South Dakota State University

1993

Analysis and Forecasting of Seasonal Changes in Cash Prices for Corn, Wheat, and Oats Grown in South Dakota

Prashobh Karunakaran

ANALYSIS AND FORECASTING OF SEASONAL CHANGES IN CASH PRICES FOR CORN, WHEAT, AND OATS GROWN IN SOUTH DAKOTA

BY

PRASHOBH KARUNAKARAN

A thesis submitted in partial fulfillment
of the requirements for the degree
Masters of Science
Major in Economics
South Dakota State University
1993

ANALYSIS AND FORECASTING OF SEASONAL CHANGES IN CASH PRICES
FOR CORN, WHEAT, AND OATS GROWN IN SOUTH DAKOTA

This thesis is approved as credible and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Dr. Bashir Qasmi — Date
Thesis Advisor

Dr. Larry L. Janssen — Date
Major Advisor

Dr. Ardelle Lundeen — Date
Head of Economics Dept.

ACKNOWLEDGEMENT

This thesis is dedicated to my parents, Mr. and Mrs. Karunakaran, whose patience and sacrifice have enabled me to earn my Masters of Science degree.

I would like to express my sincere gratitude to Dr. Bashir Qasmi for guiding my efforts throughout the writing of this thesis.

Sincere thanks also goes to Dr. Larry Janssen, Dr. Charles Lamberton, Dr. Roger Sandness, Dr. Richard Shane, Dr. Dillon Feuz, and Wayne Ellingson for their valuable input and time while I wrote this thesis. I would also like to thank Ranae Bickette and Nancy Kadous for checking the thesis for grammatical and sentence structure errors.

PKK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Fig. PAGE

CHAPTER ONE

INTRODUCTION

1.1 PROBLEM IDENTIFICATION

According to a recent survey, grain farmers in the tri-state area (South Dakota, North Dakota and Minnesota) predominantly used cash sales and cash forward contract methods of selling grain. Specifically, it was reported that cash sales accounted for 67% and 77% of total corn and wheat sales respectively. Cash forward sales accounted for 17% of corn sales and 12% of wheat sales. Decisions regarding the times of sales are important for efficient management and profitability of a farm. According to the survey, the tri-state farmers spread their grain sales over the entire year. Specifically, sales of corn in fall (Sep.1-Nov.30), winter (Dec.1-Feb.28), spring (Mar.1-May 31), and summer (June 1-Aug. 31) accounted for 20%, 22%, 32%, and 26%, respectively. Similarly sales of wheat in fall, winter, spring, and summer accounted for 30%, 18%, 25%, and 19%, respectively. (Sanjem, 1990, P31).

Decisions to store grains at harvest for sales at later dates within the crop year is influenced by farm policies relating to loan rates. The current farm program allows farmers to get a non-recourse loan at a low interest rate for about nine months from the Commodity Credit Corporation

(C.C.C.) against the collateral of grains. If the loan rate is set high relative to the market clearing price, as was the case during the 70's and early 80's, farmers will have incentives to get a C.C.C. loan at harvest time and later forfeit the grain (Knutson, et.al., 1990, P237). Since 1985, however, U.S. farm policy has been oriented to setting loan rates well below market price. As a result, farmers have to rely on market prices to make marketing decisions.

According to Shane (1992) farmers try to guess grain prices in different seasons by using the following sources of information:

A) Satellite information systems. This is used by about 20% of the farmers in eastern South Dakota. The most popular is the DTN (Data Transmission Network) satellite network system which has about a 95% market share. Other systems are ACRES and FARM-DATA. On the DTN network, information is carried on ten pages of a computer terminal screen which is continuously updated. The information ranges from international weather activities that will affect the commodity prices, radar reports, local temperatures, rainfall amounts to cash and futures prices. Only about 10-15% of S.D. farmers make price expectations based on futures market prices.

B) "Marketing Information" publications which focus on technical price analysis. These publications usually include graphs of open, close and settle prices for major commodity futures contracts for varying time periods. They also list economic and political factors that affect the prices of grains. The annual subscribing cost of about $200 for such publications is probably a deterrent for many farmers and elevator managers to use this method. As a result only 5-7% of farmers use such publications.

C) Price data reported in the mass media. Local and regional newspapers usually list the prices for major commodities for the three or four nearby futures contracts. Major grain prices are also reported on the radio and television. Farmers try to project prices mentally based on these prices reported in the media and the typical seasonal trends in recent years.

D) Studying weather conditions. Weather conditions also have an important bearing on commodity prices. Most estimates are adjusted for possible impacts of weather conditions. For example, the predictions are adjusted upward if there is a drought in the major growing areas of a commodity. Similarly, if there is favorable weather or a forecast of favorable weather during the growing season in the major growing area of a commodity, price expectations for commodity are adjusted downwards.

These sources of information indicate a lot of guess-work in the marketing of grains. Identifying seasonal patterns in cash prices can provide important information and help farmers improve their decisions regarding storage and timing of sales.

1.2 SCOPE OF STUDY

This study analyzes monthly prices for corn, wheat and oats. Corn, wheat and oats account for 22.0, 22.4, and 6.4 percent of harvested acres in South Dakota (Table 1.1).

Table 1.1: Selected crop acreage harvested in South Dakota; average for 1988-1990.

	HARVESTED LAND	
CROPS	Acres Harvested (in 1000).	(Ave. % of total for 1988, 89 & 90)
Corn	3262	22.0
Wheat (All)	3316	22.4
Oats	950	6.4
Soybeans	1843	12.4
Hay	4133	21.8
Others	3876	15.0
TOTAL	17380	100.0

(Source: South Dakota Agriculture Statistic, 1984-1990, 1990-1991 and 1991-1992)

The prices used in this analysis are the average monthly prices received by farmers for corn, all wheat, and oats for both South Dakota and the United States.

1.3 THE OBJECTIVE OF THE STUDY

The overall objective of this study is to identify the seasonal patterns in S.D. cash prices (received by farmers) for corn, wheat, and oats. Seasonality in S.D. cash prices may be different from the seasonality in the U.S. cash prices for a commodity. The reasons for this may be differences in the seasonal supply and demand for the commodity and the supply and demand for substitutes. The availability and price of storage and transportation can also have substantial impact on regional commodity price seasonality. Therefore, it is important that the relationship between the seasonal fluctuations in S.D. cash prices and the seasonal fluctuations in the U.S. cash prices be analyzed.

Since the seasonal indexes are computed using historical data, it is important to investigate the impact of the length of the historical data series on the reliability of the seasonal indexes.

For each of the selected grains, corn, wheat, and oats, the specific objectives are as follows:

1) To identify the seasonal patterns in S.D. and U.S. cash prices.
2) To investigate if the seasonal patterns in S.D. cash prices are different than the seasonal patterns in the U.S. cash prices.
3) To investigate if the seasonal pattern in S.D. and U.S.

cash prices are changing over time.

4) To analyze the impact of the length of the historical data series on the reliability of the forecasted price patterns.

1.4 THE ORGANIZATION OF THE THESIS

This thesis is divided into five chapters. The second chapter following this introduction deals with the review of literature. The research methods and the data are discussed in chapter three. The results and conclusions are presented in chapter four. Finally, a summary and implications of this research is discussed in chapter five.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 AN OVERVIEW OF FORCES DETERMINING GRAIN PRICES

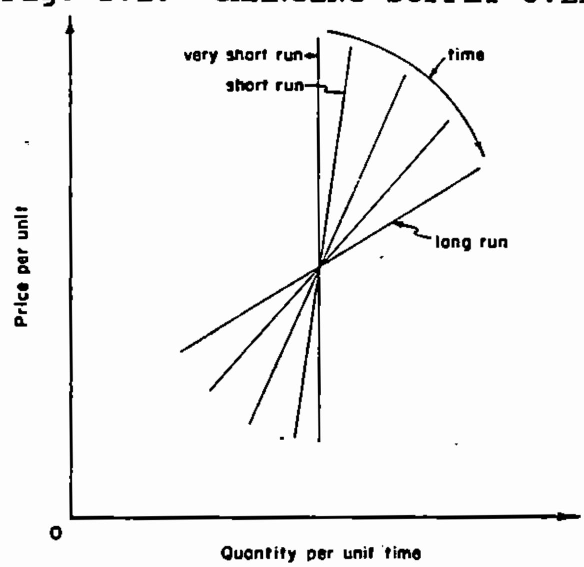
2.1.A NATURE OF SUPPLY

The market for grains is the closest example to perfect competition, where prices should be stable, but the biological nature of farm products renders farms susceptible to biostress which can result in price instability. For example, farm prices are greatly affected by unfavorable weather, diseases or insect infestations. Yields can fall short of expected levels, and farmers require at least a year to respond to price signals and change levels of production. As a result, the fluctuations in farm production are greater than for non-farm products (Tomek, et. al., 1981, P18). Thus an even more rigorous analysis of prices has to be carried out for farm products than non-farm products.

Despite the biostress the changes in prices are never as abrupt as in other industries. This is because of the low concentration level of farm production. Thousands of farms are required to supply 80% of the value of the sale (Tomek, et. al. P19).

In the short run, if there are no reserve stocks or imports and the current crop cannot be stored, the supply curve is perfectly inelastic (Fig. 2.1). In such a case, the quantity offered for sale can neither be increased nor decreased whatever the price offered. If the current price is too low, however, less will be grown in the next season. Supply can also be reduced if a part of the crop is not harvested in response to a very low price level. If the commodity is storable, the farmer can also alter quantities for sale in different seasons within a year (Knutson, et. al., 1990, P237).

Fig. 2.1: CHANGING SUPPLY OVER TIME



Source: Tomek, et. al., 1981, P76

Over the longer period, the area planted to a commodity can also be varied. As a result, the longer the time allowed for adjustment, the more elastic the supply.

Villezca-Becerra and Shumway (1992, P22) estimated state level output supply and input demand elasticities for many agricultural commodities grown in California, Iowa, Texas, and Florida, over the period 1951-90. The results showed that nearly all output supply elasticities for crops were inelastic. The output-input relationships across states showed that crop supplies decreased as input prices increased, and input demands increased as crop prices increased. Thus with a better forecast of seasonal patterns in grain prices, farmers can make higher profits by timing the sales to benefit from price seasonality.

When making decisions on storage, a S.D. farmer should also carefully study the weather patterns and production in major producing areas in the U.S. Similarly, the weather pattern and its impact on the world production should not be ignored. For example, the production of wheat in Canada, Australia, and Argentina affects grain price in the U.S.

2.1.B NATURE OF DEMAND

The demand for grains is basically a derived demand, i.e., driven by the demand for other products. For example, the demand for corn is driven by the demand for beef, pork, and poultry. Among other factors, the demand for grains is affected by consumer income levels and the size of the population. The demand for corn as feed also depends on the price of corn relative to the price of other grains and ingredients. As a result, the demand for corn is positively related to the size of the population and consumer income level, and negatively related to the price of other feed ingredients and grains.

A change in consumer attitudes toward consumption of meat as well as a mix of different meats also plays an important role in the determination of demand for corn. Since the feed to meat conversion ratio is quite low for beef and quite high for chicken, increased substitution of chicken for beef in consumers' diets will also shift the demand for corn to a lower level.

Similarly, the demand for wheat is also driven by demand for wheat products. Therefore, the demand for wheat is positively related to the population size and the level of consumer income, and inversely related to the price of wheat relative to other cereals. A change in consumer attitudes and preferences can also influence demand for wheat.

The U.S. is also a major exporter of grain especially corn and wheat. In the 1985-1986 period 19% and 42% of corn and wheat produced in the U.S. were exported (Kohls, et. al., 1990, P114). Therefore, the foreign demand for grain is an important force in the determination of U.S. price. The potential for U.S. grain export depends on grain production and the net grain surplus over shortfall in major trading countries.

It may be pointed out that demand for grain more or less spreads over the entire year; whereas, grain production is seasonal in nature. In order to match the production with demand, grains must be stored; and this is not free of cost. The cost of storage is discussed in the next section.

2.1.C STORAGE COST

Most farmers have some farm storage capacity. Storing grain on farm is not only convenient but also provides more marketing flexibility. Farmers can also store grain in commercial storage at an elevator. Studies have shown that the cost of storing in bins is close to commercial rates, which was about three cents per month in 1984 (Ferris, 1992, P3). The cost of farm storage includes the following components:

1) Transportation cost - incurred for moving the grain to and from the elevator, including labor, renting of equipment (trucks, grain wagons, dryers and augers) and fuel used in putting the corn into the bin and taking it out.
2) Repair of auger, bin, dryer, or truck while moving grain into and out of the bin.
3) The cost of aerating the bin, fumigation, and the labor for maintenance of the bins.
4) Insurance on the grain.
5) Loss due to spoilage, especially if there is too much rainfall and moisture in the air.

6) The discount due to the quality loss in the grain as it ages and shrinks.

7) The loss in premium which a farmer can get if he sells newly harvested grain.

8) The opportunity cost of the cash if the grain was sold at harvest, i.e., the return that could be obtained if the cash received from grain sales at harvest is invested in some alternative farm or financial assets. This opportunity cost should be compared with the benefits of getting a loan from the Commodity Credit Corporation (C.C.C.) on the stored grain.

9) Depreciation of bins, dryers, and augers.

For any given farmer and any given length of storage period, the storage cost per bushel will be a constant, because he/she has already invested in the fixed cost of the storage (bins, augers, etc.). However, if the farmer try to store a quantity which is more than the storage capacity available at the farm, he will have to build a new bin or rent one. As a result, his storage cost per bushel will probably increase. In general case, the storage cost will be an increasing function of the quantity stored.

2.1.D TO STORE OR NOT TO STORE -- A THEORETICAL MODEL

The decision to store for sale at a later time is influenced by a number of factors. Most important of these factors are the relevant storage costs, the expected increase in price of the commodity during the period of storage, the decision analyzer's attitude towards risk and the level of confidence in the expected price increase. The impact of these factors on the decision to store and the quantity stored can be shown in the context of a utility maximization model. The work on portfolio selection by Markowitz (1959) provided the first conceptual basis for widely used risk minimizing models in the mean variance framework. Following Markowitz, Heifner (1973), Peck (1975), and a number of other authors modeled risk minimizing behavior in a similar framework. In these studies the producers' expected utility is specified such that its value increases with an increase in the expected profit and decreases with an increase in the variance of the profit depending upon the decision makers' degree of risk aversion. This framework provides a simple but quite powerful approach to analyze the decision to store for sales at a later date. All the primary factors that affect a farmer's decision to store grain are included. The expected profit from storing grain can be defined as

$$E(\pi)=Q_k[E(P_{t+k}-P_t)-S_k], \qquad (1)$$

where:

Q_k = Quantity of the grain stored for period k at time t.

E = Expectation operator.

S_k = Per unit storage cost at time t for grain stored for period k with $\partial S_k/\partial Q_k=0$ and $\partial^2 S_k/\partial Q_k^2 > 0$ (to minimize storage cost).

P_t = Per unit price of the grain at time t.

P_{t+k} = Per unit price of the grain at time t+k, a random variable with Expectation = $E(P_{t+k})$ and Variance in equation (2).

The variance of the profit π will be:

$$var(\pi)=Q_k^2\sigma^2_{P_{t+k}} \tag{2}$$

Assuming that the expected utility of a decision maker can be reflected in the mean variance utility framework,

$$E(u)=E(\pi)-\lambda var(\pi) \tag{3}$$

where λ = risk aversion parameter, $\lambda>0$ for a risk adverse decision maker.

Substituting (1) & (2) in (3) gives:

$$E(u)=Q_k E(P_{t+k}-P_t)-Q_k S_k-\lambda Q_k^2\sigma^2_{P_{t+k}} \tag{4}$$

The quantity of grain stored which will maximize E(U) can be easily obtained by differentiating (4) with respect to the Q_k and setting it equal to zero.

$$\frac{\partial E(u)}{\partial Q_k}=E(p_{t+k}-P_t)-S_k-2\lambda Q_k\sigma^2_{P_{t+k}}=0 \tag{5}$$

rearranging the terms in (5),

$$Q_k^* = \frac{E(P_{t+k}-P_t)-S_k}{2\lambda\sigma^2_{P_{t+k}}} \; ; \tag{6}$$

Q_k^* is valid only if:

{ $E(.)-S_k>0$ and $\lambda>0$ }, or

{ $E(.)-S_k<0$ and $\lambda<0$ }; and

$Q_k^* = 0$ if:

{ $E(.)-S_k\leq 0$ and $\lambda>0$ }, or

{ $E(.)-S_k>0$ and $\lambda<0$ },

$$\text{as long as } \frac{\partial^2 E(U)}{\partial Q_k^2} = -2\lambda\sigma^2_{P_{t+k}} < 0. \tag{7}$$

From (6), the following conclusions can be deduced:

(1) The larger the value of λ, the smaller will be the Q_k^*; i.e., other things being the same, the more risk averse the individual is, the smaller will be the quantity stored.

(2) The higher the $E(P_{t+k}-P_t)$, the higher the Q_k^* will be; i.e., other things being the same, the greater the price increase expected during the time of storage, the greater will be the quantity of grain stored.

(3) The higher the S_k, the smaller the Q_k^* will be; i.e., other things being the same, an increase in the storage cost for the marginal bushel stored will result in a smaller quantity of grain stored.

(4) The higher the variance of P_{t+k}, the lower the Q_k^*; i.e.,

other things being the same, the lower the confidence in the expected increase in the price during the storage, the smaller will be the quantity of grain stored.

2.2 EMPIRICAL STUDIES ON SEASONAL PRICE PATTERNS FOR GRAINS

2.2.A FERRIS

Ferris (1992) analyzed the seasonal price patterns in Michigan for a number of commodities. For wheat he analyzed soft red wheat Chicago prices from 1960-91. The SEASON program was used to generate the price index and a projected seasonal index for 1991 and 1992. He disaggregated the price movements into trends, cycles and seasonal components. Trend was defined as consistent price movements over a number of years, Cycles were defined as the regular up and down changes that cover a number of years, and Seasonal were defined as the regular patterns within a year.

Ferris noted that on-farm storage cost was about three cents per bushel per month in 1992, which was mainly foregone interest and a small cost of maintaining the grain quality. So over the period June (harvest time) to January the cost of storage was 3 × 6 = 18¢ per bushel. Assuming the harvest price is $2.75 to $3.00, a 7.5% increase in the projected price index over that six months corresponds to a price increase of 20¢ to 23¢ per bushel. This is more than the storage cost. Thus there is a potential for profit.

Another more direct approach was to look at the raw data. Considering the monthly average prices in the top section of Table 2.1, one could compare the prices between any two or more months and develop strategies for storage. For example, between October and the following January, wheat prices increased by an average of 9¢ per bushel in the 15 years from 1975-76 crop year to the 1989-90 crop year. With 3¢ per bushel per month storage cost (3 cents × 3 months = 9 cents), regular storage would have been a breakeven proposition and storage would have paid off in only six out of the fifteen years. Thus there is a 40% (6/15 × 100%) probability that storage will pay off if wheat was stored between October and January.

From January to June, the average price increase in this period was 17¢ per bushel compared with an assumed 15¢ per bushel storage cost, just over the breakeven level. Storage between January and June would have been profitable in 8 out of 15 years, or a 53% (8/15 × 100%) chance of making a profit.

