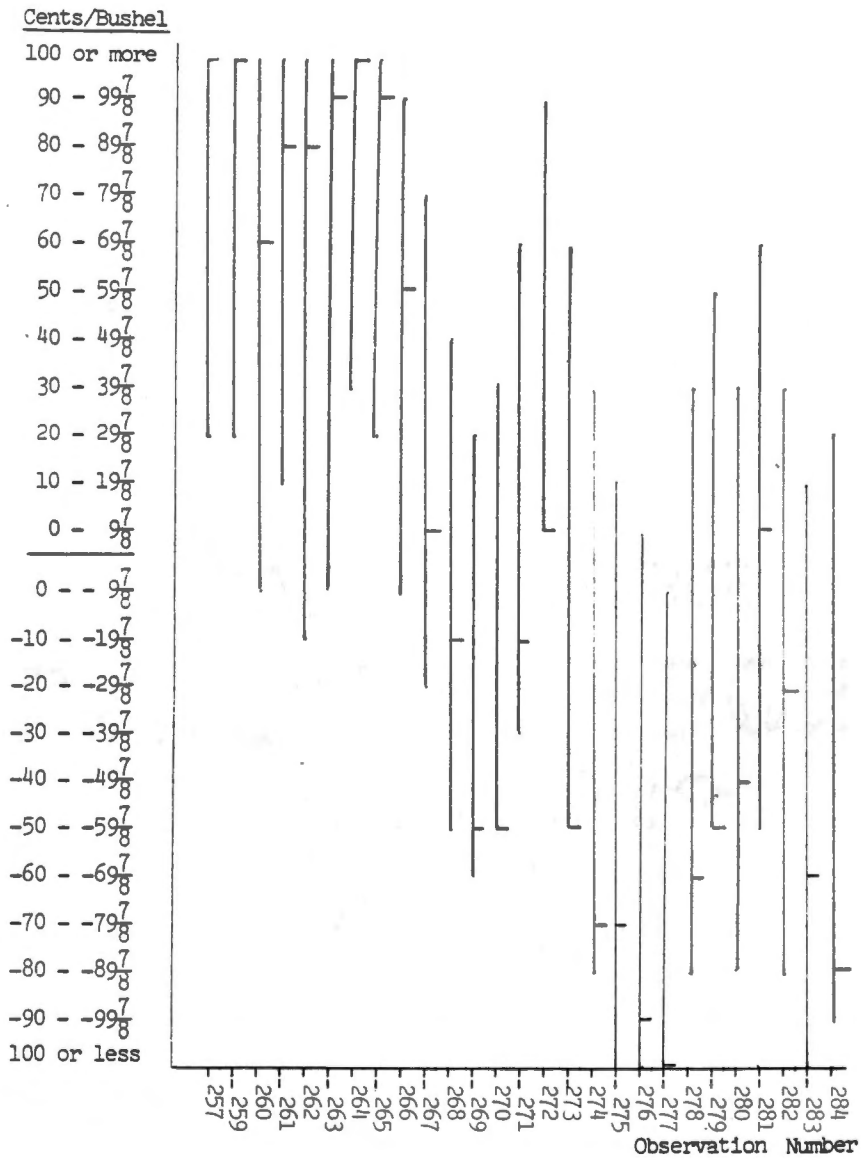

FIGURE 2. Range of Price Changes from the First Day of the Observation Time Period, Including the Price Change Between the First and Thirty-First Day, for the -$.90 Model, Test Year 1982/1983.

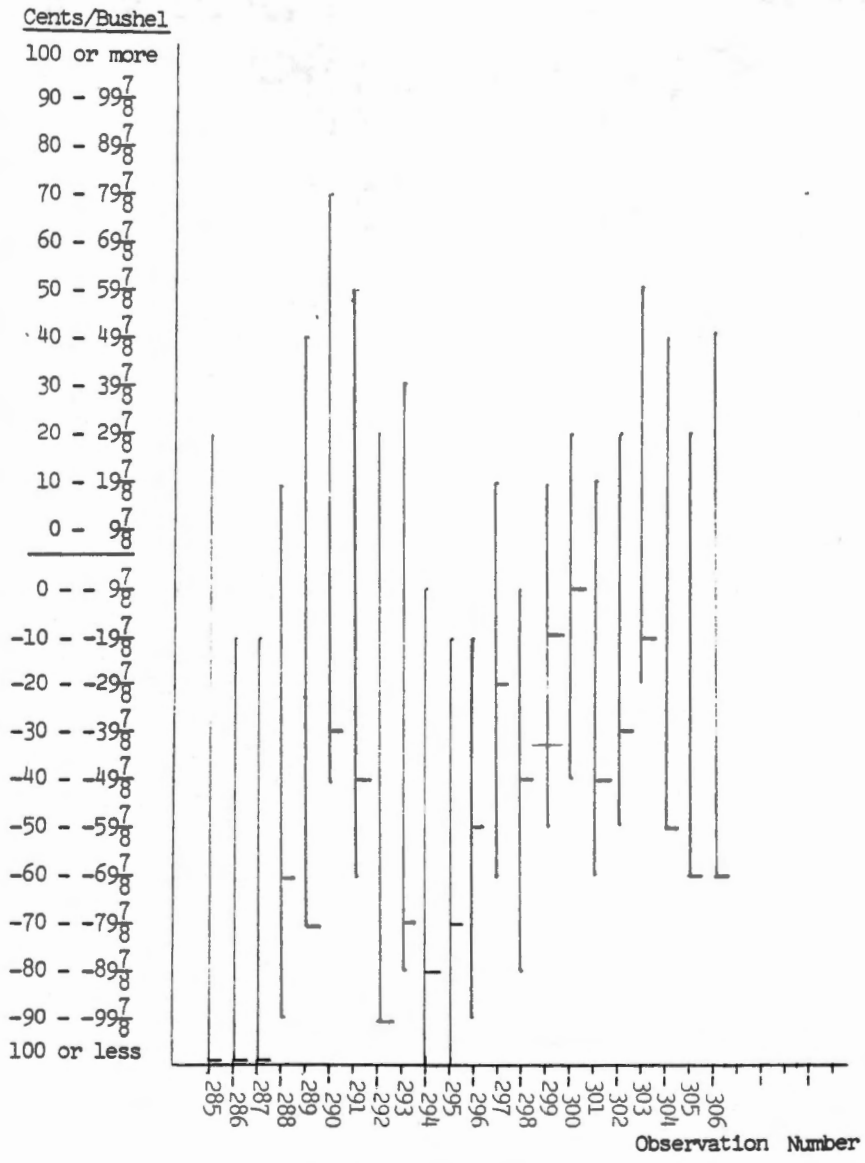

FIGURE 2 (Continued)