Table 2.1: Seasonality of cash soft red wheat prices at Chicago.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1960	2.03	2.01	2.06	2.11	2.07	1.91	1.85	1.88	1.93	1.97	2.02	2.08
1961	2.15	2.14	2.07	1.93	1.98	1.89	1.94	1.90	1.98	2.01	2.05	2.09
1962	2.06	2.04	2.08	2.13	2.17	2.17	2.15	2.11	2.07	2.05	2.10	2.13
1963	2.13	2.11	2.11	2.16	2.13	1.96	1.84	1.83	1.97	2.15	2.17	2.20
1964	2.24	2.21	2.03	2.12	2.03	1.53	1.43	1.46	1.49	1.52	1.55	1.52
1965	1.53	1.53	1.51	1.49	1.46	1.44	1.48	1.55	1.58	1.59	1.66	1.69
1966	1.71	1.71	1.63	1.64	1.66	1.79	1.90	1.90	1.86	1.72	1.76	1.80
1967	1.71	1.70	1.80	1.73	1.67	1.58	1.50	1.49	1.51	1.52	1.45	1.46
1968	1.49	1.51	1.50	1.41	1.38	1.30	1.28	1.22	1.20	1.25	1.32	1.33
1969	1.38	1.36	1.32	1.32	1.33	1.28	1.30	1.27	1.31	1.36	1.41	1.48
1970	1.49	1.55	1.53	1.55	1.48	1.41	1.43	1.52	1.67	1.74	1.77	1.74
1971	1.75	1.74	1.70	1.67	1.61	1.64	1.54	1.45	1.45	1.53	1.60	1.71
1972	1.69	1.61	1.62	1.66	1.63	1.46	1.53	1.76	2.02	2.11	2.28	2.60
1973	2.65	2.47	2.37	2.45	2.71	2.82	3.08	4.75	5.11	4.75	5.47	5.84
1974	6.30	6.50	5.59	4.33	3.48	3.91	4.40	4.34	4.41	5.03	4.98	4.60
1975	4.02	3.84	3.62	3.63	3.25	3.03	3.42	3.82	4.06	3.84	3.49	3.32
1976	3.45	3.78	3.66	3.34	3.30	3.47	3.37	3.01	2.89	2.72	2.60	2.66
1977	2.73	2.74	2.63	2.53	2.35	2.29	2.20	2.08	2.20	2.27	2.59	2.65
1978	2.69	2.64	2.82	3.11	3.14	3.19	3.22	3.32	3.42	3.51	3.68	3.68
1979	3.73	3.88	3.79	3.60	3.86	4.36	4.39	4.23	4.28	4.30	4.13	4.26
1980	4.36	4.39	4.18	3.96	4.04	3.96	4.17	4.21	4.38	4.70	4.92	4.54
1981	4.57	4.34	4.15	4.18	3.80	3.60	3.70	3.70	3.87	3.97	4.08	3.86
1982	3.77	3.57	3.59	3.70	3.43	3.31	3.36	3.35	3.18	2.98	3.33	3.23
1983	3.32	3.40	3.36	3.51	3.55	3.53	3.59	3.71	3.62	3.56	3.42	3.55
1984	3.47	3.34	3.57	3.65	3.65	3.51	3.44	3.49	3.47	3.51	3.62	3.49
1985	3.51	3.55	3.55	3.63	3.34	3.27	3.09	2.87	2.83	3.04	3.33	3.46
1986	3.34	3.37	3.40	3.39	3.25	2.52	2.58	2.44	2.36	2.57	2.73	2.76
1987	2.87	2.91	3.11	3.16	3.08	2.63	2.54	2.61	2.77	2.82	2.80	3.00
1988	3.23	3.23	2.94	3.02	3.13	3.56	3.52	3.61	3.84	4.07	4.09	4.25
1989	4.39	4.30	4.31	4.04	4.07	3.87	3.92	3.94	3.93	4.07	4.07	4.03
1990	4.03	3.92	3.61	3.83	3.71	3.26	3.04	2.83	2.62	2.62	2.53	2.52
1991	2.50	2.53	2.78	2.80	2.83	2.86	2.79	2.97	3.24	3.50	3.57	3.79

INDEX OF SEASONALITY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INDEX	104.3	103.6	101.4	100.5	98.1	94.8	95.0	96.2	98.2	100.0	102.6	103.6
STD DEV	5.7	6.4	6.0	7.3	8.2	7.7	6.8	6.8	6.6	6.0	5.7	5.3
TREND	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	-0.1	0.0	0.0	-0.1

PROJECTED SEASONAL INDEX

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1991	103.9	103.1	101.7	102.6	100.1	96.3	96.3	96.5	97.4	100.0	102.6	102.5
1992	103.8	103.1	101.7	102.7	100.3	96.4	96.3	96.5	97.3	100.0	102.6	102.5

Source: Ferris, 1992

2.2.B OBER

Ober (1988) studied S.D. wheat marketing practices and seasonality. The two categories of wheat he studied were S.D. Hard Red Winter (HRW) wheat and Hard Red Spring (HRS) wheat. He used the cash prices for S.D. wheat delivered to Minneapolis which he found to be the predominant destination for S.D. wheat. The data series was the daily cash price reported at the Minneapolis Grain Exchange (MGE) for HRS wheat and HRW wheat from July 1, 1980, through December 30, 1986. HRS wheat prices were classified according to protein levels, from ordinary (10.5 %) protein HRS wheat through 17% protein HRS wheat. HRW wheat prices were separated according to protein levels from ordinary to 16%. The protein premiums for HRS wheat and HRW wheat for the same period were calculated by subtracting closing futures prices from daily cash prices. This method of calculating premium is different from elevator method S.D. farmers are accustomed. At the elevators wheat of 13.0% to 13.5% protein is taken as the base price. Protein premiums are offered for wheat with higher protein content and protein discounts are associated with wheat of lower protein content. In Ober's survey, he found the majority of the HRW wheat marketed in S.D. to be of 10% to 14% protein content. He classified the HRW wheat into ordinary protein HRW wheat, 12% protein, and 14% protein. Similarly, he classified the HRS wheat into 12% protein, 14% protein, and 16% protein. The X11 (discussed in 2.4.A) program was used to analyze the seasonality of wheat prices. Actual prices were converted to price indexes (monthly price divided by average for the year multiplied by 100%) with the program.

Ober concluded that there was strong statistical (99% confidence) evidence showing stable seasonal price pattern for both HRW wheat and HRS wheat. The statistical tools used by him were standard deviation, confidence interval, coefficient of variation, regression analysis, and F-test. All six protein levels had similar yearly price pattern, though the yearly highs fell at a different time for different protein levels. The higher the protein level the earlier was the seasonal high. He reported that for all protein levels there is a larger variation in cash prices for April through September as compared to other months. This period corresponds to the planting and harvesting seasons.

Ober found that the absolute cash prices did follow the futures prices. Cash prices were consistently higher in November for all protein levels of wheat. Higher protein levels of wheat had a more positive impact on the cash prices of all wheat.

The main limitation of this study was that, the data series Ober used covered only seven year. This could cause the long term trend, or business cycle components to be inaccurate.

2.2.C HOFFMAN AND DAVISON

Hoffman and Davison (1992) made use of futures prices to forecast cash prices for U.S. soybeans. The historical monthly average basis was computed and deducted from nearby futures price to obtain a monthly farm price forecast. To compute the season average price the monthly price forecasts were weighted by the fraction of crop marketed in each month. The results provided a reasonably accurate forecast of the season average price received by farmers.

2.3 EMPIRICAL STUDIES ON SEASONAL PRICE PATTERNS FOR OTHER COMMODITIES.

2.3.A BLAKE AND CLEVENGER

Blake and Clevenger (1984) used a linked annual and monthly model for forecasting alfalfa hay prices. They developed a regression model to forecast the monthly alfalfa hay price before the first harvest. Basically, they specified the price for each month as a function of the price in the preceding month.

2.3.B LEUTHOLD

Leuthold (1992) evaluated the performance of the frozen pork belly futures market for the period 1970-1990. He tried to determine whether the seasonality in frozen pork belly futures had changed over time. He computed the average difference in the highest and lowest price indexes and the average coefficient of variation measures for different time periods (1970-1974, 1975-1979, 1980-1984, 1985-1990).

2.4 REVIEW OF STATISTICAL MODELS AND COMPUTER PROGRAMS FOR SEASONALITY ANALYSIS

2.4.A THE X11 PROGRAM

The X11 program is based on techniques developed by Frederick R. Macaulay in the 1920's for the Bureau of Census Department (Shiskin, et. al., 1976). X11 program uses the ratio-to-moving average technique. This program, now a part of the SAS software package, divides the data into:

a) Seasonal, S - Seasonal variations are the intrayear variations that are repeated constantly on an evolving fashion from year to year.

b) Cyclicical, C - This is the cyclical variation that occur over several years, like the business cycle.

b) Trend, T - Trend is the long term linear variation.

d) Irregular components, I - The irregular component are the residual variations or the short term variations of the data, such as sudden impacts, political events, unseasonal weather, and reporting and sampling errors.

This program does not provide a forecast automatically. It is more useful for seasonally adjusting monthly or quarterly time series. The adjustments can be specified either as additive (original time series = O_t = S+C+TD+I) or multiplicative (O_t = S×C×TD×I). Once the adjustments are specified, the X11 provides an output data set containing the adjusted time series (SAS Institute Inc., 1990).

2.4.B THE ARIMA MODEL

The ARIMA (Autoregressive Integrated Moving Average model) model was introduced in 1970 by Box and Jenkins for engineering purposes. It has since been incorporated in SAS. proc ARIMA as it is called in SAS, has been used mainly in analysis of economic time series where the data points are limited and forecasting is the main aim (Shumway, 1988). The ARIMA procedure models a value in the time series as a linear combination of its past values, past errors (shocks), and past values of other time series. The input time series have to be independent of each other (SAS Institute inc.). In a simple form, the ARIMA model relates X_t, the value of X at time t, to X_{t-1}, the value of X at time t-1 and W_t, an error term; i.e., $X_t = X_{t-1} + W_t$ (Shumway, 1988, P129). In a relatively more usable form, the ARIMA model includes two parameters, the autoregressive and the moving average parameter (A_1 and B_1 respectively).

The ARIMA model is an integration of two models, namely, the autoregressive (AR) and the moving average (MA) models. The autoregressive model is defined as follows:

$$X_t = (A_1X_{t-1} \ldots + A_pX_{t-p}) + E_t \qquad (8)$$

where A_i is the autoregressive parameter.

And the moving average model is defined as:

$$X_t = -(B_1E_{t-1} \ldots + B_qE_{t-q}) + E_t \qquad (9)$$

where B_i is the moving-average parameter, and p and q are the order of the model. Combining (8) & (9) yields the ARMA model:

$$X_t = (A_1X_{t-1} \ldots +A_pX_{t-p}) - (B_1E_{t-1} \ldots +B_qE_{t-q}) + E_t \qquad (10)$$

These models, AR, MA and ARMA are called differenced or stationary series. For nonstationary series an additional term, the trend parameter, is added. The equation for the ARIMA (I stands for Integrated) model is:

$$X_t = B_o + (A_1Z_{t-1} \ldots A_pZ_{t-p}) - (B_1E_{t-1} \ldots +B_qE_{t-q}) + E_t \qquad (11)$$

where B_o is the trend parameter (Hoff, 1983).

2.4.C THE SEASON PROGRAM

The SEASON program uses the idea of projecting a moving average indexed price as done by the ARIMA model. The SEASON program was written specifically to enable the study of economic time series of prices of agricultural commodities.

It computes measures of seasonality which are variants of the ratio-to-moving-average procedure. The ratio-to-moving average procedure is used to define the seasonal trend in prices and also project the seasonal trend. The program was written to isolate and measure seasonality in economic time series.

The program calculates simple averages by period, averages of differences or ratios between successive periods, averages of differences or ratios between the original observations and any moving average of the original observations. It also calculates the averages of differences or ratios between the original observations and the annual averages.

The SEASON program was written in FORTRAN. The user is encouraged to write subroutines in FORTRAN to expand the capabilities of the program. The program can handle 24 or fewer observations per year and 360 or fewer total observations. But this limitation can be altered by changing the DIMENSION statement at the beginning of the FORTRAN program.

The program enables techniques proposed by Hannan for computing seasonal constants when a moving average is used which does not weigh all of the periods equally. Often the seasonal component is constant from year to year and the trend plus cycle component cannot be adequately represented by a moving average formula which weighs all periods equally.

In such cases, Hannan's techniques can be used in the SEASON program. When using a moving average technique to analyze a time series, the peaks and valleys are cut across leaving the underlying cycle. Using a moving average process such as the Spencer five point formula and Hannan's correction, it is possible to compute cycle plus trend components which reach higher into the peaks and lower into the troughs than by using formulas which have equal weighs for all periods.

Compared to the X11 and proc ARIMA, the SEASON program was the most user friendly; mainly because microcomputers which are used to run it don't require as much waiting time as when using mainframe terminals (both X11 and proc ARIMA require this). The outputs are also smaller and this saves time in printing and reviewing results.

The procedures to use the SEASON program are shown in the first part of the appendix.

Table 2.2: Input to the SEASON program

```
12
SEPOCTNOVDECJANFEBMARAPRMAYJUNJULAUG
060601
  1  2  2  2  2  2  2  2  2  2  2  2  1


01050204020711
01011993
CASH PRICES RECEIVED BY S.D. FARMERS (CORN)
091970081991
(2X,12F5.2)
70 1.21 1.17 1.18 1.21 1.26 1.29 1.30 1.30 1.31 1.32 1.27
71 1.11 1.00 1.00 1.03 1.05 1.07 1.07 1.07 1.11 1.11 1.11
72 1.10 1.08 1.01 1.16 1.19 1.19 1.17 1.19 1.33 1.71 1.72
73 1.97 1.97 1.95 2.15 2.30 2.43 2.48 2.28 2.34 2.41 2.70
74 3.33 3.30 3.30 3.26 3.10 2.89 2.63 2.73 2.75 2.72 2.68
75 2.83 2.54 2.29 2.33 2.34 2.36 2.39 2.38 2.48 2.75 2.79
76 2.64 2.36 2.19 2.29 2.40 2.35 2.46 2.36 2.34 2.13 1.86
77 1.54 1.50 1.67 1.68 1.80 1.81 1.92 2.05 2.10 2.06 1.88
78 1.70 1.61 1.68 1.87 1.85 1.95 1.91 1.94 2.06 2.21 2.29
79 2.03 1.88 1.79 1.91 1.98 2.01 1.99 2.04 2.12 2.25 2.46
80 2.61 2.70 2.94 2.95 3.06 3.04 3.03 3.06 3.02 3.00 3.00
81 2.42 2.13 2.14 2.21 2.31 2.34 2.35 2.42 2.44 2.44 2.16
82 2.08 1.93 1.88 1.93 2.13 2.38 2.53 2.78 2.79 2.84 2.90
83 3.03 2.94 3.00 3.03 3.03 2.95 3.05 3.17 3.25 3.23 3.15
84 2.85 2.42 2.39 2.50 2.44 2.46 2.49 2.54 2.53 2.54 2.50
85 2.29 2.05 2.08 2.09 2.18 2.19 2.15 2.14 2.20 2.11 1.92
86 1.33 1.29 1.32 1.33 1.30 1.29 1.30 1.45 1.57 1.61 1.52
87 1.37 1.37 1.47 1.59 1.64 1.69 1.78 1.78 1.88 2.33 2.75
88 2.50 2.43 2.45 2.41 2.46 2.46 2.45 2.39 2.44 2.40 2.29
89 2.02 2.00 2.07 2.13 2.09 2.10 2.17 2.37 2.46 2.44 2.43
90 2.07 1.92 1.91 2.01 2.07 2.14 2.23 2.28 2.23 2.17 2.13
0002
END
```

Table 2.3: A list of the output from the SEASON program.

1) Distribution of seasonal components:
   - i) Monthly means.
   - ii) Standard error of mean.
   - iii) Standard deviation.
   - iv) Correlation of means.
   - v) Mean minus standard deviation.
   - vi) Mean plus standard deviation.

2) Least square trend statistics:
   - i) A and B value.
   - ii) Standard error of B.
   - iii) T-value.
   - iv) R-square.
   - v) Correlation of A and B.
   - vi) Standard deviation for forecasted year.
   - vii) Correlation estimate for forecasted year.
   - viii) Estimate minus standard deviation for forecasted year.
   - ix) Estimate plus standard deviation for forecasted year.

3) Seasonality of cash price:
   - i) Index of seasonality, i.e. the average index for each month.
   - ii) Average standard deviation for each month.
   - iii) Average trend for each month.

4) Projected seasonal index for two years in the future.

2.5 CHAPTER SUMMARY

The listed conditions for storing an amount of grain (see page 15 and 16) all relate to having a better understanding of grain price movements and forecast. More grain will be stored with a smaller value of λ (the risk aversion parameter), a higher value of $E(P_{t+k}-P_t)$ (the expected increase in price), lower S_k (per unit storage cost), and lower the variance of P_{t+k} (price at a future time). All these factors will be more predictable or favorable for storing grain if the farmer has a better idea of when prices will rise or fall within the year.

The seasonal price index is computed by dividing the monthly price by the average price for the year and multiplying it by 100. The SEASON program can calculate the average seasonal index for a specific number of years. It also provides the average yearly changes in the monthly indexes to reflect changes in the seasonality. The SEASON program enables computation of large number of indexes for different time periods for comparison of seasonality in S.D. and U.S. The price index computation method ensures that the natural basis (the difference between S.D. price and U.S. price) does not interfere with the comparison and automatically limits the inflation bias, if any, to within one year. The SEASON program will also list an out-of-sample monthly indexes for two years beyond the data series.

CHAPTER THREE

RESEARCH METHODS

This chapter describes the procedures used to make the analysis for the research. There is a section devoted to each of the objectives listed in chapter one.

3.1 DATA, SOFTWARE, AND EQUIPMENT

The data used for this research are the USDA (U.S. Department of Agriculture) average monthly price received by farmers for corn, wheat and oats for S.D. and U.S. from 1948 to 1991. The S.D. data for 1948 to 1990 were obtained from Wayne Ellingson. The U.S. data for 1960 to 1990 were obtained from Michigan State University, and the U.S. data from 1948 to 1959 were obtained from South Dakota Agricultural Statistics Service of Sioux Falls, S.D.

The data were converted to Quattro Pro 4.0 spreadsheets, which were used in most of the calculations, and for plotting graphs. The SAS (Statistical Analysis System) program was used initially on the mainframe and later more efficiently on the microcomputer. The SEASON program was used extensively to find price indexes and to forecast prices based on indexes. Since the SEASON program required the data input in ASCII format, the data in Quattro spreadsheets were imported into Wordperfect 5.1 and then converted to ASCII.

In this thesis a year refers to the marketing year which starts in September and ends in August. For example, the year 1990 is actually the marketing year starting in September 1990 and ending in August 1991. Accordingly, the first month refers to September, the second month refers to October, and so on. Prices refers to prices received by farmers.

3.2 DETERMINING THE SEASONAL PRICE PATTERN

The seasonal price index patterns of cash prices were determined by using the SEASON program. The SEASON program first calculates the average price for each year, the actual price for each month of the year is divided by this average price, and multiplied by 100 to get the price index for each month. This procedure limits the affects of inflation to within one year. Thus all the actual prices are changed to price indexes. Next, the average of the price index for each of the twelve months, for all the years in the data series, is calculated. This procedure was followed to derive the seasonal price patterns for corn, wheat and oats for S.D. as well as U.S.

3.3 COMPARING THE DIFFERENCE IN S.D. AND U.S. PRICE PATTERNS

The indexes for both South Dakota and the United States were plotted and appeared to follow a cubic functional form. Following the suggestion of Lamberton (1992) and Lacher (1992), in order to determine if the seasonal price pattern for S.D. was significantly different from the seasonal pattern for the U.S., the Full/Reduced model framework was utilized. Specifically, the test was applied on the 21-year average price index for S.D. and U.S. as follows.