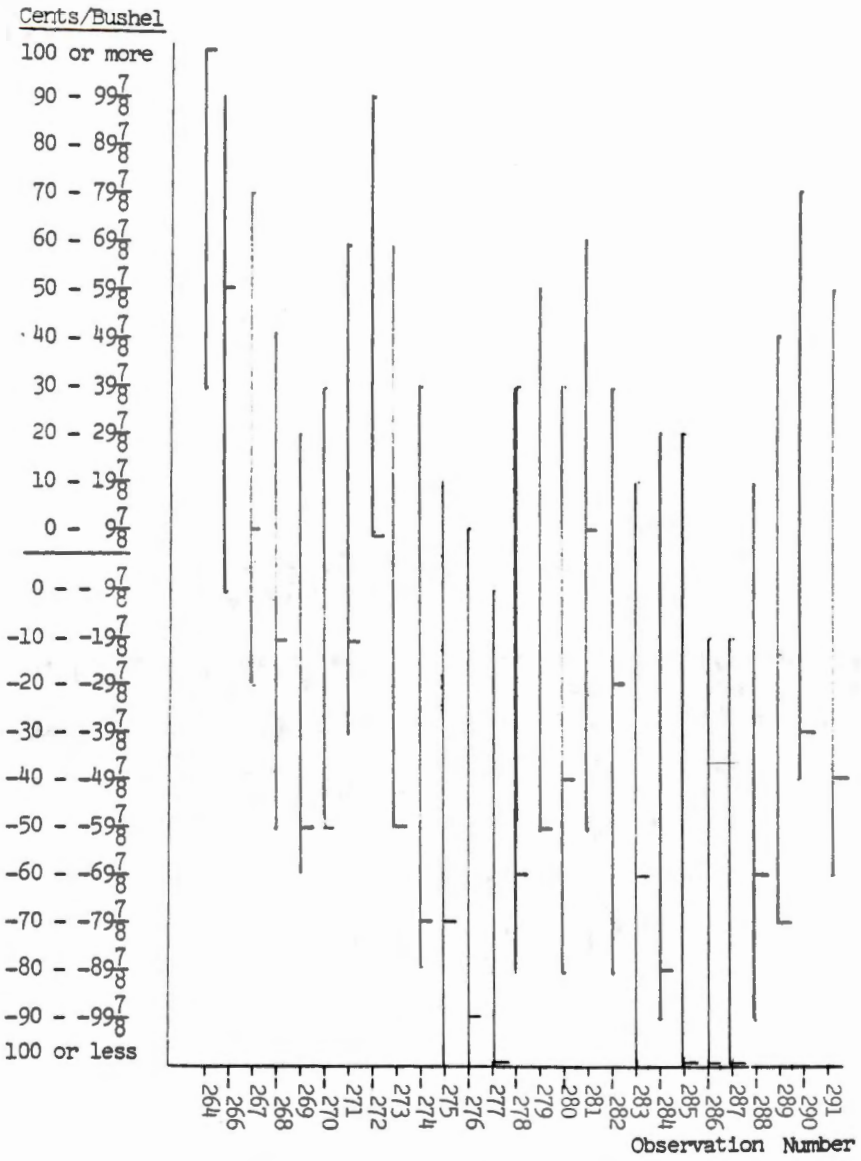

FIGURE 3. Range of Price Changes from the First Day of the Observation Time Period, Including the Price Change Between the First and Thirty-First Day, for the -$.80 Model, Test Year 1982/1983.

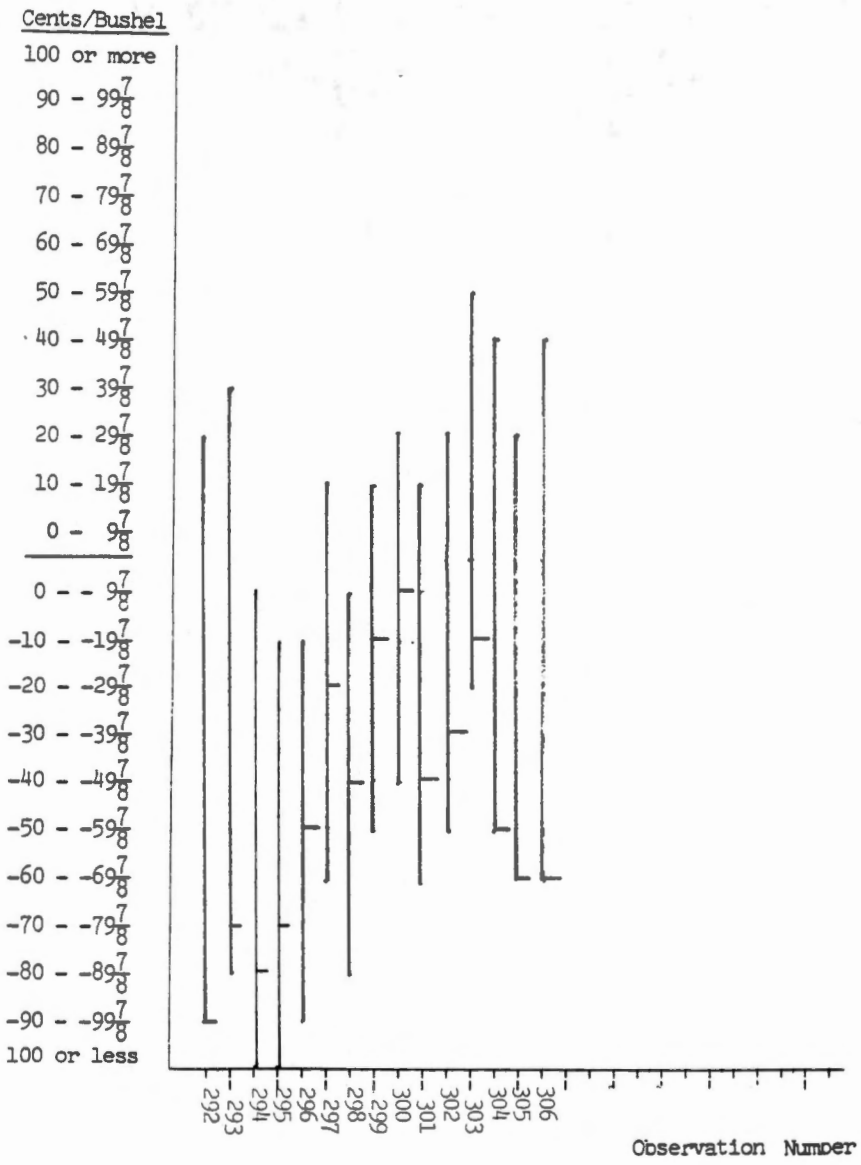

FIGURE 3 (Continued)

Figure 1 corresponds to the -$1.00 criterion. This criterion predicted 38 observations as sell signals. Of these sell signals 68.42 percent were not actual sell signals but price had decreased from the first day by at least one-half of the cutoff criterion. Furthermore, 42.11 percent of these decreased in price from the first day by at least three-fourths of the cutoff criterion. The closer these percentages are to 100 percent, the closer these observations misclassified as sell signals are to actual sell signals. Of these observations 39.47 percent increased in price from the first day by at least one-half of the absolute value of the cutoff criterion. Of these observations 26.32 percent increased in price by at least three-fourths of this amount. The closer to 0 percent these percentages are, the closer each of these sell signals are to actual sell signals.

Figure 2 corresponds to the -$.90 criterion. This criterion predicted 49 observations as sell signals. Of these sell signals 75.51 percent were not actual sell signals but had decreased in price from the first day of the observation time period by at least one-half of the cutoff criterion. Furthermore, 53.06 percent decreased in price from the first day by at least three-fourths of the cutoff criterion. Of these observations 44.90 percent increased in price from the first day by at least one-half of the absolute value of the cutoff criterion. Of these observations 30.61 percent increased in price from the first day by at least three-fourths of this amount.

Figure 3 corresponds to the -$.80 criterion. It predicted 42 observations as sell signals. Of these sell signals 85.71 percent were not actual sell signals but had decreased in price from the first

day by at least one-half of the cutoff criterion. Furthermore, 61.90 percent decreased in price from the first day by at least three-fourths of the cutoff criterion. Of these sell signals 35.71 percent increased in price from the first day by at least one-half of the absolute value of the cutoff criterion. Of these observations 11.05 percent increased in price from the first day by at least three-fourths of this amount.

Overall, the -$.80 criterion performed the best of the three models for correctly classifying the larger number of sell signals. For incorrectly classified handsoff signals as sell signals, the -$.80 criterion had the largest percentage which decreased in price from the first day by at least one-half of the cutoff criterion and again by at least three-fourths of the cutoff criterion. Also the -$.80 criterion had the lowest percentage of observations misclassified as a sell that increased in price from the first day by at least one-half and three-fourths of the absolute value of the cutoff criterion.

However accurate classification of individual sell signals is, it is not, by itself, sufficient. The producer typically hedges once or twice a year, and according to our assumptions, as mentioned before, he will not place a hedge until five sell signals have been predicted in succession. A "run" of five sell signals was arbitrarily chosen as the trading rule, to reduce the chances of a producer placing a hedge on a single sell signal, which could turn out to be an observation misclassified as a sell signal. For analysis, it was assumed that the hedge would be lifted at the time of harvest (approximately 15 October) and the resulting profits compared to the profits of lifting

the hedge on the last day of the contract. Therefore, each criterion must not only predict a sufficient number of sell signals to have any predictive worth, but must also predict a run of at least five sell signals in succession.

All three criteria exhibited a run of five sell signals or more in 1982/1983. This run occurred approximately the same time for each criterion. The run started late in the contract year and persisted through the life of the contract.

During this time, the -$1.00 criterion started the run of sell signals on 9/14/83, the same time as the -$.90 criterion. The hedge was placed on 9/21/83 at $9.29. The hedge was then lifted at either harvest time or on the last day of the contract's life. If the hedge was lifted at harvest time on 10/14/83 at $8.86, the profit would equal $.43. If the hedge was lifted on the last day of the contract, 11/20/83, at $7.84 the resulting profit per bushel would be $1.45.

The -$.80 criterion started the run of sell signals on 9/23/83. The producer would hedge on 9/30/83 at $8.70. If the hedge was lifted at harvest time 10/14/83, the loss would equal $.16. If the hedge was lifted on the last day of the contract's life, 11/20/83, the profit would equal $.86. Table 4 summarizes these results.

In addition, the high for 82/83 contract year was $9.49 on 9/9/83. The -$1.00 and -$.90 criteria hedged at $9.29; $.20 lower than the optimal price to hedge at. The -$.80 criterion hedged at $8.70; $.79 lower than the contract year's high. In this respect, the -$1.00 and the -$.90 criteria performed better than the -$.80 criterion.

TABLE 4. 1982/1983 Profit Per Bushel for Each Cutoff Criterion at Harvest Compared to the Profit Per Bushel on the Last Day of the Contract

Cutoff Criterion	Place Hedge	-	Lift Hedge	=	Profit or (Loss)/Bushel
-$1.00	$9.29 (9/21/83)		$8.86 (10/14/83)		$ .43 At Harvest
	$9.29 (9/21/83)		$7.84 (11/20/83)		$1.45 Last Day
-$ .90	$9.29 (9/21/83)		$8.86 (10/14/83)		$ .43 At Harvest
	$9.29 (9/21/83)		$7.84 (11/20/83)		$1.45 Last Day
-$ .80	$8.70 (9/30/83)		$8.86 (10/14/83)		($ .16) At Harvest
	$8.70 (9/30/83)		$7.84 (11/20/83)		$ .86 Last Day

Although the -$.80 criterion out-performed the -$1.00 criterion and the -$.90 criterion in accuracy of classification, the -$1.00 and the -$.90 criterion yielded much higher profits per bushel when the hedge was lifted either at the time of harvest or the last day of the contract's life.

The -$1.00 criterion and -$.90 criterion resulted in the same run of sell signals and the same profit per bushel. But since the -$1.00 criterion was more accurate in classification than the -$.90 criterion, it will be used for prediction on 1983/1984. Similarily, the -$.80 criterion will be used for prediction on 1983/1984 because it performed best of all three criteria in classifying sell signals and in minimizing differences between observations misclassified as sell signals and actual sell signals.

3. CONTRACT YEAR 1983/1984

The -$1.00 and -$.80 criteria were employed to predict observations in 1983/1984 by discriminant analysis after the model had been updated. Updating the model consisted of dropping the oldest year in the data base (1973/1974) and adding 1982/1983. Apriori, the more frequently the model is updated, the better the model should predict. Although it would not be practical to update the model with every new piece of data, e.g., the last day's close, updating on a monthly or quarterly basis could improve classification results. The updating process resulted in new values for the variance-covariance matrices and for the handsoff and sell means. The same prior probabilities of 84 percent

for handsoff and 16 percent for sell, were used in this model. The updated model's variance-covariance matrices were tested for homogeneity, and were determined to be different with a probability of .9999. Therefore, the determinants of the variance-covariance matrices will remain in the likelihood ratio and the within-group variance-covariance matrices are used instead of the pooled matrix, and Equation 4 will be used as the classification rule for prediction on 1983/1984.

Table 5 depicts the prediction results for the -$1.00 criterion for 1983/1984. This criterion predicted 86 observations as sell signals; 5 correctly and 81 incorrectly.

Table 6 depicts the prediction results for the -$.80 criterion for 1983/1984. This criterion predicted 66 observations as sell signals; 5 correctly and 61 incorrectly.

Figure 4 corresponds to the -$1.00 criterion. It classified 86 observations as sell signals. Of these sell signals 13.95 percent were not actual sell signals but had decreased in price from the first day by at least one-half of the cutoff criterion. Furthermore, 10.47 percent decreased in price from the first day by at least three-fourths of the cutoff criterion. Although 5.81 percent had increased from the first day by at least one-half of the absolute value of the cutoff criterion, none had increased in price from the first day by an amount greater than three-fourths of this amount.

Figure 5 corresponds to the -$.80 criterion. It classified 66 observations as sell signals. Of these observations 34.85 percent were not actual sell signals but had decreased in price from the first

TABLE 5. Prediction Results for Cutoff Criterion Equalling -$1.00 for Test Year 1983/1984

	Actual Signal	Predicted As: Handsoff	Predicted As: Sell	Total
Cutoff Criterion = -$1.00	Handsoff	193	81	274
	Sell	12	5	17
	Total	205	86	291

TABLE 6. Prediction Results for Cutoff Criterion Equalling -$.80 for Test Year 1983/1984

	Actual Signal	Predicted As: Handsoff	Predicted As: Sell	Total
Cutoff Criterion = -$.80	Handsoff	201	61	262
	Sell	24	5	29
	Total	225	66	291