Full model:

$$Y = \beta_0+\beta_1X+\beta_2X^2+\beta_3X^3+\gamma_0D+\gamma_1DX+\gamma_2DX^2+\gamma_3DX^3+\mu \qquad (12)$$

where:

Y = Price index
X = month (1 = Sept., 2 = Oct.,.....12 = Aug.)
D = Shift variable (0 for S.D. and 1 for U.S.)
μ = random error

If D = 0 or/and when $\gamma_0 = \gamma_1 = \gamma_2 = 0$, (12) reduces to (reduced model):

$$Y = \beta_0+\beta_1X+\beta_2X^2+\beta_3X^3+\mu \qquad (13)$$

if D = 1, (12) reduces to:

$$Y = (\beta_0+\gamma_0)+(\beta_1+\gamma_1)X+(\beta_2+\gamma_2)X^2+(\beta_3+\gamma_3)X^3+\mu \qquad (14)$$

Given this framework, the following null hypothesis (H_o) and alternate hypothesis (H_a) are applicable:

Ho: $\gamma_0 = \gamma_1 = \gamma_2 = \gamma_3 = 0$

=> reduced model is appropriate, and

Ha: at least one of $\gamma_i \neq 0$.

If $\gamma_0 = \gamma_1 = \gamma_2 = \gamma_3 = 0$ holds, then the full model will not be any better fit to the data and the error sum of squares from reduced model will not be significantly larger as compared to the error sum of squares from the full model. Therefore, the following F-statistics test is appropriate.

$$F^* = \frac{(SSE_r - SSE_f)/(k-m)}{SSE_f/(n-k-1)} \tag{15}$$

where:

SSE_r = error sum of square for reduced model,
SSE_f = error sum of square for full model,
n = number of data points used (24 in this case),
k = number of predictor variables in the full, model (12 in this case), and
m = number of predictor variables in the full model but not in the reduced model (13 in this case).

Reject H_o if $F^* > F_{\alpha,K-m,n-k-1}$ where α is the predetermined level of significance.

The data input for each grain was created by stacking the S.D. and U.S. data observations as shown in the Table 3.1. The first 12 rows contain the data for S.D. and the next 12 rows contain the data for U.S.

Table 3.1: Format of input data for Full/Reduced model. 1/

Y	X	D
98.00	1	0
92.50	2	0
92.60	3	0
96.00	4	0
97.80	5	0
98.60	6	0
99.40	7	0
101.20	8	0
103.90	9	0
106.60	10	0
105.30	11	0
103.60	12	0
98.20	1	1
95.80	2	1
96.20	3	1
99.30	4	1
98.80	5	1
99.00	6	1
99.20	7	1
100.20	8	1
102.00	9	1
103.60	10	1
101.80	11	1
99.60	12	1

1/ This data (in ASCII) is for corn in S.D.

The parameters in equation (12) were estimated by using the ordinary least square (O.L.S.) method. $\alpha = 0.01$ was chosen.

If the null hypothesis is rejected the reduced model is appropriate. This means the cubic graph for S.D. is different from the cubic curve for the U.S. This implies that the seasonal pattern of S.D. prices is different from the seasonal pattern in U.S. price.

3.4 INVESTIGATING THE CHANGES IN THE SEASONAL PRICE PATTERNS OVER TIME

The seasonal price pattern can change over time. Even if the seasonal patterns in S.D. prices differ from the seasonal patterns in U.S. prices, one would expect that over time, given improved communications and transportation, the S.D. price patterns may approach the U.S. price patterns. In this regard, changes over time in the relative differences in S.D. seasonal price patterns and U.S. seasonal price patterns were analyzed. For the preliminary analysis the indexes for S.D. prices and U.S. prices for different spans of time period were graphed and visually compared. In addition four other techniques were utilized for this investigation:

1) The Full/Reduced model. This model previously described, was used to compare S.D. prices with U.S. prices for different time spans. A low F statistic value indicates that the seasonality of S.D. price and U.S. price are

similar. Different time periods for this analysis were 1960-90, 1965-90, 1970-90,1975-90, 1980-90, and 1985-90 (i.e. 31, 26, 21, 16, 11 and 6 years respectively).

2) The coefficient of determination, r^2, between S.D. price and U.S. price for different spans of time. The value of r^2 can vary from zero to one depending upon the degree of fit. The equation below defines r^2.

$$r^2 = \frac{SSTO-SSE}{SSTO} = \frac{SSR}{SSTO} \tag{16}$$

$$\text{where: } SSE = \sum_{i=1}^{n} (Y_i-\hat{Y}_i)^2,$$

$$SSTO = \sum_{i=1}^{n} (Y_i-\overline{Y}_i)^2, \text{ and}$$

$$SSR = \sum_{i=1}^{n} (\hat{Y}_i-\overline{Y}_i)^2$$

(Neter, Wasserman and Kutner, 1989, P92-100).

It was assumed that the S.D. price (Y_i) was a function of the U.S. price (X) in the regression. The regressions were estimated using Quattro 4.0 spreadsheet. For example, for 21 years of historical data, the estimated equation was $\hat{Y} = 0.70735 + 0.687578\ X$, where $\hat{Y}$ is the estimated S.D. price and X is the U.S. price. r^2 ranges from 0 to 1.0 and approaches to 1.0 as SSR approaches SSTO, i.e.:

$$\sum_{i=1}^{n} (\hat{Y}_i-\overline{Y}_i)^2 \approx \sum_{i=1}^{n} (Y_i-\overline{Y}_i)^2 \qquad (17)$$

In other words r^2 test will indicate how closely associated are the S.D. and U.S. price. If the difference in the seasonality of S.D. prices and U.S. prices is getting less pronounced during recent time periods, the r^2 for these periods will be larger (closer to 1.0). r^2 was computed for the same time periods as were done for the Full/Reduced model in (1).

3) Comparing sum of squared differences between S.D. and U.S. prices ($\sum d^2$) for different time periods i.e.

$$\sum_{i=1}^{n} d^2 = \sum_{i=1}^{n} (\text{ S.D. price} - \text{U.S. price })^2 \qquad (18)$$

If the S.D. price is becoming more equal to the U.S. price lately, this sum should decrease with the later time spans (Evanson, 1992). Time periods used were the same as for r^2.

4) Analyzing difference between the high and low price indexes within a year. Three-year-moving average difference between the highest and lowest prices within a year were computed for S.D. as well as U.S. price indexes for the years 1970-88 for each of the grains studied. In addition, the coefficients of variation of the differences was computed for

the years 1970-88. The coefficient of variation is defined as:

$$CV = \frac{SD}{\bar{d}}$$

$$\text{where:} \quad SD = \sqrt{\frac{\sum_{i=1}^{n} (d-\bar{d})^2}{(n-1)}} \qquad (19)$$

A low coefficient of variation indicates less seasonality in the price and vice versa. The graph of coefficient of variation was compared with the graph of the loan rates in the U.S. to study how decreasing the loan rates much below cash prices (as was done in 1980, and 1985 by USDA) is related to the price variation.

3.5 RELATIONSHIP BETWEEN SAMPLE DATA SIZE AND RELIABILITY OF PRICE FORECAST

Generally, the reliability of a forecast is positively related to the number of observations in the analysis, the analysis covering the longer period is expected to lead to more reliable forecasts. Different factors influencing the regional self sufficiency, transportation cost, storage cost, and relative cost of production, as well as government farm policies, do not remain unchanged over time. Therefore, to determine if the longer time period leads to a better forecast is an empirical issue and the answer has to be specific to a commodity, location and time period (Qasmi, 1992). If enlarging the time period in the analysis improves the forecast only marginally, the issue is whether the marginal improvement in the forecast is significant enough to justify longer period for estimation.

The SEASON program computes the trend in monthly indexes. Using this trend and average index for each month, the program provides monthly forecast indexes for a period of 24 months beyond the sample time period. Of these forecasted indexes, 12 months beyond the sample time period were used. The data series of six crop years 1975-80 (six crop years) was used to make the forecast for 1981, then the data series of 1976-81 (six crop years) was used to make the forecast for 1982. This procedure was continued till annual forecasts for 1981-90 were generated. Next the data series of eleven years (1970-80, 1971-81, 1972-82, etc.) were used to produce the forecasts for 1981-90. The same was done using sixteen years' data (1965-80, 1966-81, etc.), twenty one years' data (1960-80, 1961-81 etc.), twenty six years' data (1955-80, 1956-81 etc.), and thirty one years' data (1950-80, 1951-81 etc.). Thus, data series of 6, 11, 16, 21, 26 and 31 years size were used to generate forecasts for the years 1981-90. These data series are shown in Table 3.2. A total of 540 forecasts was made for this analysis.

With all the monthly forecast indexes for 1980-90 at hand, the next step was to convert the price index to

Table 3.2: Data series of different sizes used to make forecast for 1981-90.

Forecast	6 years data	11 years data	16 years data	21 years data	26 years data	31 years data
1981	1975-80	1970-80	1965-80	1960-80	1955-80	1950-80
1982	1976-81	1971-81	1966-81	1961-81	1956-81	1951-81
1983	.	.	.	.	.	.
1984	.	.	.	.	.	.
1985	.	.	.	.	.	.
1986	.	.	.	.	.	.
1987	.	.	.	.	.	.
1988	.	.	.	.	.	.
1989	.	.	.	.	.	.
1990	1984-89	1979-89	1974-89	1969-89	1964-89	1959-89

The total number of forecast made for the analysis is:
6 (31, 26, 21, 16, 11, 6 years) x 3 (S.D. crops)
x 3 (U.S. crops) x 10 (1975-80, 1976-81 etc.)
= 540 different forecasts.

dollars. This was done by updating the forecasted price index with the actual price for the last month in the data series. For example, for the 1975-80 data series, the actual price for August of 1975, 1976, 1977, 1978, 1979, and 1980 were used to convert the forecasted index for each of the months of 1975, 1976, 1977, 1978, 1979, and 1980 into dollar terms. Illustrating further, if the actual price for August 1975 was $2.16, and the price index for August 1975 [$2.16 × 100/(average price for the 1975 crop year)] was 113. Suppose the forecasted index for November 1975 was 107, then the forecasted price in dollar terms will be
$2.16 × 107/113 = $2.05.

To evaluate different forecasts, the mean square forecasting errors (MSE) were calculated.
The MSE is defined as:

$$MSE = \frac{\sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2}{n-2} = \frac{SSE}{n-2} \qquad (20)$$

(Neter, Wasserman and Kutner, 1989, P92).
where Y hat is the forecast price, Y is the actual price and n is the number of observations.

CHAPTER FOUR

RESULTS AND CONCLUSIONS

4.1 INTRODUCTION

This chapter is devoted to presenting the results and conclusions. The results will be discussed in the order of the objectives listed in chapter one. As it was described in chapter three, seasonal patterns for corn, wheat, and oats were estimated using monthly prices for 6, 11, 16, 21, 26, and 31 (these numbers came about because 1985-90 = 6 years, and 1980-90 = 11 years, etc.) crop years time periods. An evaluation of monthly price indexes based on different lengths of data periods is presented later in this chapter. It was concluded that monthly price indexes based on 21 years data provided an overall best measure of seasonal patterns for corn, wheat, and oats.

4.2 THE SEASONAL PATTERN IN S.D. AND U.S. PRICE

In conjunction with the first objective of study the seasonal patterns, based on 21 crop years data, are discussed in detail. Unless indicated otherwise, the remainder of this chapter uses terms "seasonal patterns", "indexes", "seasonal price patterns", "price indexes", "average price indexes" and "average monthly price indexes" synonymously to refer to the average monthly price indexes which are based on 21 crop years data. In order to make comparison easier, average monthly price indexes for S.D. and for U.S. are shown graphically for different grains. Average monthly price indexes along with standard deviations and trends in these indexes are presented in table form.

4.2.A SEASONAL PATTERNS IN CORN PRICES

Both S.D. and U.S. corn prices decline following harvest to the lowest price in October, thenceforth prices rises and reach the peak in summer. The monthly corn price indexes for S.D. as well as for U.S. are presented in Table 4.1. The S.D. corn prices are lowest in October (index = 92.5), at about average in March and April (index = 99.0, and 101.2 respectively) and reach highest in June (index = 106.6). The corn prices received by S.D. farmers in June are about 14% higher than the price received in October.

The U.S. corn prices also show a similar pattern (Table 4.1). The U.S. price index is lowest in October (95.8), about average in March and April (99.2 and 100.2 respectively) and highest in June (103.6). The relative variation in these indexes as shown by the coefficient of variation is greatest in August and September (harvesting season) and lower in December through February for both S.D. and U.S. (Table 4.1).

The Table 4.1 also shows the trends in the monthly price indexes. This is the yearly percentage change in the monthly

Table 4.1: Corn price seasonal indexes, standard deviation, and trend.

CORN (S.D.) 1970-1990

Months	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Ave. index	98	92.5	92.6	96	97.8	98.6	99.4	101.2	103.9	106.6	105.3	103.6
Ave. + std.	106.6	100.3	99.6	101.3	101.8	102.6	105.6	109.2	112.3	112.9	112.3	112.8
Ave. - std.	89.4	84.7	85.6	90.7	93.8	94.6	93.2	93.2	95.5	100.3	98.3	94.4
Std.	8.6	7.8	7	5.3	4	4	6.2	8	8.4	6.3	7	9.2
C.V. 1/	8.8%	8.4%	7.6%	5.5%	4.1%	4.1%	6.2%	7.9%	8.1%	5.9%	6.6%	8.9%
Trend	-0.5	-0.4	-0.1	-0.2	-0.2	-0.1	0.1	0.4	0.5	0.4	0.5	-0.3

CORN (U.S.) 1970-1990

Months	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Ave. index	98.2	95.8	96.2	99.3	98.8	99.0	99.2	100.2	102.0	103.6	101.8	99.6
Ave. + std.	109.4	106.1	104.3	105.7	106.2	106.6	107.0	109.5	111.4	112.1	111.9	113.2
Ave. - std.	87.0	85.5	88.1	92.9	91.4	91.4	91.4	90.9	92.6	95.1	91.7	86.0
Std.	11.2	10.3	8.1	6.4	7.4	7.6	7.8	9.3	9.4	8.5	10.1	13.6
C.V.	11.4%	10.8%	8.4%	6.4%	7.5%	7.7%	7.9%	9.3%	9.2%	8.2%	9.9%	13.7%
Trend	-0.3	-0.4	-0.2	-0.5	0.0	0.0	0.1	0.4	0.5	0.5	0.5	-0.3

1/ C.V. = coefficient of variation = $\frac{\text{Standard deviation}}{\text{Average index}} \times 100\%$

price index during the period of investigation. For example, the S.D. corn price index for September is estimated to decrease, on an average, by 0.5 each year. The trend estimates show that price indexes are getting smaller for September and October, and getting larger for May, June, and July. Consequently, during the last 21 year period, the seasonality in S.D. corn prices has become more pronounced. This issue of over time changes in seasonal patterns will be under the third objective.

The seasonal pattern for S.D. corn prices is more pronounced as compared to the seasonal pattern for U.S. corn prices (Fig. 4.1). As a result the S.D. corn price index for months March through August is higher than the U.S. corn price index. It may be noted that on the average, corn prices received by S.D. farmers are lower as compared to the average corn prices received by U.S. farmers (Fig 4.2). The most probable reason for this is the higher cost of transporting grain from S.D. to terminal markets as compared with other main corn producing states like Iowa or Illinois. This is partly due to the fact that S.D. grain has to be transported for longer distance to reach the terminal markets.

The more pronounced seasonality in S.D. corn prices can also be explained by a relatively higher transportation cost during the months following harvest. At harvest, S.D. farmers are paid lower (than the average price for the year)

Fig. 4.1: CORN PRICE SEASONAL INDEXES
(1970-90 AVERAGE)

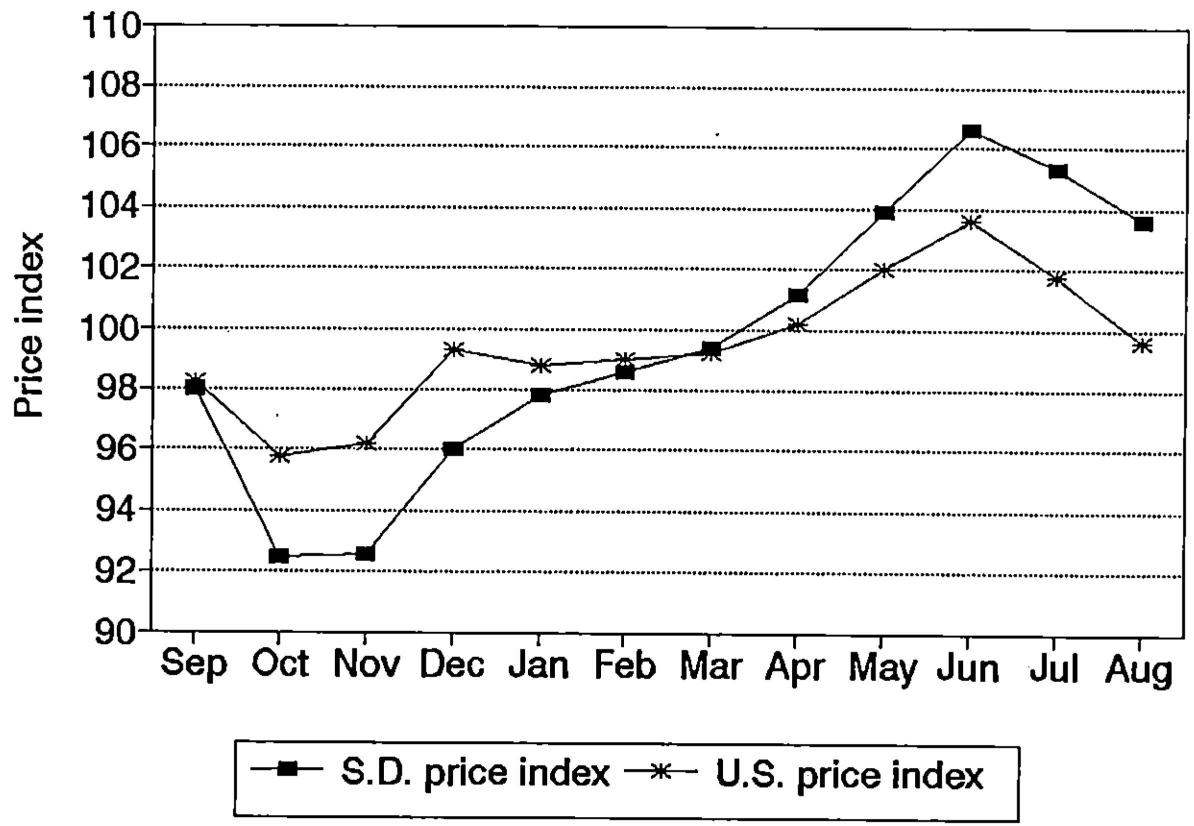
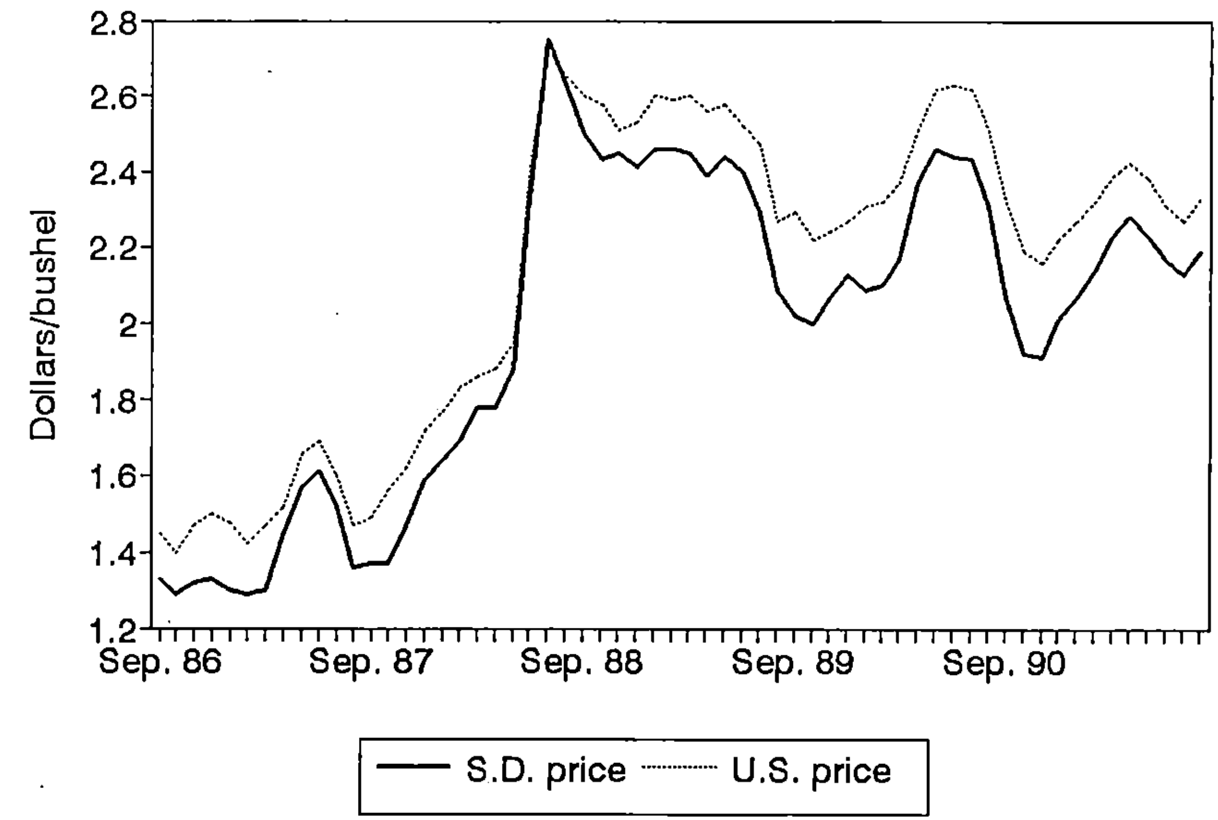


Fig. 4.2: CORN, PRICES RECEIVED BY FARMERS
(MONTHLY AVERAGE, 1986-90)



due to the competition for trucks, and railcars from larger corn producing states. This strong seasonal demand for grain transportation from surrounding states like Minnesota, Nebraska, and Iowa increases the cost of transportation and reduces farmers' receipts in S.D. during the months of October through December. By June a portion of the S.D. corn supplies is depleted by cattle feeding activity in the state and S.D. corn prices are generally higher as compared to the average for the year. Based on the seasonal indexes, the average increase in the value of corn stored in S.D. from October to January, October to April, and October to June are expected to be about 5%, 8%, and 13% respectively.