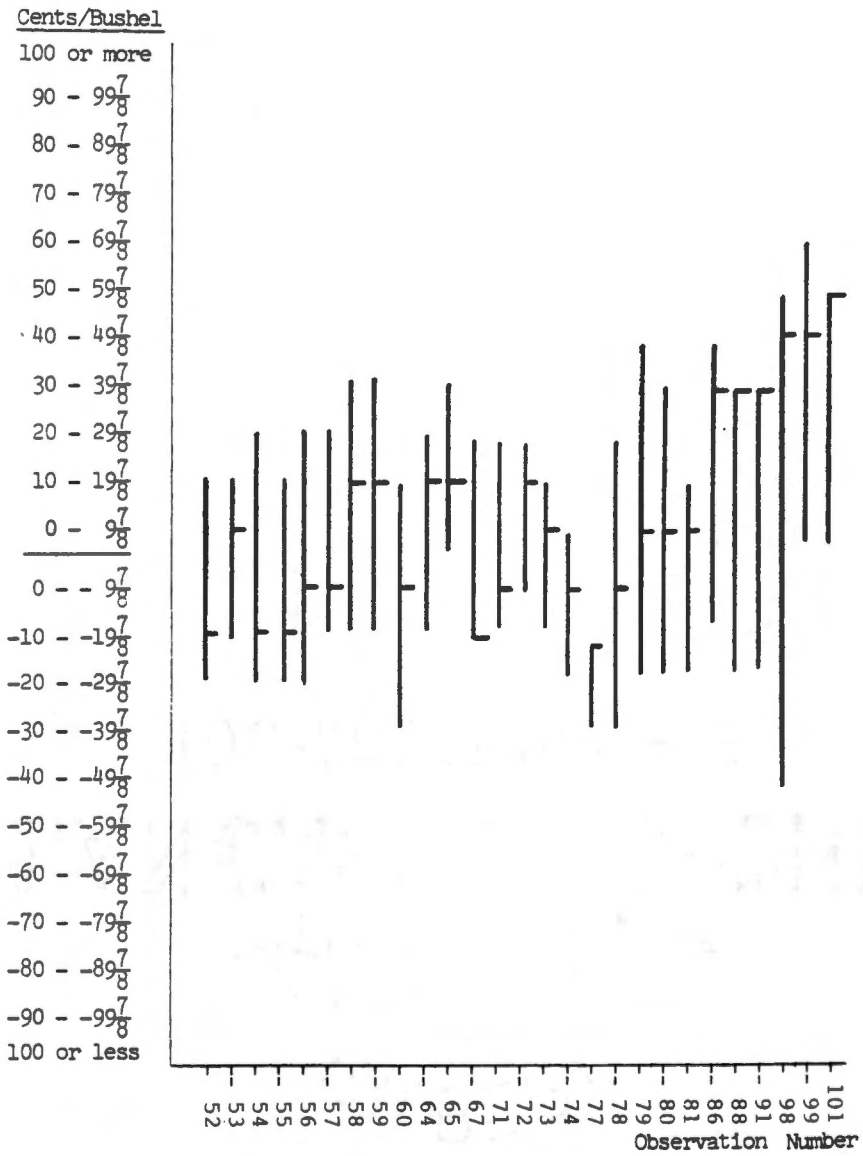

FIGURE 4. Range of Price Changes from the First Day of the Observation Time Period, Including the Price Change Between the First and Thirty-First Day, for the -$1.00 Model, Test Year 1983/1984.

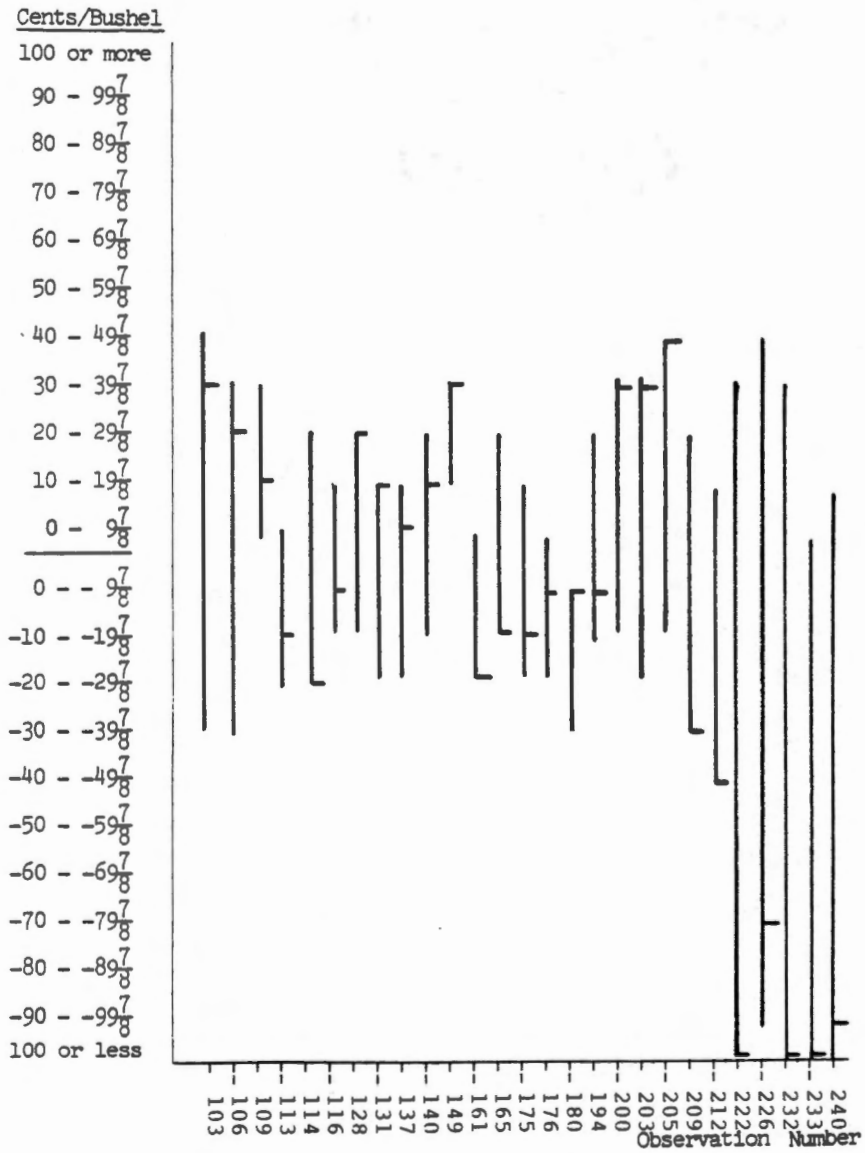

FIGURE 4. (Continued)

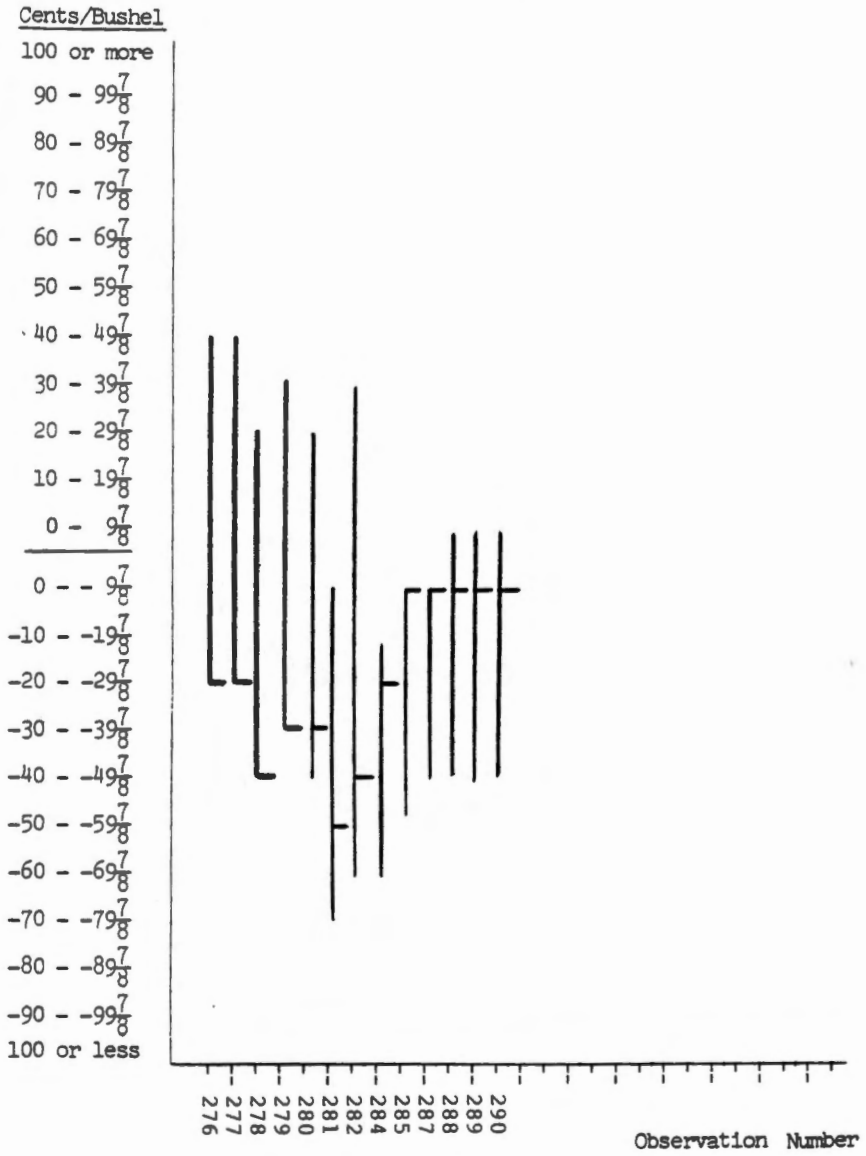

FIGURE 4 (Continued)

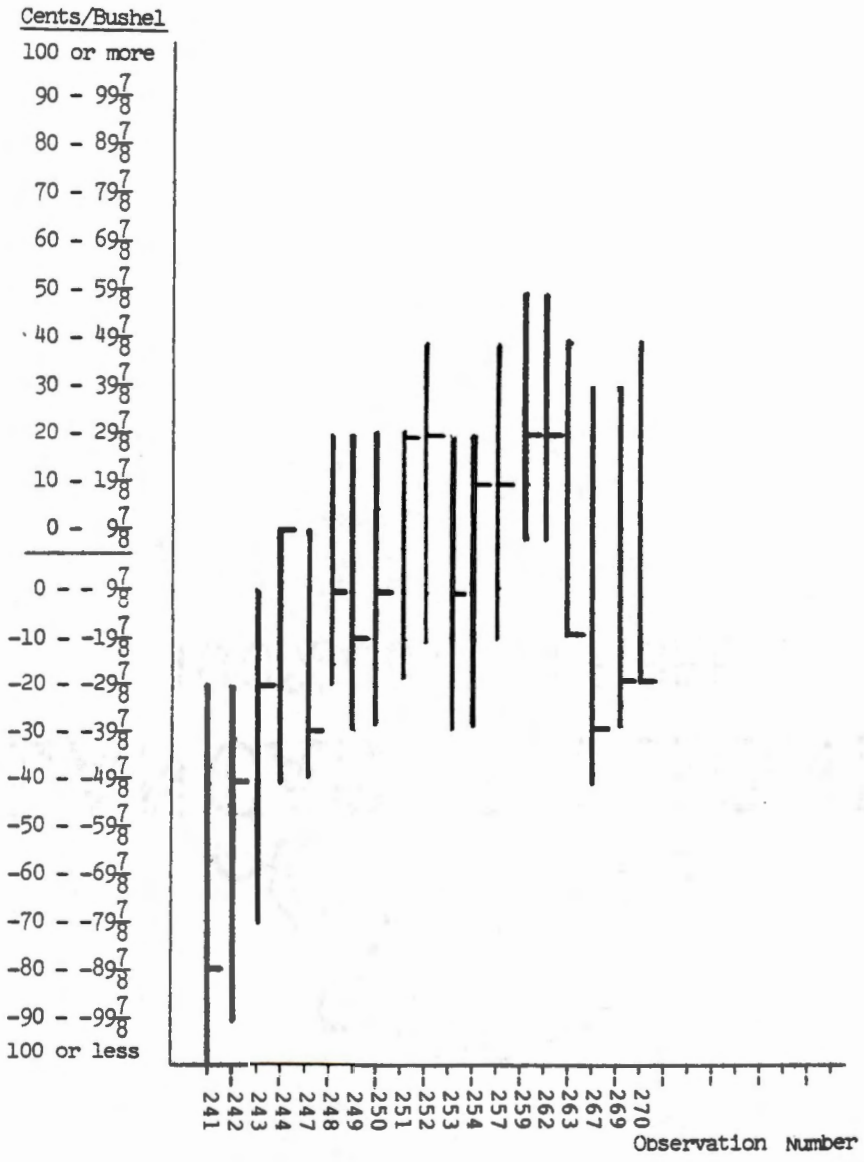

FIGURE 4 (Continued)

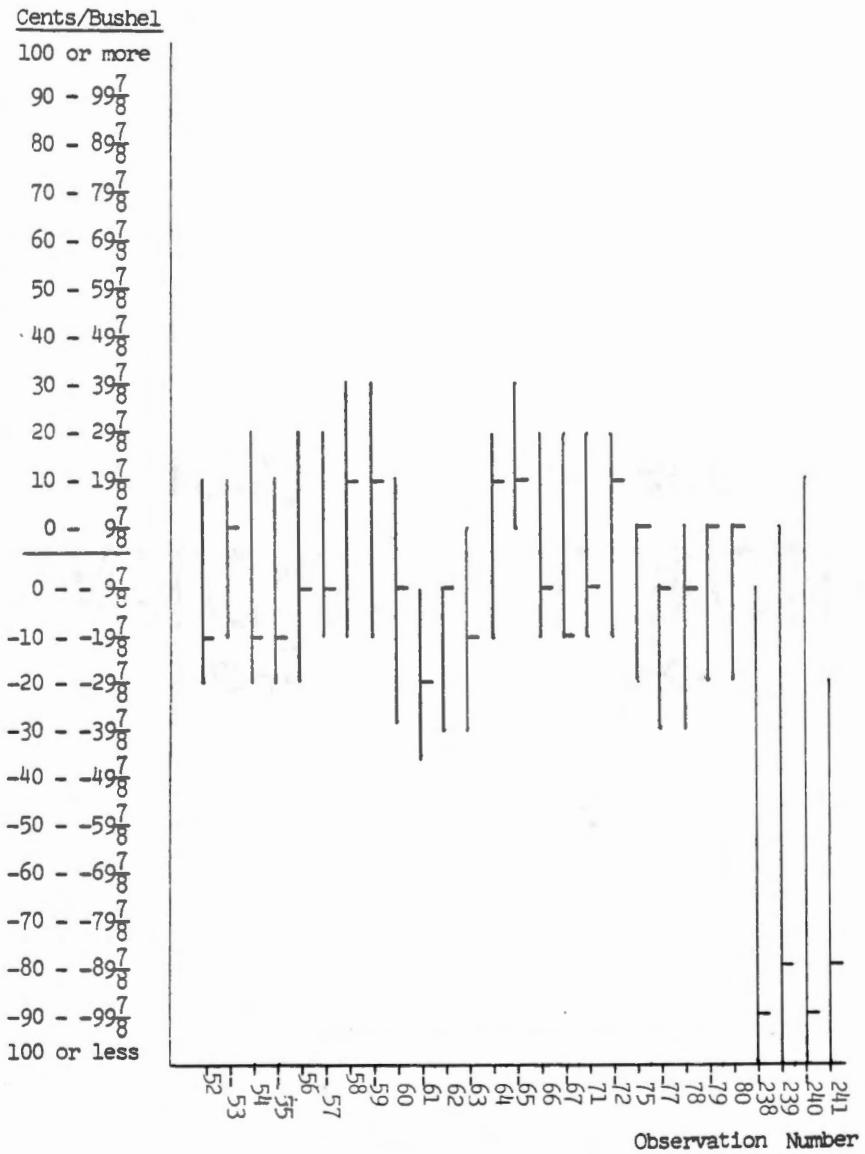

FIGURE 5. Range of Price Changes from the First Day of the Observation Time Period, Including the Price Change Between the First and Thirty-First Day, for the -$.80 Model, Test Year 1983/1984.