4.2.B SEASONAL PATTERNS IN WHEAT PRICES

In S.D., spring wheat is harvested from July to August, while winter wheat is harvested in June and July. Thus the period June to August is the harvesting season for wheat. S.D. wheat prices start declining following harvest and are at the peak in November (Fig. 4.3). The monthly wheat price indexes for S.D. as well as for U.S. are presented in Table 4.2. S.D. wheat prices are lowest in July (index = 93.1), and highest in November (index = 101.3). The difference in price between the highest and lowest price month is 5.4 % (101.3 -95.9).

The average U.S. wheat prices also show a similar pattern with price index lowest in July (93.9) and highest in

Table 4.2: Wheat price seasonal indexes, standard deviation, and trend.

WHEAT (S.D.) 1970-1990

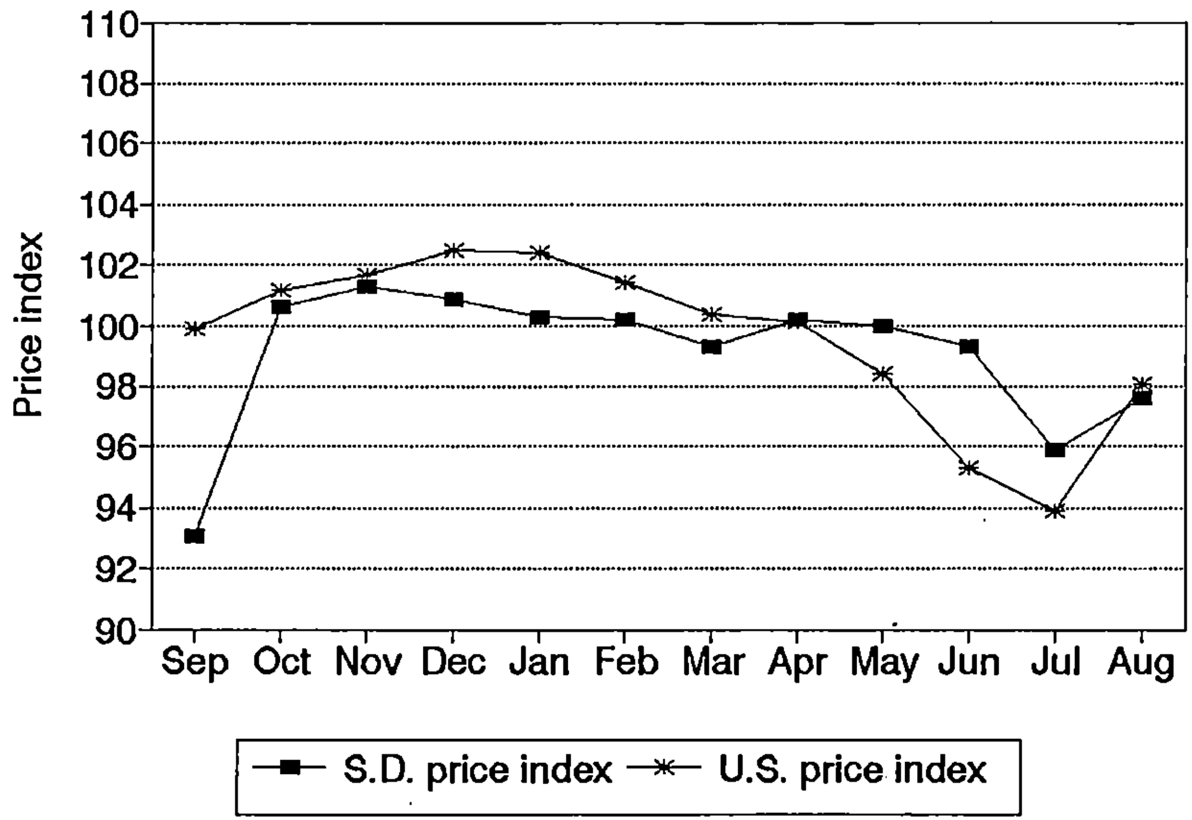
Months	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Ave. index	93.1	100.6	101.3	100.9	100.3	100.2	99.3	100.2	100	99.3	95.9	97.6
Ave. + std.	100.6	106.6	107.1	106.9	107	106.5	106.2	108.4	109.6	107.3	105.1	106.7
Ave. - std.	85.6	94.6	95.5	94.9	93.6	93.9	92.4	92	90.4	91.3	86.7	88.5
Std.	7.5	6	5.8	6	6.7	6.3	6.9	8.2	9.6	8	9.2	9.1
C.V. 1/	8.1%	6.0%	5.7%	5.9%	6.7%	6.3%	6.9%	8.2%	9.6%	8.1%	9.6%	9.3%
Trend	-0.5	-0.4	-0.3	-0.3	-0.4	-0.1	0.2	0.7	1.0	0.7	0.1	-0.4

WHEAT (U.S.) 1970-1990

Months	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Ave. index	99.9	101.2	101.7	102.5	102.4	101.4	100.4	100.1	98.4	95.3	93.9	98.1
Ave. + std.	107.5	107.7	107.2	109.4	108.7	108.1	107.2	108.2	107.3	104.3	102.0	106.5
Ave. - std.	92.3	94.7	96.2	95.6	96.1	94.7	93.6	92.0	89.5	86.3	85.8	89.7
Std.	7.6	6.5	5.5	6.9	6.3	6.7	6.8	8.1	8.9	9.0	8.1	8.4
C.V.	7.6%	6.4%	5.4%	6.7%	6.2%	6.6%	6.8%	8.1%	9.0%	9.4%	8.6%	8.6%
Trend	-0.5	-0.5	-0.2	-0.4	-0.3	-0.1	0.3	0.7	0.8	0.5	0.3	-0.5

1/ C.V. = coefficient of variation = $\frac{\text{Standard deviation}}{\text{Average index}} \times 100\%$

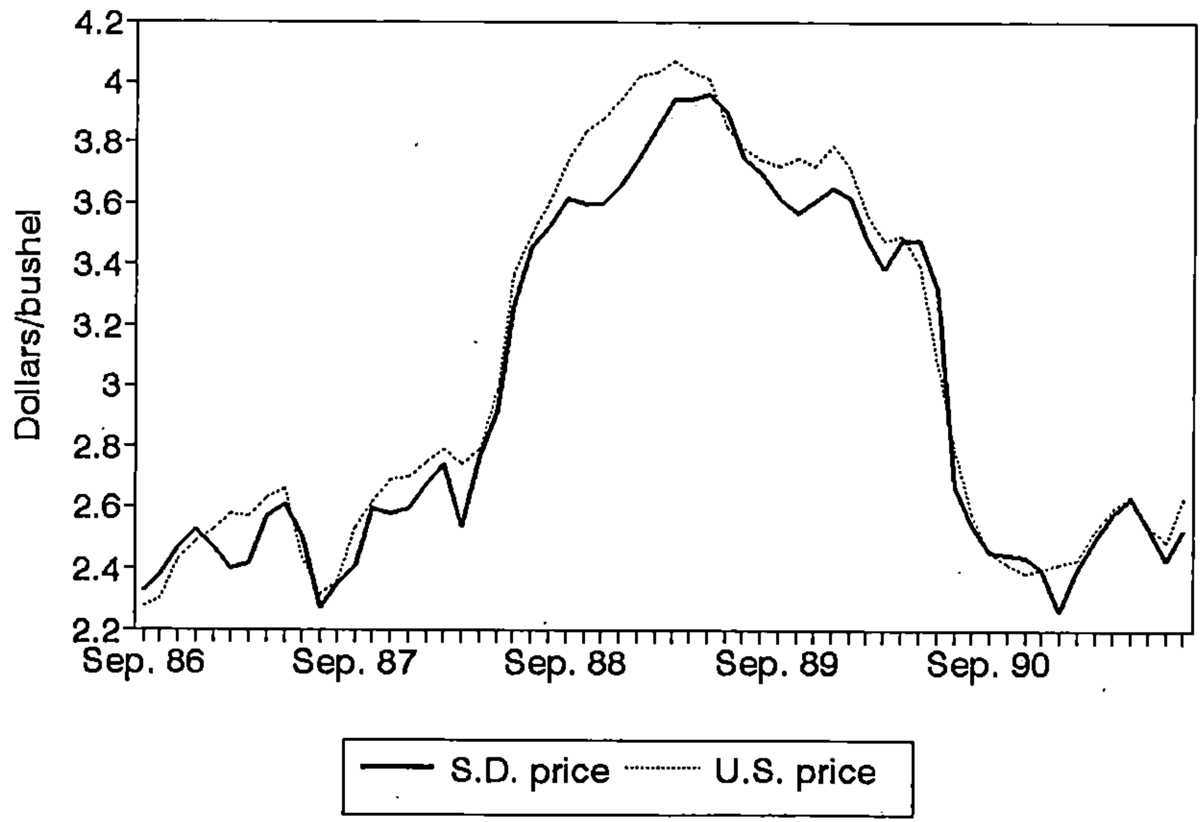
Fig. 4.3: WHEAT PRICE SEASONAL INDEXES
(1970-90 AVERAGE)



December (Table 4.2). The relative variation in these indexes as shown by coefficient of variation is high in June through August (harvesting season) and low in October through December for both S.D. and the U.S. As reflected by the price index trends, the average wheat price index during the last 21 years increased for the months March through July and decreased for the months August through February (Table 4.2).

The seasonal pattern for S.D. wheat prices is also relatively more pronounced when compared to the seasonal pattern for U.S. wheat prices (Fig. 4.3). The price received by S.D. farmers for wheat, however, is lower than the average price received by all wheat farmers in the U.S. during the 1986-90 period (Fig. 4.4). The higher cost of transporting S.D. wheat is probably the main reason for the lower price. Similarly, the pronounced seasonality of S.D. wheat can be explained by the deficient supply of transportation at harvest time, leading to lower prices for S.D. farmers at the period following harvest. In 1992, S.D. produced 40,850,000 bushels of spring wheat making it the third largest producer of spring wheat in U.S. (S.D. ranked sixteen in winter wheat with 16,880,000 bushels, and fifth in durum wheat with 990,000 bushels). It is probable that the trucks and railcars which carry wheat concentrate more on larger wheat producing areas like North Dakota and Kansas during the early part of the marketing year, later around October,

Fig. 4.4: WHEAT, PRICES RECEIVED BY FARMERS
(MONTHLY AVERAGES, 1986-90)



November, and December when the local supplies are relatively depleted, more transportation is available and the price paid to farmers starts rising. On average, the value of wheat stored from September to November, September to April, and September to May is expected to increase by 8%, 7%, and 6% respectively.

By the time wheat supplies in the U.S. and Canada are depleted, the wheat harvested from countries in the Southern Hemisphere (Argentina and Australia) is available. As a result wheat prices show relatively much less seasonal fluctuation compared to corn prices (Fig. 4.1 & 4.3).

4.2.C SEASONAL PATTERNS IN OATS PRICES

Both S.D. and U.S. oats prices start declining following harvest in July and reach a peak between December and February (Fig. 4.5). The monthly oats prices indexes for S.D. as well as for U.S. are presented in Table 4.3. S.D. oats prices were lowest in August (index = 91.0), at a plateau from February through June (index = 102.7), and at a peak in January (index = 105.4). On the average the oats prices received by S.D. farmers are about 14% higher in January than in August.

The average U.S. oats prices show a similar pattern with the price index lowest in August (index = 91.8), reaching a plateau between February and June (index = 103.1), and highest in May (index = 111.4).

Table 4.3: Oats price seasonal indexes, standard deviation, and trend.

OATS (S.D.) 1970-1990

Months	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Ave. index	92.3	95.7	100.3	104.8	105.4	103.1	102.8	102.5	103.4	102	92.2	91
Ave. + std.	101	102.5	105.6	108.7	109.3	108.4	110.5	110.6	112.2	111	103.3	101.7
Ave. - std.	83.6	88.9	95	100.9	101.5	97.8	95.1	94.4	94.6	93	81.1	80.3
Std.	8.7	6.8	5.3	3.9	3.9	5.3	7.7	8.1	8.8	9	11.1	10.7
C.V. 1/	9.4%	7.1%	5.3%	3.7%	3.7%	5.1%	7.5%	7.9%	8.5%	8.8%	12.0%	11.8%
Trend	-0.4	-0.1	-0.1	-0.1	0.0	-0.3	0.1	0.3	0.2	0.4	0.1	-0.4

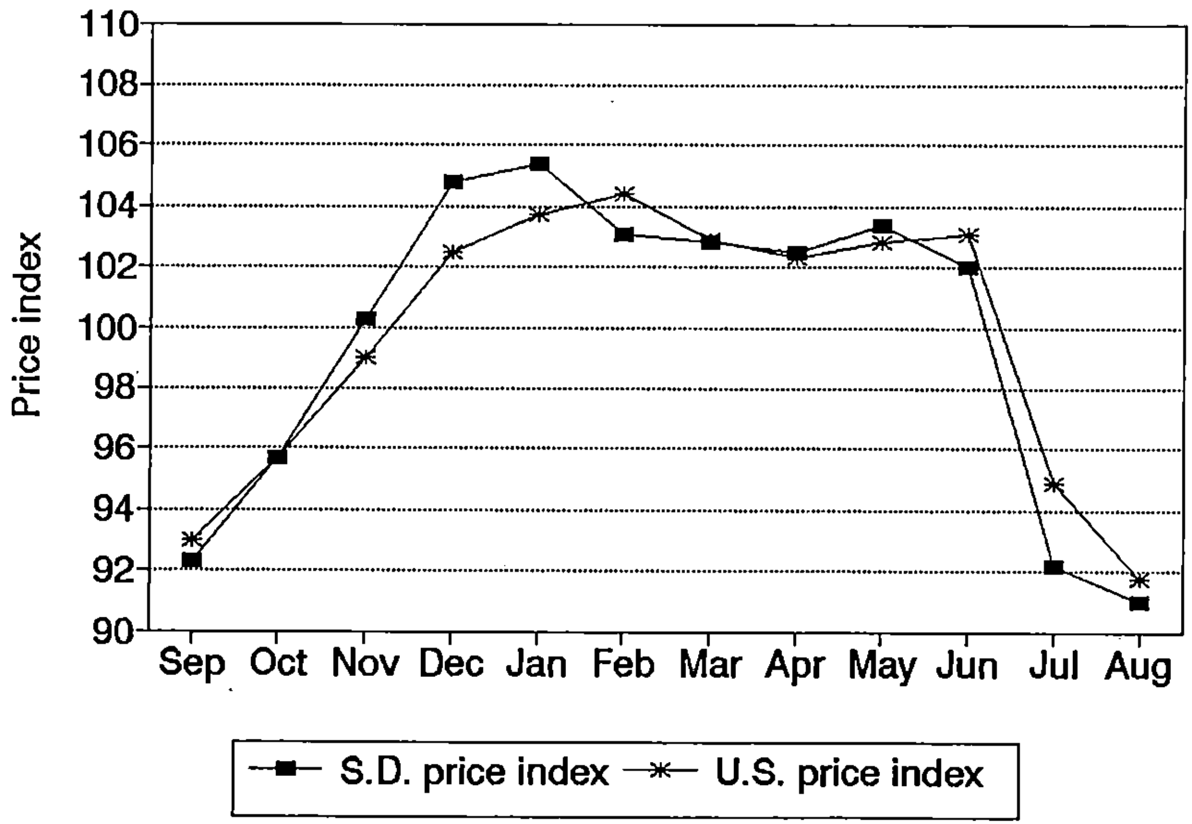
OATS (U.S.) 1970-1990

Months	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Ave. index	93.0	95.7	99.0	102.5	103.7	104.4	102.9	102.3	102.8	103.1	94.9	91.8
Ave. + std.	100.6	101.8	103.3	106.7	106.9	109.1	109.5	110.1	111.4	110.0	105.2	101.2
Ave. - std.	85.4	89.6	94.7	98.3	100.5	99.7	96.3	94.5	94.2	96.2	84.6	82.4
Std.	7.6	6.1	4.3	4.2	3.2	4.7	6.6	7.8	8.6	6.9	10.3	9.4
C.V.	8.2%	6.4%	4.3%	4.1%	3.1%	4.5%	6.4%	7.6%	8.4%	6.7%	10.9%	10.2%
Trend	-0.4	-0.1	0.0	0.1	-0.1	-0.1	0.1	0.4	0.4	0.2	-0.2	-0.5

1/ C.V. = coefficient of variation = $\frac{\text{Standard deviation}}{\text{Average index}} \times 100\%$

Fig. 4.5: OATS PRICE SEASONAL INDEXES

(1970-90 AVERAGE)



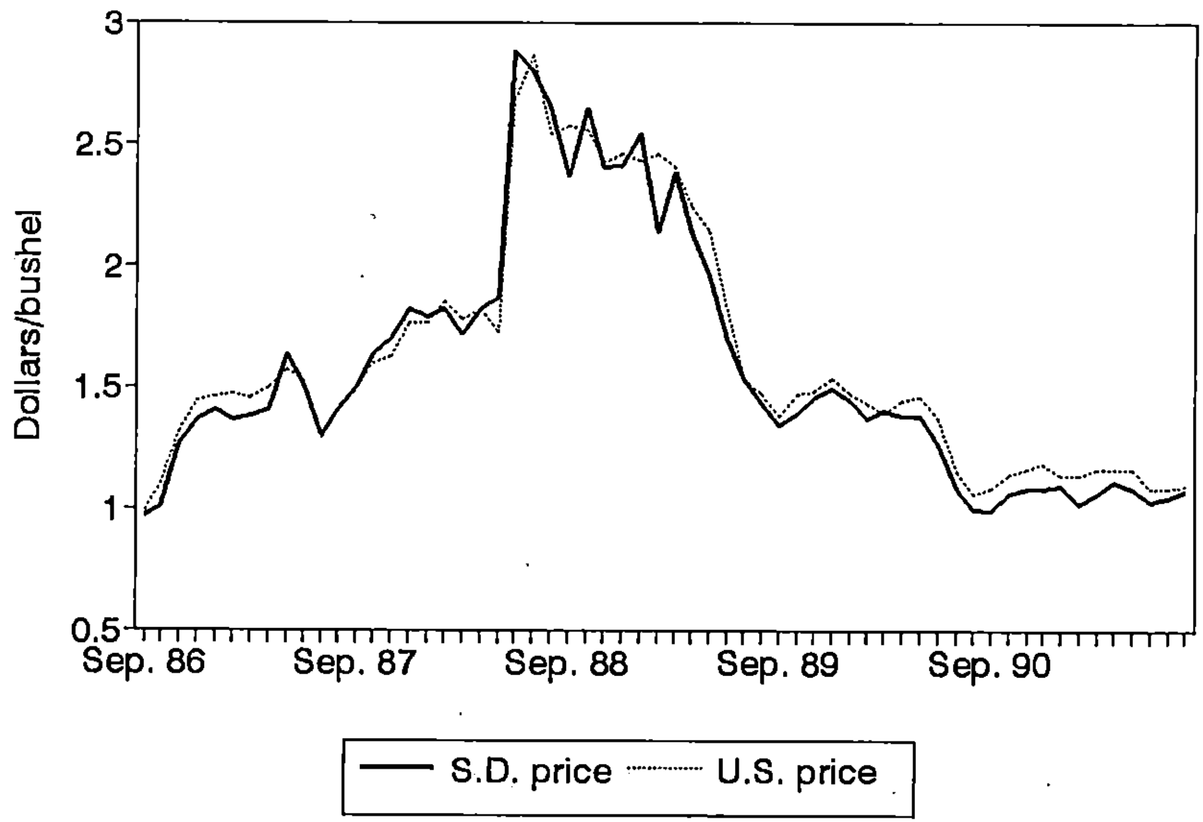
The relative variation in these indexes as shown by the coefficient of variation are highest in July and August (just after harvest) and lowest in December and January for both S.D. and U.S. (Table 4.3).