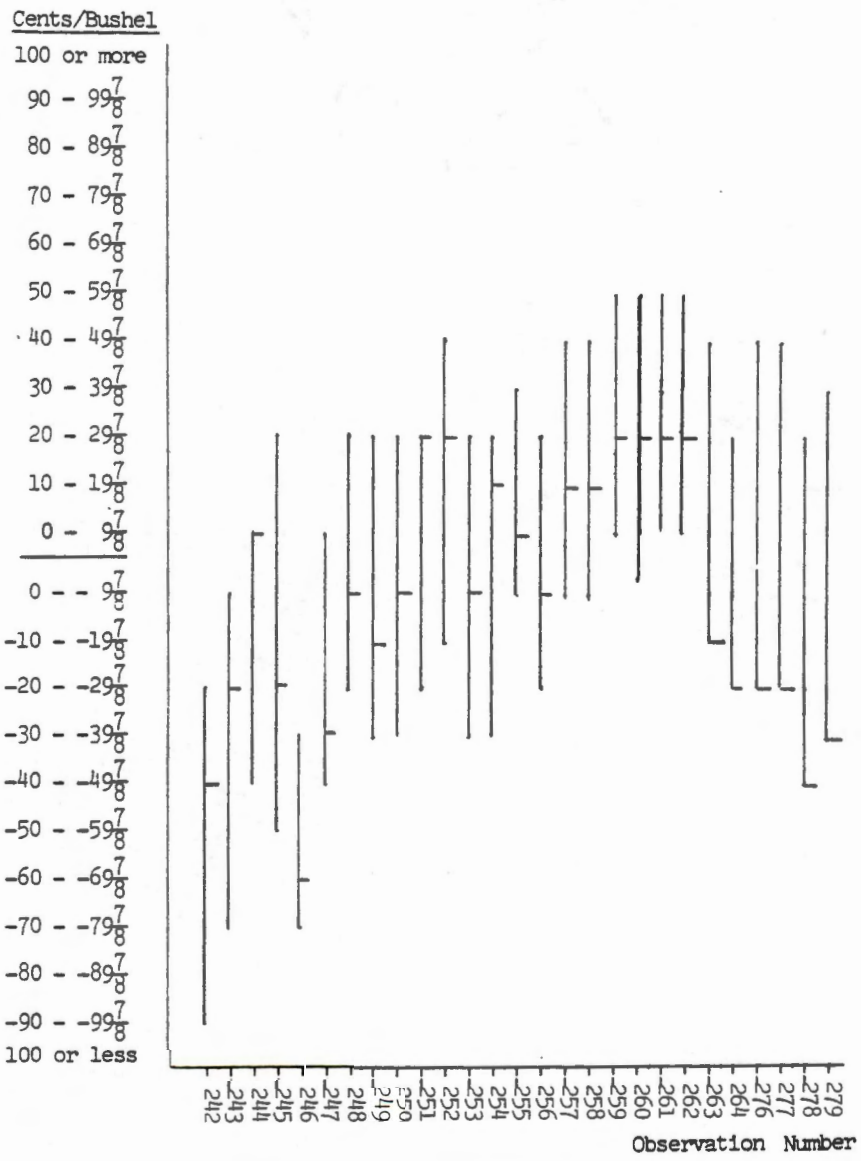

FIGURE 5 (Continued)

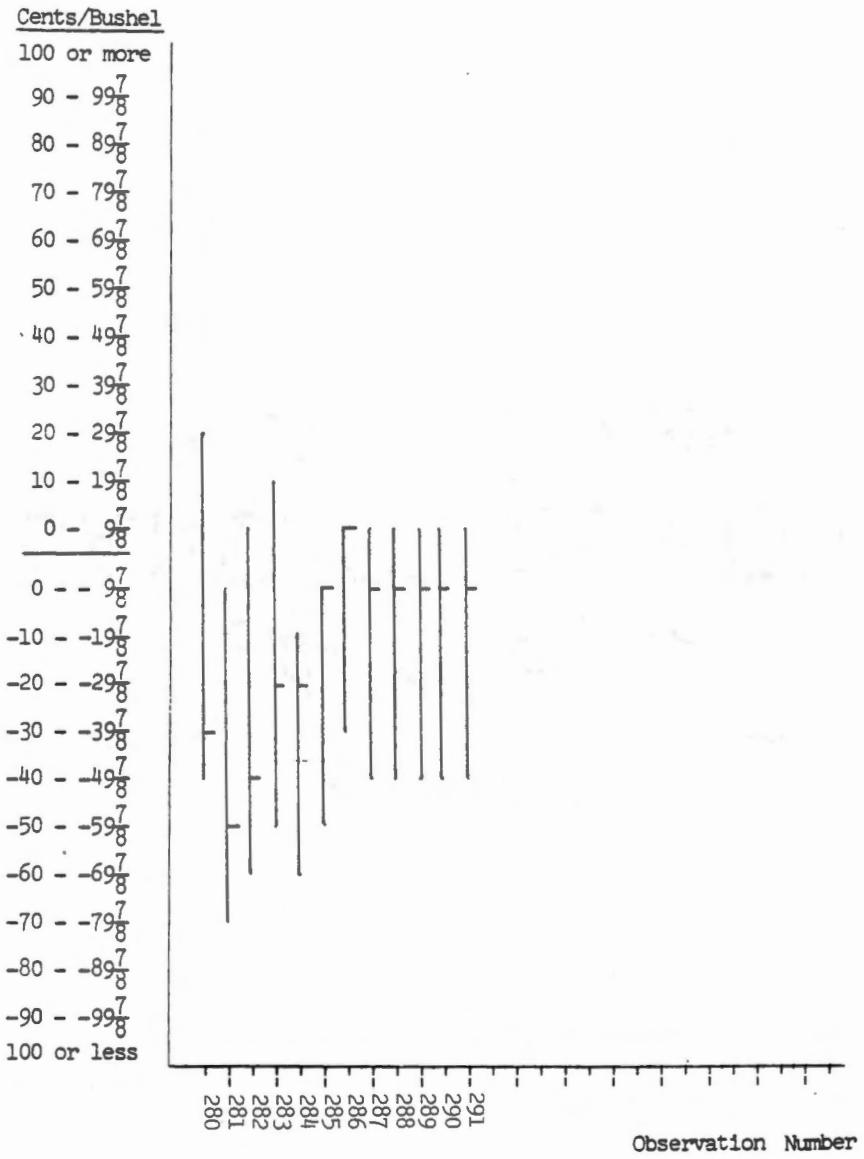

FIGURE 5 (Continued)

day by at least one-half the cutoff criterion of -$.80, and 15.15 percent decreased in price from the first day by at least three-fourths of the cutoff criterion. Coincidentally, 15.15 percent of these sell signals increased in price from the first day by at least one-half of the absolute value of the cutoff criterion. None of these observations increased in price from the first day by an amount greater than the three-fourths of this amount.

The -$1.00 criterion had five runs of sell signals. The first one started on 11/14/83. The hedge was placed on 11/21/83 at $6.80. If the producer lifted the hedge at the time of the harvest, 10/15/84, at $6.33, the profit per bushel would equal $.47. If the producer lifted the hedge on the last day of the contract, 11/20/84 at $6.04, the profit per bushel would equal $.76. The second run started on 12/28/83. The producer placed the hedge on 12/28/83 at $7.18. If the producer lifted the hedge at the time of harvest, the resulting profit would equal $.85/bushel. If the producer lifted the hedge on the last day of the contract, the profit would equal $1.14/bushel. The third run started on 8/10/84 and the hedge was placed on 8/17/84 at $6.39. If the hedge was lifted at the time of harvest, the profit would equal $.06/bushel. If the hedge was lifted on the last day of the contract, the resulting profit would equal $.35/bushel. The fourth run started on 8/21/84 and the hedge was placed on 8/28/84 at $6.50. If the producer lifted the hedge at the time of harvest, the resulting profit would be $.17/bushel. If the hedge was lifted on the last day of the contract, the profit per bushel would equal

$.46. The final run started on 10/2/84 and the hedge was placed on 10/9/84 at $6.01. If the hedge was lifted at the time of harvest, the loss per bushel would equal $.32. If the hedge was lifted on the last day of the contract year the loss per bushel would equal $.03. Table 7 summarizes these results.

The -$.80 criterion had two sell signal runs for contract year 1983/1984. The first run started on 11/14/83 and the hedge was placed on 11/21/83 at $6.80. If the hedge was lifted on 10/15/84 at $6.33, the profit per bushel equalled $.47. If the hedge was lifted on 11/20/84 at $6.04, the profit per bushel equalled $.76.