The monthly oats price trends show that, on the average, the oats prices increased from March through July and decreased from August through February (Table 4.3).

The seasonality in S.D. oats prices is slightly higher compared to U.S. oats prices (Fig. 4.5). The S.D. oats prices were generally lower compared to the U.S. oats prices during the period 1986-90 (Fig. 4.6). Transportation cost may be a probable reason for the lower prices. The seasonality in oats prices is more pronounced compared to the seasonality in wheat prices. This is because oats are produced mostly in S.D. and surrounding states. While S.D. grew only 2% and 5% of U.S. corn and wheat in 1992, the state lead the nation with about 16% of U.S. oats production. Most of the grain produced in S.D. and surrounding states is sold for cash, which leads to the lower cash price just after harvest, and thus a higher seasonality. Due to small quantity of oats produced in the southern hemisphere, there is very little downward push on the oats prices during the winter and spring months, which contributes to the high seasonality.

Based on these seasonal price changes, on average, the price value of oats stored in S.D. from August to November,

Fig. 4.6: OATS, PRICES RECEIVED BY FARMERS
(MONTHLY AVERAGES, 1986-90)



August to January, and August to April are expected to increase by about 9%, 14%, and 12% respectively.

4.3 COMPARISON OF THE SEASONAL PATTERN IN S.D. AND U.S. PRICES

This section is devoted to investigating the difference in the seasonal patterns of grain prices in S.D. and the U.S. Intuitively, this can be done by comparing the S.D. monthly price index with that of U.S. monthly price index. Fig. 4.1 shows that seasonality is much more pronounced in S.D. corn prices than U.S. corn prices. The S.D. and U.S. corn price index curves cross only once and are generally separated by a wider space. Fig. 4.3 shows that seasonal patterns in S.D. prices and U.S. prices for wheat are similar with the two price index curves crossing twice. Fig. 4.5 for oats shows that the S.D. and U.S. curves are very close to each other with the two curves crossing four times. This visual examination of the graphs points up a difference in the seasonal pattern for corn in S.D. and U.S., but shows a similar seasonal price pattern in S.D. and U.S. for wheat and oats.

To test the differences in seasonal patterns statistically, the Full/Reduced model was applied on seasonal price indexes for S.D. and U.S. for each grain. The model and the input for the model were discussed in Chapter Three.

The calculations and output for the Full/Reduced model for corn, wheat, and oats are shown in Tables 4.4, 4.5, and 4.6 respectively. The results of Full/Reduced model test show that for corn prices, the null hypothesis is rejected at .01 level of significance. This indicates the seasonal pattern in S.D. corn prices is not similar to that of U.S. corn prices.

The results of the Full/Reduced model test for both wheat and oats prices show that the null hypothesis cannot be rejected at .01 level of significance. This implies that seasonal patterns in S.D. prices and U.S. prices are similar for wheat and oats. It will still not be accurate to replace S.D. price with U.S. price because of the crossing over of the S.D. and U.S. average price index curves. If they did not cross each other and there was a constant amplitude difference between the two price indexes, the relevant basis or spread in dollars can be added to the U.S. forecast to get the S.D. forecast. Since the monthly U.S. grain prices are forecasted more frequently by many researchers all over the country, it is imperative that these forecast be translated for S.D. farmers. One way to make this translation is by adjusting the average U.S. monthly price forecasts for spread between the average U.S. price and the average S.D. price in recent years. The average monthly price spread for 1988-90 crop years (three years) for corn, wheat, and oats is shown in Table 4.7.

Table 4.4: Corn, Full/Reduced model output.

SAS 11:54 Wednesday, March 3, 1993 1
Model: MODEL 1
Dependent Variable: Full model of corn price index

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	7	264.6004	37.8001	20.6700	0.0001
Error	16	29.2596	1.8287		
C Total	23	293.8600			

Root MSE	1.3523	R-square	0.9004
Dep Mean	99.5500	Adj R-sq	0.8569
C.V.	1.3584		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob>|t|
INTERCEPT	1	100.5797	2.2125	45.4600	0.0001
X	1	-4.9680	1.4148	-3.5120	0.0029
X2	1	1.0819	0.2478	4.3660	0.0005
X3	1	-0.0537	0.0126	-4.2800	0.0006
D	1	-1.1727	3.1289	-0.3750	0.7127
DX	1	2.7731	2.0008	1.3860	0.1848
DX2	1	-0.5473	0.3504	-1.5620	0.1379
DX3	1	0.0249	0.0178	1.4040	0.1795

SAS 11:54 Wednesday, March 3, 1993 2
Model: MODEL 2
Dependent Variable: Reduced model of corn price index

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	228.0740	76.0247	23.1130	0.0001
Error	20	65.7860	3.2893		
C Total	23	293.8600			

Root MSE	1.8136	R-square	0.7761
Dep Mean	99.5500	Adj R-sq	0.7426
C.V.	1.8218		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	99.9934	2.0982	47.6570	0.0001
X	1	-3.5814	1.3417	-2.6690	0.0147
X2	1	0.8083	0.2350	3.4390	0.0026
X3	1	-0.0413	0.0119	-3.4670	0.0024

H_o: Reduced model is appropriate.
H_a: Full model is appropriate.

$$F^* = \frac{(SSE_r - SSE_f)/(k - m)}{SSE_f/(n-k-1)} \qquad (21)$$

$$F^* = \frac{(65.7860 - 29.2596)/(7-3)}{29.2596/(24-7-1)}$$

$$= \frac{9.1316}{1.8287}$$

$$= 4.99$$

From Table @ $\alpha = 0.01$,

$F_{k-m,n-k-1} = F_{4,24-7-1}$

$= F_{4,16}$ (where 4 is the df of numerator, and 16 is the df of denominator)

$= 4.77$

Hence there is sufficient evidence to reject the null hypothesis. That is S.D. price for corn cannot be replaced by U.S. price at $\alpha = 0.01$.

Table 4.5: Wheat, Full/Reduced model output.

SAS 11:56 Wednesday, March 3, 1993 1
Model: MODEL 1
Dependent Variable: Full model of wheat price index

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	7	86.2224	12.3175	9.4070	0.0001
Error	16	20.9509	1.3094		
C Total	23	107.1733			

Root MSE	1.1443	R-square	0.8045
Dep Mean	99.5833	Adj R-sq	0.7190
C.V.	1.1491		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob>|t|
INTERCEPT	1	98.5566	1.8722	52.6430	0.0001
X	1	1.1465	1.1972	0.9580	0.3525
X2	1	-0.1643	0.2097	-0.7840	0.4448
X3	1	0.0048	0.0106	0.4540	0.6557
D	1	-2.6889	2.6477	-1.0160	0.3249
DX	1	2.9698	1.6931	1.7540	0.0985
DX2	1	-0.5638	0.2965	-1.9010	0.0755
DX3	1	0.0276	0.0150	1.8330	0.0855

SAS 11:56 Wednesday, March 3, 1993 2
Model: MODEL 2
Dependent Variable: Reduced model of wheat price index

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	75.7220	25.2409	16.0510	0.0001
Error	20	31.4500	1.5725		
C Total	23	107.1730			

Root MSE	1.25401	R-square	0.7065
Dep Mean	99.5833	Adj R-sq	0.6625
C.V.	1.25925		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	97.2121	1.4507	76.0080	0.0001
X	1	2.6314	0.9277	2.8370	0.0102
X2	1	-0.4462	0.1625	-2.7460	0.0125
X3	1	0.0186	0.0082	2.2590	0.0352

H_o: Reduced model is appropriate.
H_a: Full model is appropriate.

$$F^* = \frac{(SSE_r - SSE_f)/(k-m)}{SSE_f/(n-k-1)}$$

$$F^* = \frac{(31.45072 - 20.95093)/(7-3)}{20.95093/(24-7-1)}$$

$$= \frac{2.62495}{1.30943}$$

$$= 2.004$$

From Table @ $\alpha = 0.01$,

$F_{k-m,n-k-1} = F_{4,24-7-1}$

$= F_{4,16}$ (where 4 is the df of numerator, and 16 is the df of denominator)

$= 4.77$

Hence there is insufficient evidence to reject the null hypothesis. That is S.D. price for wheat can be replaced by U.S. price at $\alpha = 0.01$.

Table 4.6: Oats, Full/Reduced model output.

SAS 12:00 Wednesday, March 3, 1993 1
Model: MODEL 1
Dependent Variable: Full model of oats price index

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	7	484.1289	69.1612	19.6580	0.0001
Error	16	56.2910	3.5182		
C Total	23	540.4200			

Root MSE	1.8757	R-square	0.8958
Dep Mean	99.6500	Adj R-sq	0.8503
C.V.	1.8823		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob>|t|
INTERCEPT	1	86.7444	3.0688	28.2670	0.0001
X	1	5.9785	1.9623	3.0470	0.0077
X2	1	-0.5088	0.3437	-1.4800	0.1582
X3	1	-0.0031	0.0174	0.1790	0.8601
D	1	2.4596	4.3399	0.5670	0.5788
DX	1	-2.0868	2.7752	-0.7520	0.4630
DX2	1	0.3487	0.4861	0.7170	0.4834
DX3	1	-0.1526	0.0247	-0.6190	0.5447

SAS 12:00 Wednesday, March 3, 1993 2
Model: MODEL 2
Dependent Variable: Reduced model of oats price index

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	478.4645	159.4880	51.485	0.0001
Error	20	61.9555	3.0980		
C Total	23	540.4200			

Root MSE	1.7601	R-square	0.8854
Dep Mean	99.6500	Adj R-sq	0.8682
C.V.	1.7662		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	87.9742	2.0362	43.2060	0.0001
X	1	-4.9351	1.3020	3.7900	0.0011
X2	1	-0.3345	0.2281	-1.4670	0.1580
X3	1	-0.0045	0.0116	-0.3900	0.7009

H_o: Reduced model is appropriate.
H_a: Full model is appropriate.

$$F^* = \frac{(SSE_r - SSE_f)/(k - m)}{SSE_f/(n-k-1)}$$

$$F^* = \frac{(61.9555 - 56.29109)/(7-3)}{56.29109/(24-7-1)}$$

$$= \frac{1.41611}{3.51819}$$

$$= 0.40251$$

From Table @ $\alpha = 0.01$,

$$F_{k-m,n-k-1} = F_{4,24-7-1}$$

$$= F_{4,16}$$ (where 4 is the df of numerator, and 16 is the df of denominator)

$$= 4.77$$

Hence there is insufficient evidence to reject the null hypothesis. That is S.D. price for oats can be replaced by U.S. price at $\alpha = 0.01$.

Table 4.7: Average monthly spread between S.D. and U.S. prices.

Months	Corn	Wheat	Oats
Sep.	-0.21 1/	-0.07	0.69
Oct.	-0.21	-0.13	0.71
Nov.	-0.16	-0.11	0.69
Dec.	-0.18	-0.14	0.86
Jan.	-0.19	-0.17	0.47
Feb.	-0.18	-0.10	0.73
Mar.	-0.17	-0.08	0.53
Apr.	-0.15	-0.04	0.37
May.	-0.15	0.01	0.28
Jun.	-0.15	0.09	0.28
Jul.	-0.17	-0.07	0.22
Aug.	-0.17	-0.06	0.23

1/ (Average S.D. price minus average U.S. price) for 1988-90.

4.4 CHANGES IN S.D. AND U.S GRAIN PRICES OVER TIME.

To investigate if the seasonal patterns in S.D. prices are becoming more similar to the seasonal patterns in the U.S. prices, the Full/Reduced model was applied to S.D. and the U.S. monthly price indexes based on data periods 1960-90, 1965-90, 1970-90, 1975-90, 1980-90, and 1985-90. In addition, the coefficient of determination, (r^2) between S.D. and U.S. monthly prices, and sum of squared deviations, (Σd^2) of S.D. prices from U.S. prices were also computed for the same data periods.

A comparison of results show that the F-statistic gets smaller when the price indexes based on recent years' data were used in Full/Reduced model. The smaller the F-statistic, the more difficult it is to reject the null hypothesis (Table 4.8). This result was consistent in the case of corn as well as for wheat and oats. In recent years (1980-90) even the S.D. corn prices have shown a seasonality which is very similar to the seasonality in U.S. corn prices.

r^2 ranges from 0 to 1. The closer r^2 is to 1 the closer the seasonality of two price series. The results of the r^2 test also showed that S.D. and U.S. prices are highly correlated and the seasonality was more similar over the later span of years as shown by the steadily increasing r^2 (Table 4.8). This can be clearly seen in the results for corn but not for wheat and oats. The seasonality for wheat

Table 4.8: Comparison of seasonality for S.D. and U.S. for selected time periods.

Commodity / Time periods	FULL/REDUCED MODEL a/			
	F test statistic	Reject Ho at α = 0.01	r^2 c/	Σd^2 d/
CORN				
1960-90	3.04 b/	No	0.799	41.6
1965-90	4.14	No	0.761	40.8
1970-90	4.99	Yes	0.685	40.4
1975-90	7.25	Yes	0.595	38.8
1980-90	0.77	No	0.982	5.0
1985-90	0.82	No	0.974	1.7
WHEAT				
1960-90	1.42	No	0.973	11.9
1965-90	1.95	No	0.971	11.1
1970-90	2.00	No	0.952	10.6
1975-90	1.20	No	0.898	8.0
1980-90	1.01	No	0.911	4.4
1985-90	0.50	No	0.932	1.7
OATS				
1960-90	0.43	No	0.989	2.4
1965-90	0.39	No	0.987	2.1
1970-90	0.40	No	0.981	2.0
1975-90	0.24	No	0.969	1.8
1980-90	0.06	No	0.969	1.3
1985-90	0.07	No	0.978	0.1

a/ Ho: Seasonality of S.D. and U.S. price are similar, and
Ha: Seasonality not similar

b/ For different α values the F distribution values are: $F(\alpha = 0.01) = 4.77$, $F(\alpha = 0.05) = 3.01$
$F(\alpha = 0.10) = 2.33$, $F(\alpha = 0.25) = 1.50$

c/ r^2 = Correlation between U.S. and S.D. price.

d/ Σd^2 = Sum of square deviations of S.D. price from U.S. price.

and oats for S.D. and U.S. was similar for all the different spans of time with r^2 generally above 0.9 levels.

From the results of the sum of squared deviations of S.D. prices from U.S. price patterns, it was obvious that the sum of squared difference between S.D. price and U.S. price decreases as later spans of years were used in the analysis. This test gave the most consistent result pointing to the fact that the seasonality in the S.D. and U.S. prices are getting more similar, for all three grains.

From all three tests one can conclude S.D. price patterns are merging with U.S. prices in recent years. The most likely reason for this is the technological advances in telecommunications and transportation. Satellite market information systems such as DTN have enabled S.D. farmers and grain traders to know the latest prices for grains posted at the Chicago Board of Trade instantaneously. This means they will be less willing to accept a lesser price from a buyer. Transportation has also improved as larger, more efficient, and more numerous trucks haul grain on better highways. With the use of hopper cars and unit trains, railways are also more efficient in hauling grain as compared to the past.

Over the recent years the USDA has been reducing the loan rate for grains well below the market price. To study the effect of this lowering of loan rates, the three-year-moving average difference between the highest ($\bar{d}$) and lowest price index, and the coefficient of variation (CV) were computed for 1972-88. Both $\bar{d}$ and CV decreased over time until around 1980-85 and then started increasing (Fig. 4.7 and Fig. 4.8). Fig. 4.7 shows the three-year moving average difference between the highest and lowest price index for these grains in S.D. The graph shows a marked decrease in the variability towards the end of the 70's and an increase in the variability starting in the beginning of the 80's. This coincides with the USDA's move in setting the loan rate below market price following the 1980 farm bill. The 1985 farm bill lowered the loan rate even more. As a result, since 1980, the loan rate does not interfere with the market clearing price for these grains in the U.S. Consequently, the natural seasonality in prices during the crop year, caused by the seasonal supply and demand variation, is becoming more pronounced. This result was consistent for corn, wheat, and oats in both S.D. and U.S. prices.

Fig. 4.8 shows the changes in the coefficient of variation over time which is a slightly better measure of variability of prices. This graph can be compared with the effective loan rate for wheat in U.S. (Fig. 4.9). There seems to be an inverse relationship between the loan rate and the three-year moving average coefficient of variation of prices. This shows that the lower loan rate is associated with higher variability of prices within the crop year. This is quite intuitive because loan rates act as a stabilizer of

Fig. 4.7: RANGE OF PRICE INDEX
(THREE YEAR MOVING AVERAGE)

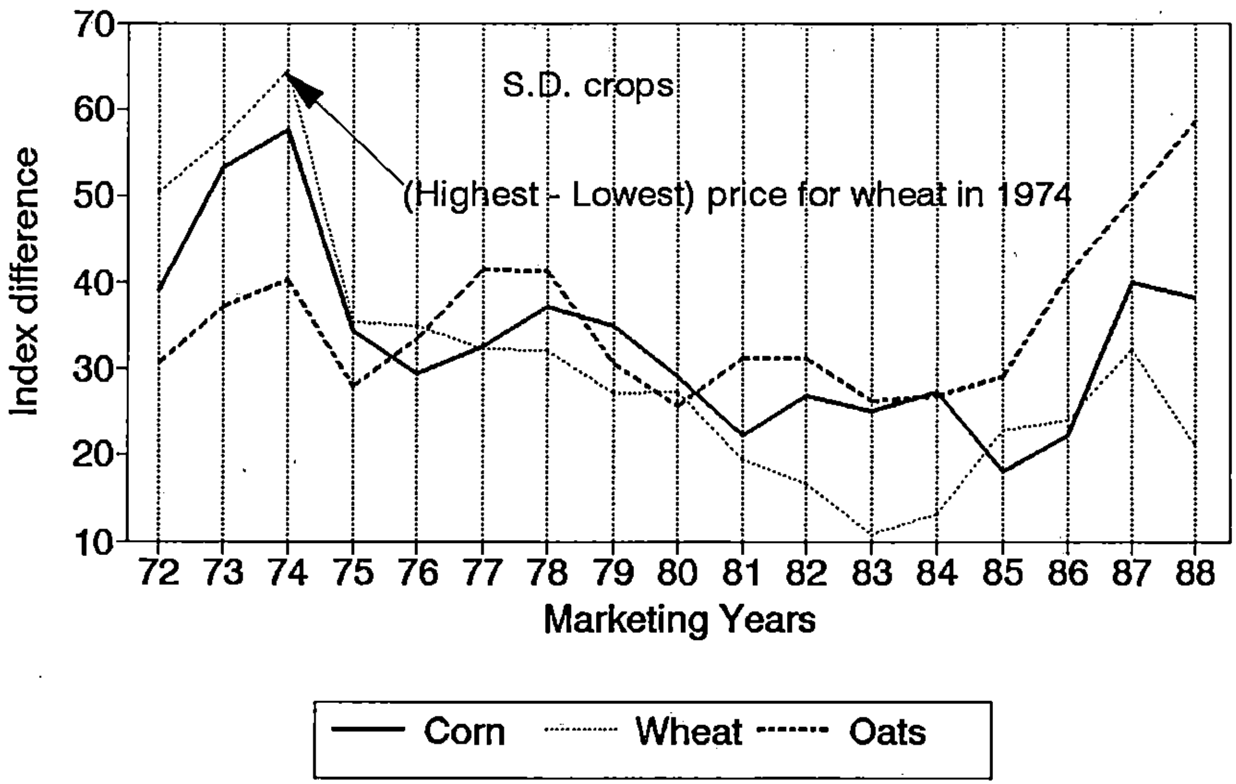


Fig. 4.8: CV OF PRICES
(3 year averages)

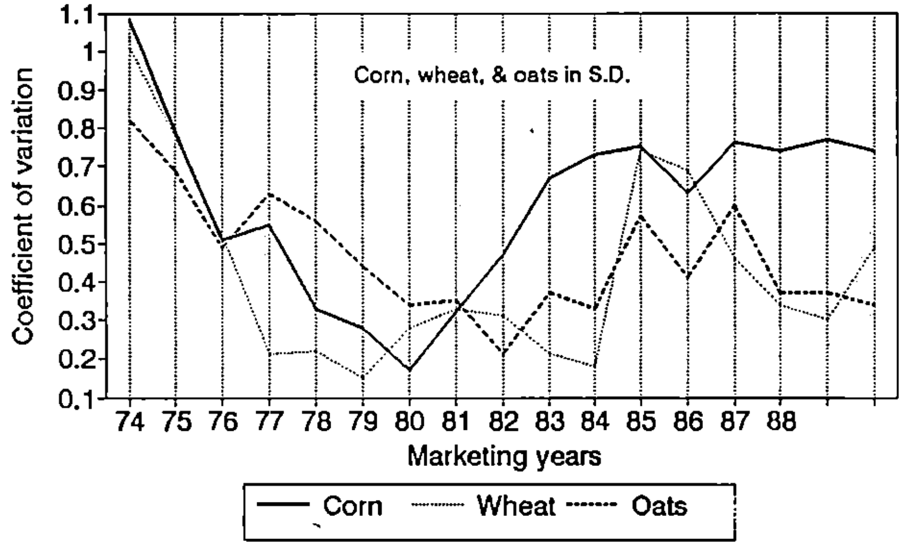
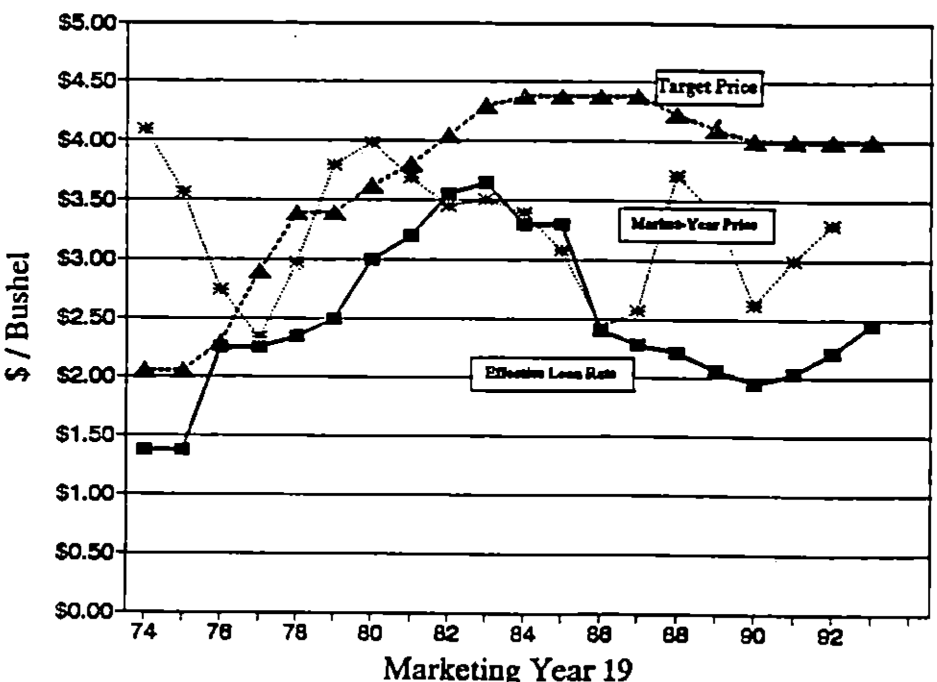


Fig. 4.9: U.S. WHEAT: EFFECTIVE LOAN RATES



Source: Bahn, 1993

prices and effectively removing it should increase variability of prices within a year. The figures from which these graphs were drawn are shown in the appendix (Table A.10).

It would also be useful to find out how the monthly variability of prices in the last two decades compares with the monthly variability in the prior two decades. This was investigated by plotting the average seasonal pattern for 1951-70 and 1971-90 (Fig.4.10 through Fig. 4.15).

The comparison of the standard deviations of monthly price indexes shows that there has been an increased variability in S.D. corn prices during the period 1971-90 compared to the period 1951-70 (Fig. 4.10 and 4.11). Similarly, there is evidence of an increased variability in S.D. wheat prices and S.D. oats prices during the period 1971-90 compared to the period 1951-70 (Fig. 4.12 to 4.15).

Fig. 4.10: CORN IN S.D.: AVE. INDEX FOR 1951-70

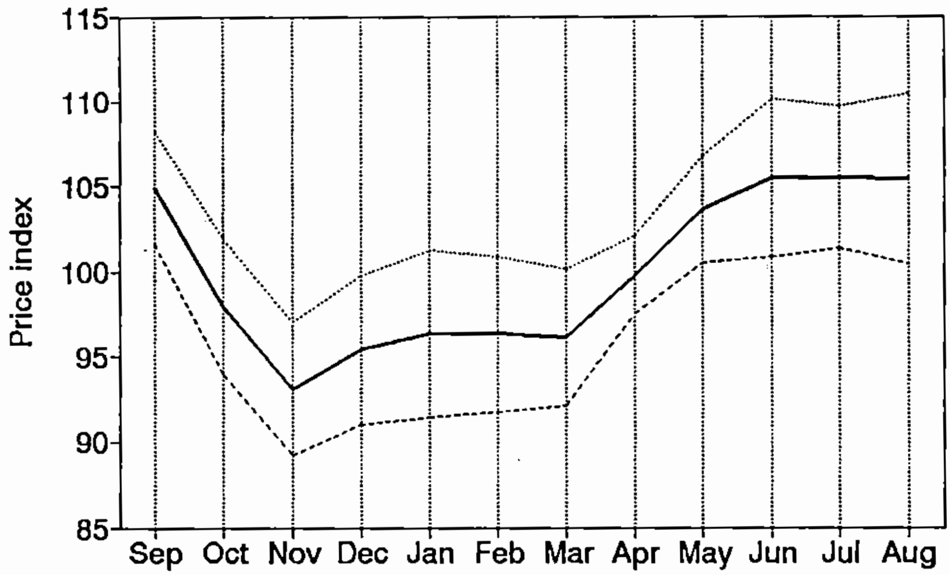


Fig. 4.11: CORN IN S.D.: AVE. INDEX FOR 1971-90

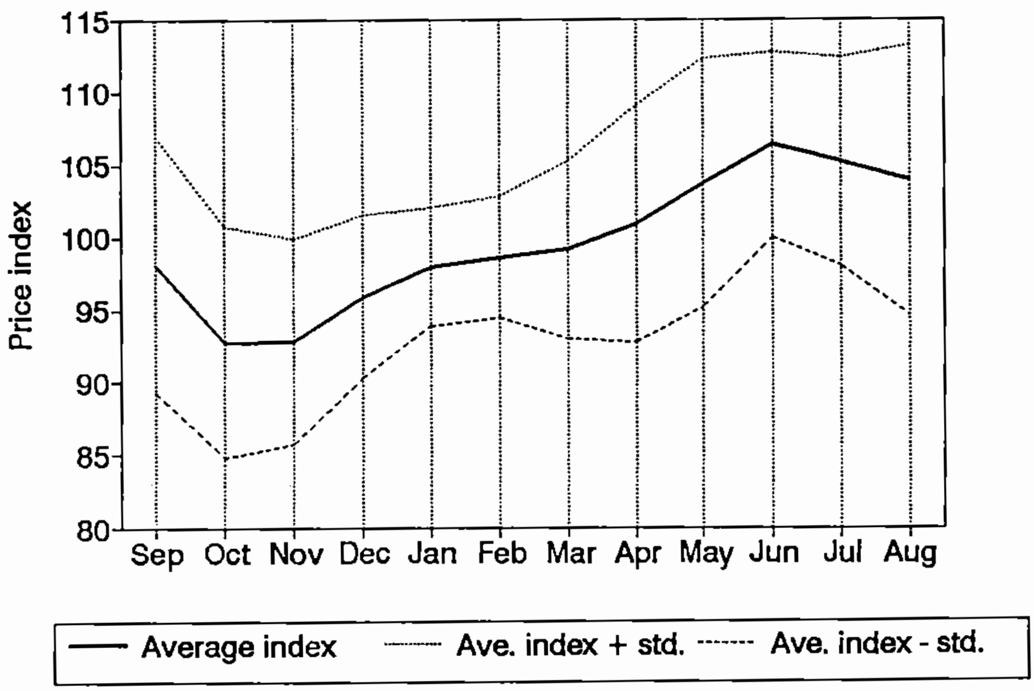


Fig. 4.12: WHEAT IN S.D.: AVE. INDEX FOR 1951-70

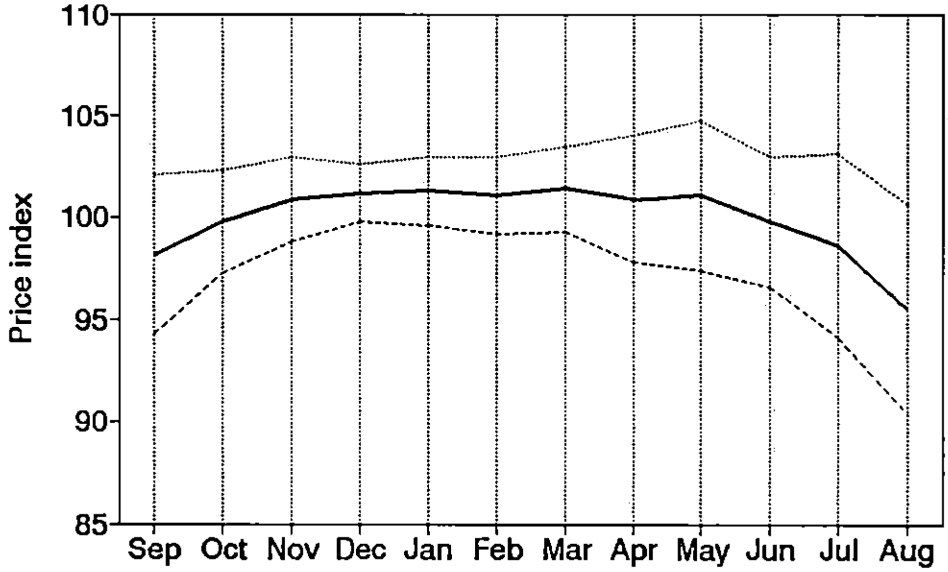


Fig. 4.13: WHEAT IN S.D.: AVE. INDEX FOR 1971-90

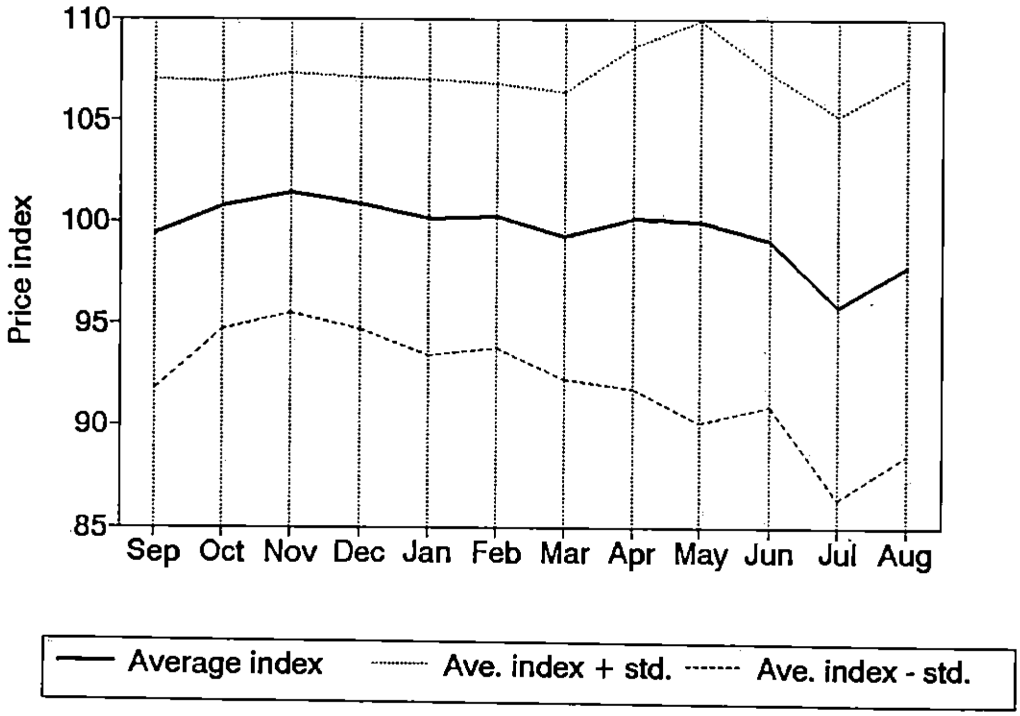


Fig. 4.14: OATS IN S.D.: AVE. INDEX FOR 1951-70

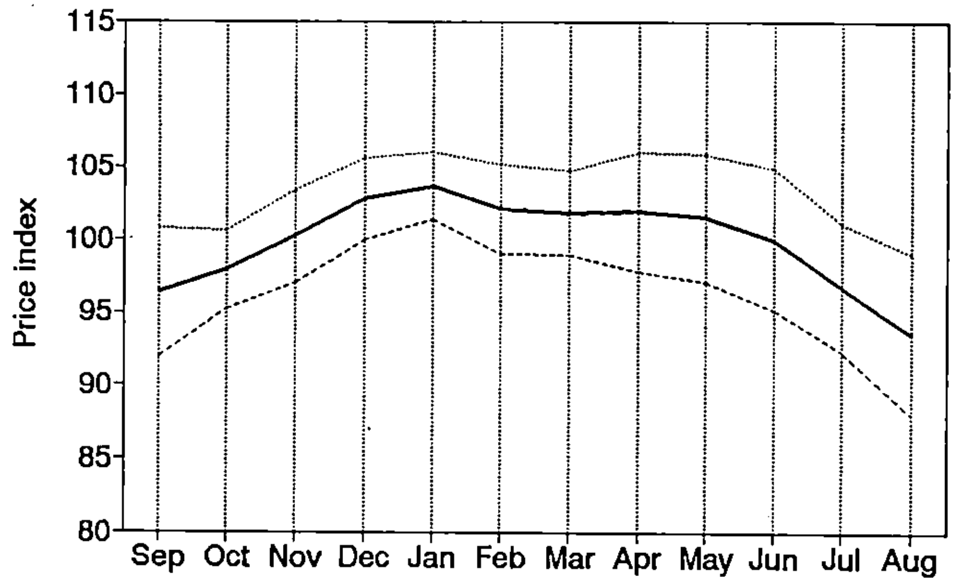
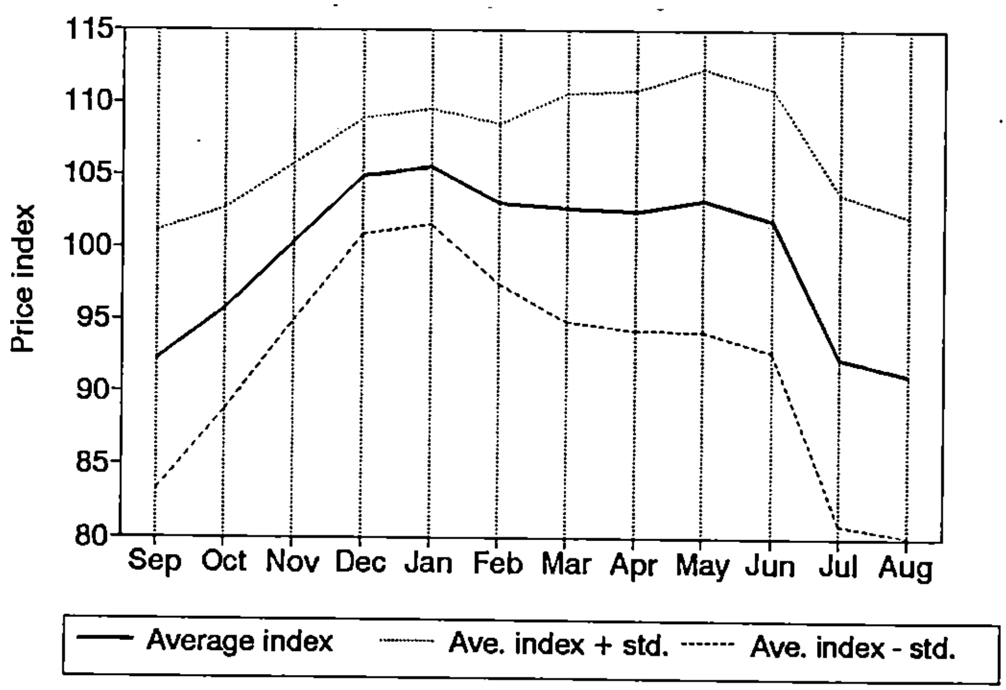


Fig. 4.15: OATS IN S.D.: AVE. INDEX FOR 1971-90



4.5 SAMPLE SIZE AND SEASONAL INDEX RELIABILITY

Generally, one would expect that if all other factors remain unchanged, the larger the size of the sample the better the estimate of seasonality index. However, the seasonal patterns change over time and the shifts in seasonal patterns for different crops may occur at different points in time. If the seasonal patterns have shifted in the recent past, the monthly price indexes estimated using longer data series may be less reliable and provide poorer forecasts. To resolve this issue up to 12 months out of sample price forecasts based on different price indexes were computed and updated every 12 months. Specifically, price forecasts for the period 1981-90 were computed utilizing the price indexes based on 6, 11, 16, 21, 26, and 31 years of historical data and were evaluated in terms of the mean sum of square forecasting errors (MSE).