The second run started on 8/8/84 and hedged on 8/15/84 at $6.59. If the hedge was lifted at the time of harvest the resulting profit would equal $.26 per bushel. If the hedge was lifted on the last day of the contract, the profit would equal $.55 per bushel. Table 7 summarizes these results.

The high for contract year 83/84 occurred on 6/21/84 at $7.62. None of the runs of sell signals for either -$1.00 or -$.80 criteria were hedged at a price close to the year's high. The -$1.00 criterion hedged below the contract high by $.82, $.44, $1.23, $1.12 and $1.61 for the first through the fifth run, respectively. The -$.80 criterion hedged below the contract high by $.82 and $1.03 for the first and second run, respectively.

TABLE 7. 1983/1984 Profit Per Bushel for Each Run for Cutoff Criteria -$1.00 and -$.80 at Harvest Compared to the Profit Per Bushel on the Last Day of the Contract

Cutoff Criterion	Run #	Place Hedge	Lift Hedge	Profit or (Loss)/Bushel
-$1.00	1	$6.80 (11/21/83)	$6.33 (10/15/84)	$ .47 At Harvest
		$6.80 (11/21/83)	$6.04 (11/20/84)	$ .76 Last Day
	2	$7.18 (12/28/83)	$6.33 (10/15/84)	$ .85 At Harvest
		$7.18 (12/28/83)	$6.04 (11/20/84)	$1.14 Last Day
	3	$6.39 (8/17/84)	$6.33 (10/15/84)	$ .06 At Harvest
		$6.39 (8/17/84)	$6.04 (11/20/84)	$ .35 Last Day
	4	$6.50 (8/28/84)	$6.33 (10/15/84)	$ .17 At Harvest
		$6.50 (8/28/84)	$6.04 (11/20/84)	$ .46 Last Day
	5	$6.01 (10/9/84)	$6.33 (10/15/84)	$(.32) At Harvest
		$6.01 (10/9/84)	$6.04 (11/20/84)	$(.03) Last Day
-$ .80	1	$6.80 (11/21/83)	$6.33 (10/15/84)	$ .47 At Harvest
		$6.80 (11/21/83)	$6.04 (11/20/84)	$ .76 Last Day
	2	$6.59 (8/15/84)	$6.33 (10/15/84)	$ .26 At Harvest
		$6.59 (8/15/84)	$6.04 (11/20/84)	$ .55 Last Day

CHAPTER IV

SUMMARY AND CONCLUSION

1. SUMMARY

The importance of soybeans to producers, processors, exporters and ultimately consumers has been increasing rapidly, pushing soybeans from a botanical curiosity in the 1920's to the second most important cash crop produced in the United States.

Prices play an important role in the industry. Producers, exporters, processors and other businesses related to soybeans and soybean products require accurate and timely information on soybean prices to promote efficient business flow and to allow for long-term planning. This benefits the consumer by providing a steady supply of products at stable prices.

The objectives of this study were to: (1) determine if recent price changes from close to close of November soybean futures can be used to indicate a weak market in the short run, and, if so (2) to determine if the indication of a weak market in the short run also indicates a good time to forward contract for harvest delivery. These objectives were accomplished by classifying November soybean futures with discriminant analysis as either handsoff signals or sell signals.

Three models with different cutoff criteria of -$1.00, -$.90 and -$.80 were developed on 1973/1974 through 1981/1982 data. All

three models had annual averages of actual sell signals and annual averages of observations classified as sell signals for each criterion that were high enough to warrant using each criterion for prediction on 1982/1983.

All three criteria were used for prediction on 1982/1983. The -$1.00 criterion predicted 38 sell signals; 7 were correctly classified. The -$.90 criterion predicted 49 sell signals; 13 were correctly classified. The -$.80 criterion predicted 38 sell signals; 19 were correctly classified.

Of these misclassified observations, 85.71 percent for the -$.80 criterion decreased by one-half or more of the cutoff criterion; 61.90 percent decreased by three-fourths or more of the cutoff criterion. The -$.80 criterion had the largest percentage of observations misclassified as sell signals that approached a sell signal by one-half and three-fourths of the absolute value of the cutoff criterion, than either the -$1.00 or -$.90 criteria.

Of these observations misclassified as sell signals, 35.71 percent for the -$.80 criterion increased by one-half or more of the absolute value of the cutoff criterion; 19.05 percent increased by three-fourths or more of this amount. Again, the -$.80 criterion performed better than either the -$1.00 or -$.90 criterion. The -$.80 criterion had the smallest percentage of observations misclassified as sell signals that increased within the observation time period by one-half and three-fourths or more of the absolute value of the cutoff criterion.

All three criteria predicted a run of sell signals in 1982/1983. The run started on 9/14/83 for the -$1.00 and -$.90 criteria and the hedge was placed on 9/21/83 at $9.29. If the hedge was lifted at harvest (10/14/83) the profit was $.43 per bushel; $1.45 if the hedge was lifted on the last day of the contract. The run of sell signals for the -$.80 criterion started on 9/23/83. The hedge was placed on 9/30/83 at $8.70 and the loss per bushel would equal $.16, if the hedge was lifted at harvest. The profit per bushel would equal $.86 if the hedge was lifted on the last day of the contract.

The -$1.00 criterion yielded the highest profit per bushel of the three criteria, and was used for prediction on 1983/1984. The -$.80 criterion, although yielding the lowest profit per bushel, was the most accurate of the three criteria in correctly classifying the largest percentage of sell signals and minimizing the magnitude the misclassified observations deviated from actual sell signals and thus, will be used for prediction on 1983/1984.

The highest price for the contract year was $9.49 on 9/9/93. The -$1.00 criterion hedged $.20 under the contract high, while the -$.80 criterion hedged $.79 under the contract high.

The model was updated for prediction on 1983/1984 by dropping the oldest year (1973/1974) and adding 1982/1983. New values were calculated for the variance-covariance matrices, means and the log of the determinants of the variance-covariance matrices. The variance-covariance matrices were tested for homogeneity and were found to be different with a probability of .9999. Thus, the within-group

variance-covariance matrices and the log of the determinants will be used for prediction on 1983/1984.

The -$1.00 criterion predicted 86 sell signals in 1983/1984; 5 correctly. The -$.80 criterion predicted 66 sell signals in 1983/1984; 5 correctly. Of these observations, the -$.80 criterion had the largest percentage of observations misclassified as sell signals that approached a sell signal by one-half and three-fourths of the absolute value of the cutoff criterion.

The -$1.00 and -$.80 criteria both had approximately the same percentage of predicted sell signals that increased by one-half and three-fourths of the absolute value of the respective cutoff criteria.

The -$1.00 criterion predicted five runs of sell signals in 1983/1984. The most profitable run was hedged on 12/28/83 and lifted on the last day of the contract (11/20/84) resulting in a $1.41 profit per bushel. The last run of sell signals was the least profitable, resulting in a loss of $.32 per bushel, if the hedge was lifted on the last day of the contract.

The -$.80 criterion predicted two runs of sell signals in 1983/1984. The more profitable run was hedged on 11/21/83 and was lifted on the last day of the contract for a profit of $.76 per bushel.

The highest price for contract year 1983/1984 was $7.62 on 6/21/84. Neither the -$1.00 or -$.80 criteria hedged at this price. The closest hedge was placed at $7.18, according to the second run of the -$1.00 criterion. Also, the -$1.00 criterion hedged farthest from the contract high. This occurred during the fifth run and the hedge was placed at $1.61 below the contract high.

2. CONCLUSION

Although the prediction of individual sell signals is not very accurate for either the -$1.00 or the -$.80 criteria, both criteria predicted with moderate success using a run of five sell signals in succession, as a guide for the producer to hedge. But some qualifications must be noted.