The mean square forecasting error for 1981-90 period for different forecasts are given in Table 4.9. It is clear that 21 year data based indexes provide reasonably good forecasts for both S.D. as well as U.S. prices for all three commodities. For wheat and oats prices in South Dakota, the incremental decrease in MSE by using indexes based on data periods longer than 21 years was relatively small. The MSE for S.D. corn prices actually increased when indexes based on 26 years instead of 21 years were used. Comparison of MSE by

Table 4.9: Relationship between sample size and reliability of price forecast from index.

Forecast from indexes based on preceeding: 1/	S.D. Corn	S.D. Wheat	S.D. Oats	U.S. Corn	U.S. Wheat	U.S. Oats
			Mean Square Error 2/			
6 yrs. data	0.2189	0.5863	0.3265	0.4740	0.4065	0.3366
11 yrs. data	0.2377	0.2514	0.2249	0.7008	0.2546	0.1915
16 yrs. data	0.1515	0.2142	0.2877	0.2484	0.2081	0.2124
21 yrs. data	0.1366	0.1465	0.2158	0.1942	0.1407	0.1550
26 yrs. data	0.1367	0.1362	0.2001	0.1771	0.1352	0.1457
31 yrs. data	0.1366	0.1306	0.1852	0.1645	0.1325	0.1405
			Percent decrease in MSE			
11 vs 6 yrs. data	-8.6	57.1	31.1	-47.9	37.4	43.1
16 vs 11 yrs. data	36.3	14.8	-27.9	64.6	18.3	-10.9
21 vs 16 yrs. data	9.9	31.6	25.0	21.8	32.4	27.0
26 vs 21 yrs. data	-0.1	7.0	7.3	8.8	3.9	6.0
31 vs 26 yrs. data	0.1	4.1	7.4	7.1	2.0	3.6

1/ 12 month out of sample forecast updated every 12 months.

2/ Mean Square Forecasting Error for crop years 1981-90.

crop year also shows that MSE based on six, eleven, and sixteen years indexes were much higher than the forecast based on twenty one, twenty six and thirty one years index. The figures in the last two rows of Table 4.9 are obviously less than the prior three rows. The MSE seems to level off with more than 21 years of data (Fig. 4.16 through Fig. 4.21). When reading these graphs one should realize that forecast errors should be high for abnormal years when there is biostress or supply and demand shocks. This is because the forecasts was made by the SEASON program which assumes that next year's price will be similar to a moving average of the previous years' price.

The yearly comparison for corn (Fig. 4.16 and Fig. 4.17) shows that the forecast errors were much higher for the crop years 1982, 1984, and 1987 in the case of S.D. and the crop years 1982, and 1984 for U.S. This indicates a national level supply shortage in 1982 and 1984. Whereas 1987 was more of a local supply shortage for South Dakota. In the case of these abnormal years forecasts based on relatively few years data contained much larger errors.

The forecast error for wheat was higher for 1985, 1987, 1988 and 1989 in S.D. and 1985 and 1987 for the U.S. (Fig. 4.18 and 4.19). This indicates an abnormal national supply in 1985 and 1987 and an abnormal local supply for 1988 and 1989. The forecast error for oats was higher in 1988. This coincides with the forecast error for the U.S. (Fig. 4.20 and

Fig. 4.16: CORN, S.D. - FORECASTING ERROR

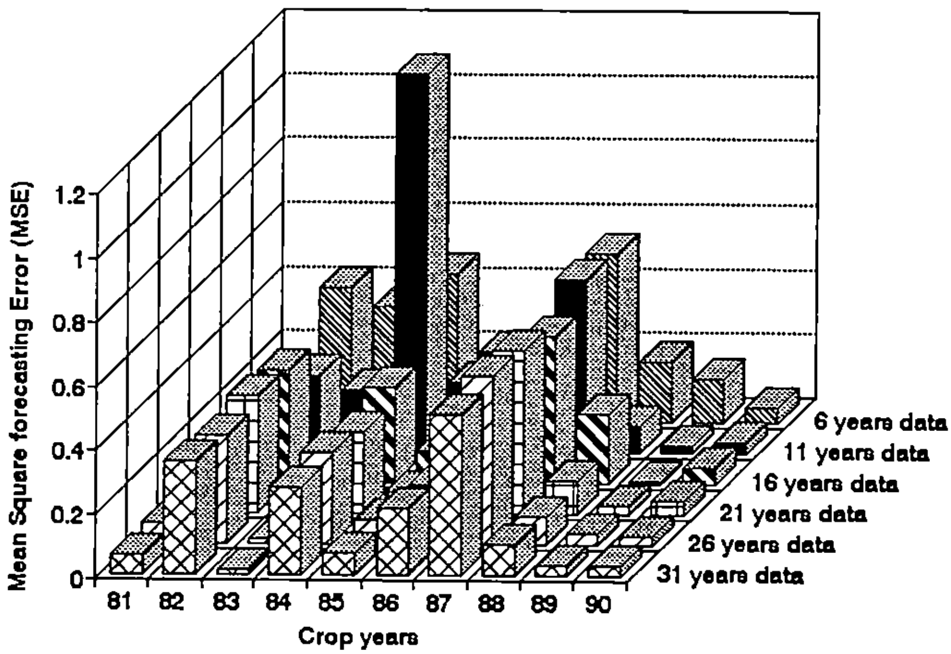


Fig. 4.17: CORN, U.S. - FORECASTING ERROR

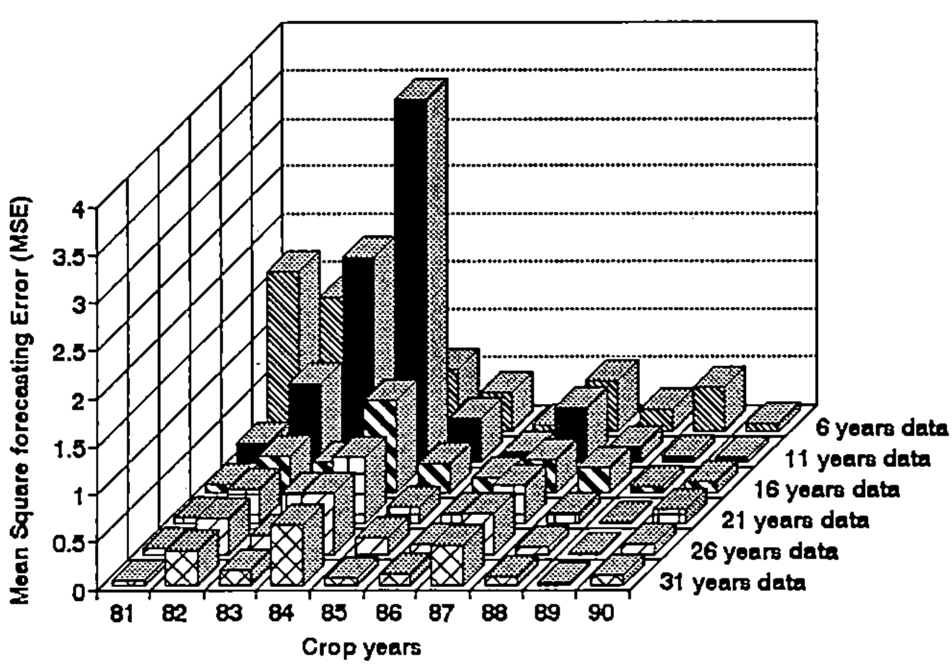


Fig. 4.18: WHEAT, S.D. - FORECASTING ERROR

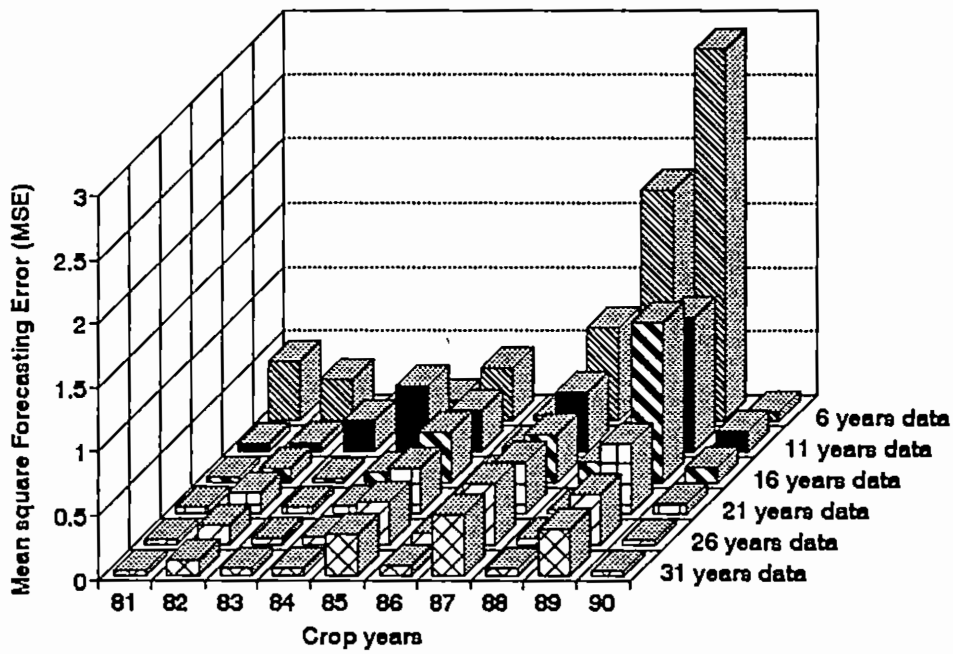


Fig. 4.19: WHEAT, U.S. - FORECASTING ERROR

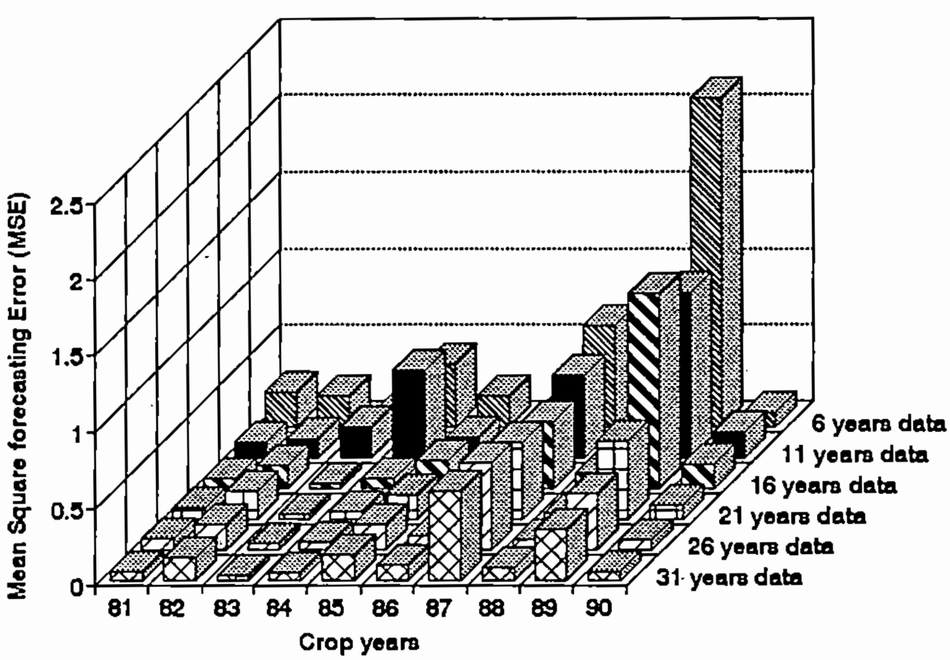


Fig. 4.20: OATS, S.D. - FORECASTING ERROR

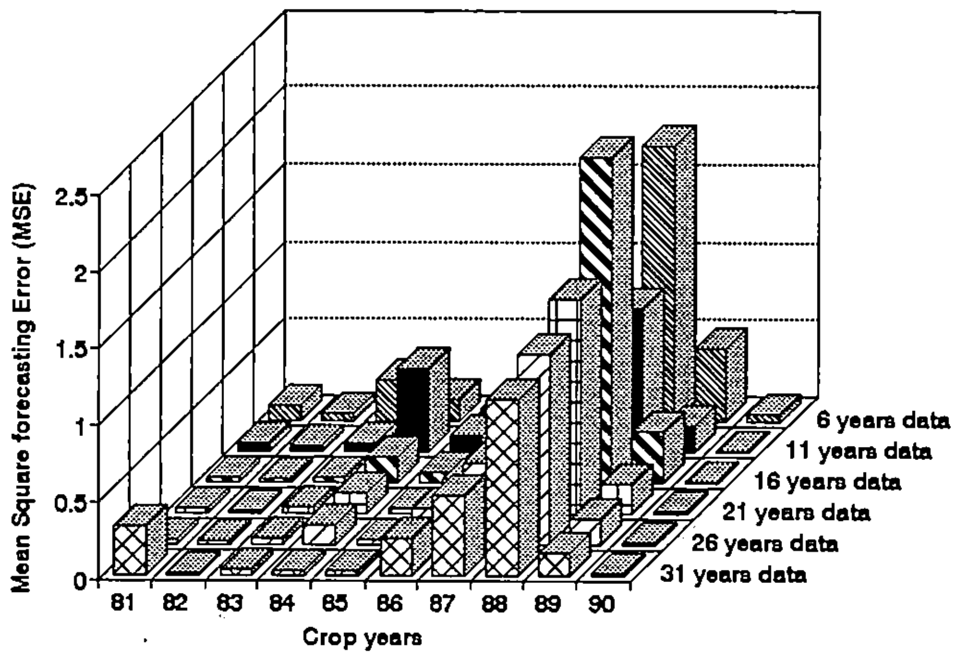
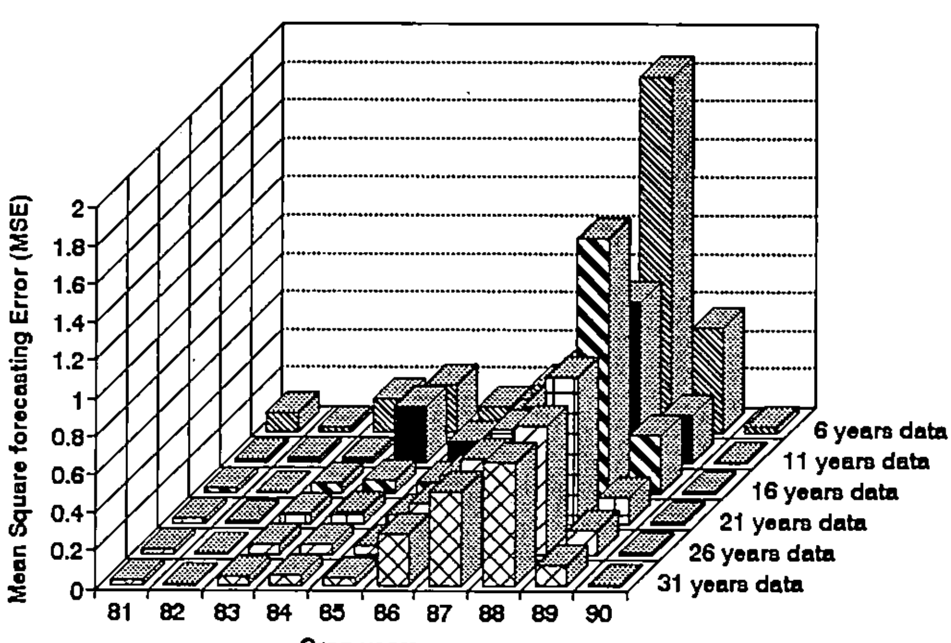


Fig. 4.21: OATS, U.S. - FORECASTING ERROR



4.21). The reason for this coincidence is the fact that S.D. is the largest producer of oats in the country. So the price trend in S.D. will reflect the price trend in the U.S.

Fig. 4.22 shows the plot of S.D. corn prices based on 21 years data (Forecast,21), 11 years data (Forecast,11), 6 years data (Forecast,6), along with actual S.D. corn prices for crop years 1981 through 1990. It is quite evident that the forecast errors have been smaller in recent years. Also it is quite clear that Forecast,21 yields better forecast. Fig. 4.23 is the same graph for U.S. Both graphs illustrate that the naive model of assuming that the prices in the near future is similar to the most recent price level is not appropriate. The forecast using six and eleven years of historical data contained larger errors as depicted by a number of high peaks. The graphs for wheat and oats showed similar behavior.