Both the -$1.00 and -$.80 criteria yielded approximately the same profits per bushel, when averaged over 1982/1983 and 1983/1984. As Table 8 depicts, if the producer lifted the hedge under the -$1.00 criterion at the time of harvest, he would average 27.67¢ profit per bushel. If the producer hedged under the -$.80 criterion, the profits per bushel would average 19¢. In this respect, the -$1.00 criterion is superior to the -$.80 criterion by 8.67¢. However, the profit per bushel does not come close to the definition of a sell signal as a decrease in price greater than the respective cutoff criterion.

If the producer hedged under the -$1.00 criterion and lifted the hedge on the last day of the contract, the profits per bushel would average out to 69.17¢ per bushel. If the producer had hedged under the -$.80 criterion and lifted the hedge on the last day of the contract, the profits per bushel would increase to an average of 72.33¢ per bushel. Hence, the -$.80 criterion is superior to the -$1.00 criterion in this instance by 3.16¢. Profits per bushel on the average, over the 2 year period 1982/1984, for both the -$1.00 criterion and the -$.80 criterion are much higher if the hedge was lifted on the last day of the contract as opposed to lifting the hedge at harvest.

TABLE 8. Comparison of the Average Profits Per Bushel Over the Two Period 1982/1983-1983/1984 by Hedging with a -$1.00 and -$.80 Criteria and Lifting the Hedge at Either Harvest or the Last Day of the Contract

Run # in 1982-1984	Harvest		Last Day	
	-$1.00	-$.80	-$1.00	-$.80
	$/bu			
1	$ .43	($.16)	$1.45	$.86
2	$ .47	$.47	$ .76	$.76
3	$ .85	$.26	$1.16	$.55
4	$ .06		$ .35	
5	$ .27		$ .46	
6	($ .32)		($ .03)	
Totals	$1.66	$.57	$4.15	$2.17
Av.	$ .2767	$.19	$ .6917	$ .7233

Ideally, the producer would like to place a hedge at the contract's high. Over the 2 year test period (1982/1983 and 1983/1984), neither criteria predicted a run of sell signals that would result in the hedge being placed on the contract's high. In fact, both criteria performed poorly in this regard. The hedges ranged from $.20 below the contract high to $1.61 below the contract high, over the 2 year test period, 1982/1983 and 1983/1984.

Thus it was found, that if the producer hedged using the -$.80 criterion and placed a hedge after five predicted sell signals occurred in succession and lifted the hedge on the last day of the contract's life, his profits per bushel could increase by 53.33¢ per bushel over lifting the hedge at the time of harvest (72.33¢-19¢). Furthermore, if the producer hedged after five predicted sell signals occurred in succession and lifted the hedge on the last day of the contract's life, his profits per bushel could increase 3.16¢ per bushel over the same trading procedure, using the -$1.00 criterion.

3. LIMITATIONS OF THE STUDY

Ideally, producers would like to know approximately the price per bushel that they will receive so that they can estimate how much to plant. Unfortunately, with the exception of a few observations in 1983/1984, the actual sell signal occurred for both 1982/1983 and 1983/1984 late in the contract year, typically mid July on. Thus, the producer is not able to use this model to hedge before or during the planting period.

Another drawback to this study is that future price movements are unknown. The producer will not have any information as to whether the price will increase above the contract price or decrease below the contract price, after the observation time period has passed.

Since prior probabilities enter into the discriminant analysis as a constant, the closer the prior probabilities are to the actual probabilities, the more accurate the model should classify the data. The prior probabilities of 84 percent for handsoff signals and 16 percent for sell signals were used for the 1983/1984 data. The actual probabilities with a -$.80 cutoff criterion for 1983/1984 were 90.04 percent for handsoff signals and 9.96 percent for sell signals. When the prior probabilities deviate from the actual probabilities, classification into one group or another becomes biased.

4. SUGGESTIONS FOR FURTHER STUDY

The observation time period of 31 days was arbitrarily chosen based on what was believed to be a reasonable length of time to have a price movement of sufficient magnitude to qualify as a sell signal. This time span covers six calendar weeks, and prices can potentially move upward to a handsoff signal and then downward to a sell signal. If this time span were shortened then any sell signals would be closer in time to the independent variables, and might result in more accurate prediction. Similarily, the set of independent variables could also be shortened and might reflect future price movements better than the original set of independent variables.

The prior probabilities enter into the calculations and affect the classification of observations into either sell or handsoff. Thus, if these prior probabilities are inaccurate by a large amount then misclassifications could increase. Since, the actual prior probabilities of the current year are not known until the year has past, an accurate set of prior probabilities must be estimated. Some possibilities are to use the last year's ratio of handsoff signals to sell signals or use an average of the past 3-5 years.

A final suggestion would be to shorten the data base. This study used 9 years of daily closes as the data base from which the classification models were developed. During this time period, soybean prices ranged from \$4.78½ to \$9.48. If the models were based on, for example the last 3-5 years, these models might prove to be more effective predictive tools.

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APPENDIX

SAS does not calculate the comparison exactly as noted in Equation 4. Instead, SAS utilizes the log of the classification rule

$$\frac{f_2(x)}{f_1(x)} \begin{matrix} < \\ > \end{matrix} \frac{p_1}{p_2} \qquad \text{Eq. 1}$$

Since this ratio is the inverse of the classification rule employed in this study, the signs are reversed as is the classification criterion. Thus, when the likelihood ratio is greater than the ratio of prior probabilities, that observation is placed into the sell group $f_2(x)$; otherwise, handsoff.

Substituting equation 2 and equation 3 for $f_1(x)$ and $f_2(x)$, respectively in equation 1 (above)

$$\frac{(2\pi)^{\frac{-n}{2}} |S_2|^{\frac{-1}{2}} \exp -\frac{1}{2}(x_i - \bar{x}_2)' S_2^{-1} (x_i - \bar{x}_2)}{(2\pi)^{\frac{-n}{2}} |S_1|^{\frac{-1}{2}} \exp -\frac{1}{2}(x_i - \bar{x}_1)' S_1^{-1} (x_i - \bar{x}_1)} \begin{matrix} < \\ > \end{matrix} \frac{P_1}{P_2} \qquad \text{Eq. 5}$$

Logs are then taken from both sides yielding

$$-\frac{1}{2} \ln |S_2|^{\frac{-1}{2}} (x_i - \bar{x}_2)' S_2^{-1} (x_i - \bar{x}_2) + \frac{1}{2} \ln |S_1| + \frac{1}{2}$$

$$(x_i - \bar{x}_1)' S_1^{-1} (x_i - \bar{x}_1) \lesseqgtr \ln P_1 - \ln P_2 \qquad \text{Eq. 6}$$

since $\log e^x = x$ and $\log \frac{A}{B} = \log A - \log B$. To simplify computations, multiply the inequality by 2 to remove the $\frac{1}{2}$ coefficients and move the log of the priors by subtraction to the left hand side resulting in

$$\ln |S_1| - \ln |S_2| + (x_i - \bar{x}_1)' S_1^{-1} (x_i - \bar{x}_1) - (x_i - \bar{x}_2)'$$

$$S_2^{-1} (x_i - \bar{x}_2) - 2 \ln p_1 + 2 \ln p_2 \lesseqgtr \emptyset \qquad \text{Eq. 7}$$

Although equation 7 (above) is utilized by SAS, in actual computations, SAS separately computes:

$$\ln |S_1| + (x_i - \bar{x}_1)' S_1^{-1} (x_i - \bar{x}_1) - 2 \ln p_1 \qquad \text{Eq. 8}$$

and

$$\ln |S_2| + (x_i - \bar{x}_2)' S_2^{-1} (x_i - \bar{x}_2) - 2 \ln p_2 \qquad \text{Eq. 9}$$

Finally, SAS subtracts equation 8 from equation 9 yielding equation 7. If the algebraic sum is positive, then that observation is classified as $f_2(x)$[sell]. If the algebraic sum is negative, then that observation is classified as $f_1(x)$[handsoff].

VITA

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