Fig. 4.22: CORN (S.D.) - ACTUAL & FORECAST PRICE

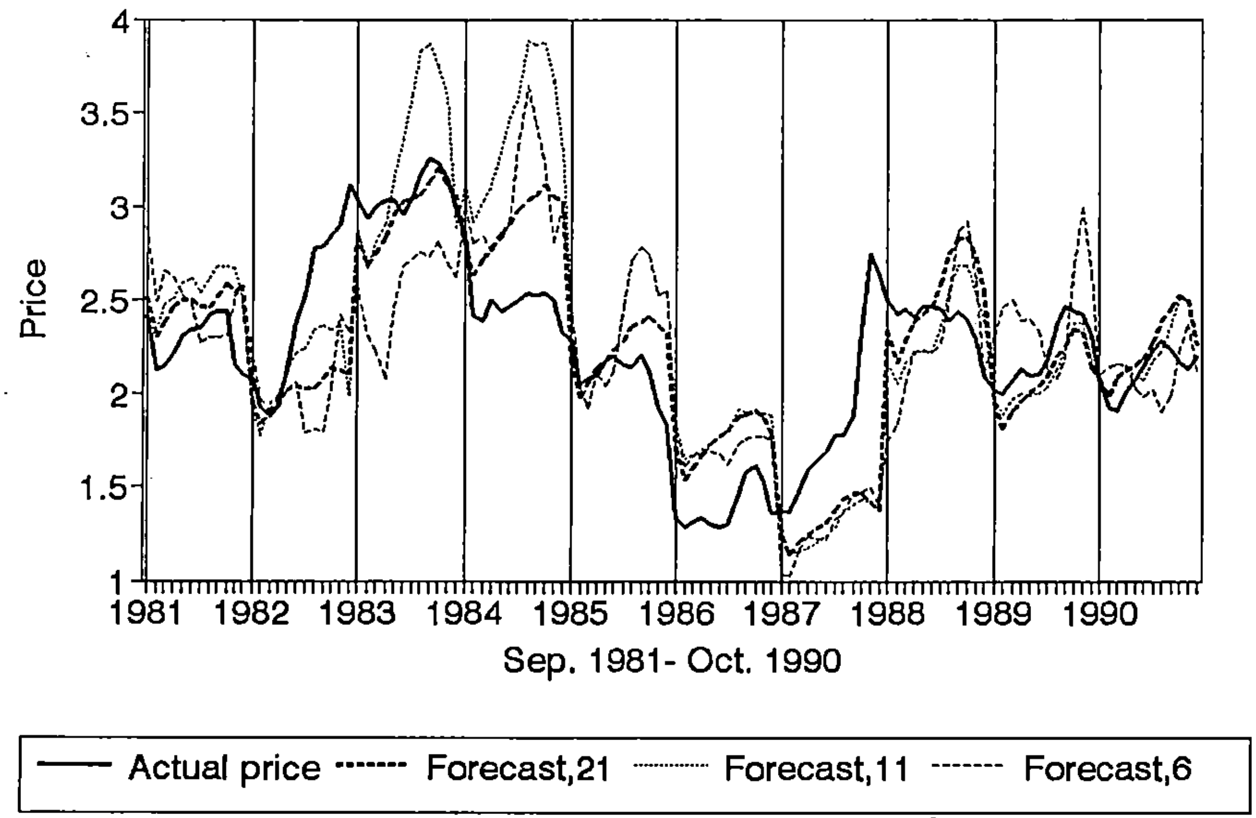
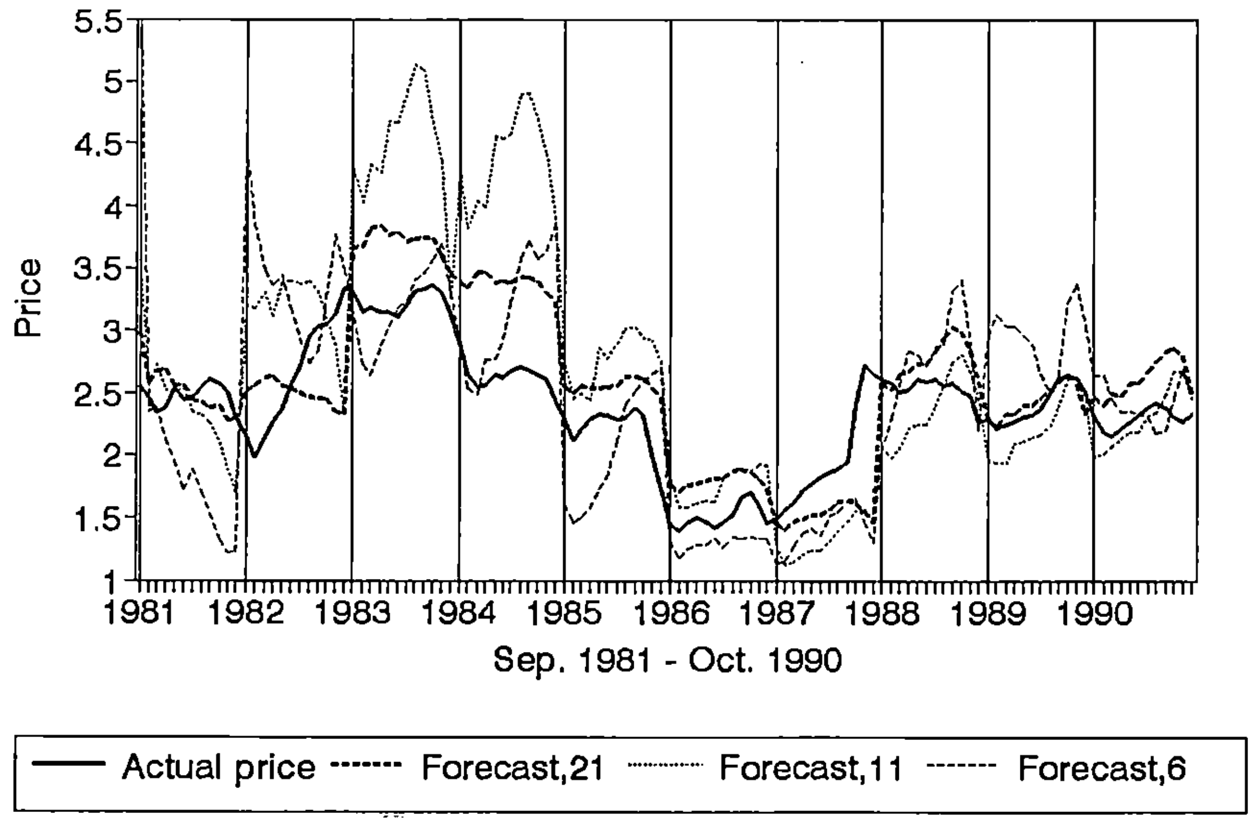


Fig. 4.23: CORN (U.S.) - ACTUAL & FORECAST PRICE



CHAPTER FIVE

SUMMARY AND IMPLICATIONS

5.1 SUMMARY

This research will enable one to form a better expectation of prices for corn, wheat and oats. The next four paragraphs will summarize the findings regarding the four objectives of this thesis.

The shape of seasonal price trends was identified. The seasonality of corn was greater than wheat or oats. The seasonality of S.D. price is greater than U.S. for corn and oats but the opposite is true for wheat. However, the difference in S.D. and U.S. wheat seasonality is very small.

Using the Full/Reduced model, the difference between the S.D. and U.S. price was statistically significant at $\alpha = 0.01$ level for corn, but not for wheat or oats.

The seasonal pattern of S.D. price is changing over time. A number of tests (the coefficient of determination, (r^2), the sum of difference between S.D. and U.S. price, (Σd^2), and Full/Reduced model) showed that S.D. and U.S. price seasonality are merging. This is probably due to the rapid improvement in telecommunication and transportation. With modern communication facilities like DTN, farmers in S.D. can get the latest update of prices within minutes. Larger and more efficient truck and rail transportation could have also contributed to the merging of S.D. and U.S. prices. In 1980 and 1985 the U.S. government (USDA) lowered the loan rates for grains much below the market clearing price. To study the affects of this on price seasonality, the three-year-moving difference between the highest and lowest price, and the coefficient of variation of the prices were determined. The yearly variation in prices increased with the lowering of the loan rates.

As the number of years of historical data used to make forecast is increased, the forecast gets better, but this trend culminates with 21 years of historical data. For corn in S.D. the forecast is worse with 26 or 31 years of historical data. For wheat and oats in both S.D. and U.S., and corn in U.S., the marginal improvement of the forecast with more than 21 years of historical data is very small. Thus 21 years of historical data is the best size of historical data to use in making a forecast for corn, wheat, and oats, in both S.D. and the U.S.

5.2 IMPLICATIONS

Using the results of the first objective, especially Fig. 4.1, 4.2 and 4.3, a farmer can predict the price in a future time within the year given the price at harvest.

The results of the second objective showed that S.D. price can be replaced by U.S. price for wheat and oats, but not for corn. Thus a S.D. farmer can expect U.S. price forecast to be applicable for wheat and oats, but not for corn.

The results of the third objective showed that S.D. and U.S. prices are merging in the latter years. This means that a S.D. farmer can expect U.S. price forecast to approach S.D. forecast in latter years for all three crops. Also the S.D. farmer can expect a greater variation in grain prices within a year because of the lowering of the loan rates much below the market clearing prices.

The fourth objective showed that 21 years of data series gave the best forecast of crop prices. This is a mathematical fact and does not depend on the changing seasonal patterns. This fact can be used especially by researchers using a moving average program to make forecast of grain prices.

A future research of interest would be to do most of the analysis done in this research for other crops, especially soybeans in S.D.

REFERENCES

Bahn, Henry. Graphs used in a speech at grain outlook conference. National Program Leader, Grain. USDA - Extension Service. South Bldg., Room 3338 Washington D.C. 20250, 1993.

Blake, Martin J. and Clevenger, Tom. A linked Annual and Monthly Model for Forecasting Alfalfa Hay Prices. Western Journal of Agricultural Economics. New Mexico State University, Agricultural Experimental Station, July 1984, P195-199.

Boland, Lawrence A. On the Futility of Criticizing the Neoclassical Maximization Hypothesis. The American Economic Review, George Banta Co., Inc., Menasha, Wisconsin. December, 1981.

Ellingson, Wayne. Associate professor, Economics Department, South Dakota State university, Brookings, South Dakota. Personal interview. 15 November 1991.

Evenson, Paul. Professor of statistics in the Plant Science Department, South Dakota State university, Brookings, South Dakota. 21 June 1992.

Ferris, John. Historical Price Data and Seasonal Price Patterns on Commodities of importance to Michigan Agriculture. Agricultural Economics Staff Paper N. 87-96. Department of Agricultural Economics, Michigan State University, East Lansing, Feb. 1992.

Ferris, John. Using Seasonal Cash Price Pattern for Selling Decisions on Corn, Soybeans and Wheat. N.C.R. Extension Publication No. 217, Producer Marketing Management - Fact Sheet #3, Department of Agricultural Economics, Michigan State University, East Lansing, 1984: P1-11.

Hannan, E.J., "The Estimation of Seasonal Variations in Economic Time Series," Journal of American Statistical Association, 58:31-44, March 1963.

Heifner, R.G., Hedging Potential in Grain Storage and Life Stock Feeding, U.S. Department of Agriculture, Agricultural Economics. Rep. No. 238, 1973.

Hoff, John C. A practical guide to Box-Jenkins forecasting. Lifetime Learning Publications, a division of Wadsworth, Inc. Belmont, California, 1983.

Hoffman, Lindwood A and Davison, Cecil W. Forecasting U.S. Soybean Prices with Futures Prices. Oil Crops situation and Outlook Report. Commodity Economics Division, Economic Research Service, USDA, Jan 1992, P23-27.

Knutson, Ronald D., Penn, J.B. and Boehm, William T. Agricultural & Food Policy. Prentice Hall, Englewood Cliffs, New Jersey 07632. 1990, P237-238.

Kohls, Richard L. and Uhl, Joseph N. Marketing of Agricultural Products. Seventh Edition. Macmillian Publishing company, N.Y. 1990, P114.

Lacher, Robert J. Professor in the Maths/statistics department, South Dakota State university, Brookings, South Dakota. Personal interview. 23 November 1992.

Lamberton, Charles E. Professor, Economics Department, South Dakota State University. Brookings, South Dakota. Personal interview. Gave advice during my seminar. 22 November 1992.

Leuthold, Raymond M. Evaluation and Performance of the Frozen Pork Belly Futures Market. Applied Commodity Price Analysis, Forecasting and Market Risk Management, NCR-132 conference, held at Chicago. April 20-21,1992, P62.

Markowitz, Harry M. Portfolio selection - Efficient Diversification of Investments, N.Y. John Wiley & Sons, 1959.

Neter, John, Wasserman, William and Kutner, Michael H. Applied Linear Regression Models. Homewood, IL: Irwin, 1989.

Ober, Broyd M. South Dakota Elevator's Winter Wheat Marketing Practices and Seasonality of Cash Wheat Prices. Unpublished M.S. Thesis, South Dakota State University, 1988, P75-108.

Peck, A.E. Hedging and Income Stability, Concepts, Implications, and an Example, American journal of Agricultural Economics 57, 1975, P410-419.

Qasmi, Bashir. Assistant Professor, Economics Department, South Dakota State university, Brookings, South Dakota. Personal interview, 26 January 1993.

SAS Institute Inc SAS/ETS User's Guide, Version 6, First Edition. SAS Institute INC, Cary, NC 27512-8000, 1988.

Senjem, Norman Readers Reveal Crop Marketing Habits. Cash sales, forward contracts are the major marketing methods. the Farmer/The Dakota Farmer, 7900 International Drive, Minneapolis, MN 55425, January 20 1990, P30-31.

Shane, Dr. Richard. Professor, Economics Department, South Dakota State University. Personal interview. 16 February 1992.

Shiskin, Julius et. al. Seasonality Analysis of Economic Time Series, Economic Research Report, ER-1, Proceedings of the Conference on the Seasonal Analysis of Economic Time Series, U.S. Department of Commerce.Washington, D.C., Sept. 9-10, 1976.

Shumway, Robert H. Applied Statistical Time Series Analysis. Prientice Hall, Englewood Cliffs, New Jersey 07632, 1988.

South Dakota Agricultural Statistics services. South Dakota Agricultural Statistics 1991-1992. Sioux Falls, SD: S.D. Department of agriculture, May 1992.

South Dakota Agricultural Statistics services. South Dakota Agricultural Statistics 1990-1991. Sioux Falls, SD: S.D. Department of agriculture, May 1991.

South Dakota Agricultural Statistics services. South Dakota Agricultural Statistics 1984-1990. Sioux Falls, SD: S.D. Department of agriculture, May 1990.

Tomek, William G. and Robinson, Kenneth L. Agricultural Product Prices. Second Edition. Cornell University Press, Ithaca and London, 1981.

Varian, Hal R. Microeconomic Analysis. 3rd ed. New York: W.W. Norton & Company, Inc., 1992.

Villezca-Becerra, Pedro A. and Shumway, C. Richard State-Level Output Supply and Input Demand Elasticities for Agricultural Commodities. The Journal of Agricultural Economics Research/Vol 44, NO. 1, Economic Research Service, USDA, 1992, P22

Wilson, Jeff. SEASON: A FORTRAN Program for Computing Measures of Seasonality in Economic Time Series. Computer Software written by Jeff Wilson, Ag. Econ. Computer Service, U. of Michigan, 1977, Microcomputer update 1987.

William G. Tomek & Kenneth L. Robinson, Agricultural Product Prices. Cornell University Press, Second Edition, Ithaca, New York, 1981.

APPENDIX

USING THE SEASON PROGRAM

The SEASON program was originally written for use on the mainframe computer and has since been modified for microcomputer (Wilson, 1987). An 80386 microprocessor with a 80387 math-coprocessor or higher is needed to run the program (Wilson, 1987). A batch file called SEASBAT is used to detect any major terror in the input program and to run the program. The user has to type: A > SEASBAT [filename].dat [filename].out

The output is an ASCII file which can be printed on ten to twelve pages of PC printouts. Because of the space between information, this can be compressed with an editor to about five pages.

For the input on Table 2.2, the instructions to the SEASON program is the first 11 lines. Of these lines, the first eight are called the parameter cards, and the last three are the data cards. The parameter cards are reproduced in Table A.1 below:

Table A.1: Parameter cards

```
(1) 12
(2) SEPOCTNOVDECJANFEBMARAPRMAYJUNJULAUG
(3) 060601
(4)   1  2  2  2  2  2  2  2  2  2  2  2  1
(5)
(6)
(7) 01050204020711
(8) 01011983
```

The first parameter card is the number 12, it is the number of observation within each year, the second card is the name given to each of the twelve observations specified in the first parameter card (in this case the months September to August). The third, fourth, fifth and sixth cards carry the constants for two moving average formulas. The seventh parameter cards designate the order of the operations to be performed on the series. This card is called the agenda card. Each of these operations are specified by the consecutive two digits of the 14 digits in the agenda card. For example, 01 stands for "read data cards and store in Y register." The eight parameter card specifies the ordering of the periods in input and output. A year is designated for evaluating the linearly changing seasonal. Thus, switching from calendar years to marketing years or vice versa with one data series can be done by changing the numbers in this card. The year 1983, in the eight data card is the year to which the forecast is to be made. This year must be two years beyond the ending year specified in the second data card.

The next three cards are the data cards as reproduced in Table A.2 below:

Table A.2: Data cards

```
(1) CASH PRICES RECEIVED BY S.D. FARMERS (CORN)
(2) 091950081981
(3) (2X.12F5.2)
```

The first data card is the name of the job. Columns 1-80 can be used to write this name. The second data card is the starting and ending date of the data series, in this case 09/1950 - 08/1981. The third data card specifies the format for reading observations. In this case, (2X,12F5.2) stands for the read data after the first two columns (reserved for years) as twelve decimal numbers each taking up five spaces and having two decimal points.

Given the actual prices of the grains in a block with months on the x-axis and years on the y-axis and price forming the block, the program computes price indices and the moving average price for each month. An estimate of the regression equation based on the moving average for each of the twelve months is made. The standard deviation of the index and the trend coefficients, which is the average change in the monthly price index, is also listed. The program also provides forecasts for the prices for two years beyond the sample data series.

After the list of prices the figures 0002 and END are required to indicate the end of the data series.

This thesis involved more than 540 runs of the SEASON program. To print all these files (both data files and output files, which was more than 1080 files), a batch file called PRINT.bat was written as shown Table A.3 below:

Table A.3: Batch file used to print some of the results.

```
copy c6070.dat prn
copy c6070.out prn
copy c6171.dat prn
copy c6171.out prn
copy c6272.dat prn
copy c6272.out prn
copy c6373.dat prn
copy c6373.out prn
copy c6474.dat prn
copy c6474.out prn
copy c6575.dat prn
copy c6575.out prn
copy c6676.dat prn
copy c6676.out prn
copy c6777.dat prn
copy c6777.out prn
```

Table A.4: Corn, S.D. - Price received by farmers.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
49	1.05	0.97	0.93	1.04	1.03	1.04	1.05	1.15	1.22	1.21	1.27	1.27
50	1.29	1.23	1.26	1.30	1.36	1.44	1.40	1.44	1.46	1.42	1.44	1.48
51	1.50	1.49	1.39	1.15	1.10	1.10	1.15	1.30	1.40	1.50	1.50	1.55
52	1.52	1.35	1.32	1.37	1.33	1.26	1.32	1.31	1.36	1.29	1.31	1.33
53	1.34	1.19	1.20	1.27	1.25	1.25	1.26	1.29	1.32	1.34	1.31	1.35
54	1.38	1.31	1.24	1.25	1.24	1.23	1.20	1.23	1.30	1.35	1.34	1.24
55	1.23	1.09	1.14	1.17	1.15	1.16	1.15	1.27	1.32	1.32	1.37	1.38
56	1.32	1.11	1.14	1.12	1.11	1.07	1.08	1.09	1.12	1.12	1.11	1.10
57	0.97	0.92	0.77	0.72	0.70	0.71	0.75	0.85	0.94	1.02	0.99	0.98
58	0.97	0.89	0.83	0.90	0.89	0.89	0.90	0.99	1.01	1.03	1.03	1.07
59	1.06	0.98	0.97	0.95	0.93	0.90	0.91	0.95	0.96	0.99	0.99	0.99
60	0.97	0.89	0.76	0.77	0.79	0.81	0.82	0.80	0.87	0.90	0.92	0.93
61	0.92	0.90	0.83	0.85	0.85	0.85	0.87	0.89	0.90	0.91	0.94	0.94
62	0.94	0.96	0.85	0.91	0.95	0.97	0.96	0.97	0.98	1.04	1.07	1.06
63	1.08	0.92	0.92	0.94	0.96	0.96	0.99	1.04	1.09	1.07	1.05	1.06
64	1.11	1.03	1.00	1.11	1.14	1.15	1.14	1.16	1.18	1.19	1.14	1.12
65	1.12	1.10	0.98	1.05	1.11	1.12	1.09	1.11	1.13	1.17	1.21	1.28
66	1.28	1.22	1.18	1.19	1.19	1.16	1.16	1.17	1.18	1.20	1.18	1.12
67	1.14	1.08	0.98	1.00	1.02	1.03	1.04	1.08	1.14	1.14	1.10	1.04
68	1.04	1.02	1.02	1.00	1.06	1.06	1.05	1.06	1.10	1.09	1.09	1.08
69	1.06	1.04	0.97	0.97	0.97	1.00	1.00	1.02	1.04	1.05	1.07	1.10
70	1.21	1.17	1.18	1.21	1.26	1.29	1.30	1.30	1.31	1.32	1.27	1.13
71	1.11	1.00	1.00	1.03	1.05	1.07	1.07	1.07	1.11	1.11	1.11	1.11
72	1.10	1.08	1.01	1.16	1.19	1.19	1.17	1.19	1.33	1.71	1.72	2.24
73	1.97	1.97	1.95	2.15	2.30	2.43	2.48	2.28	2.34	2.41	2.70	3.31
74	3.33	3.30	3.30	3.26	3.10	2.89	2.63	2.73	2.75	2.72	2.68	2.97
75	2.83	2.54	2.29	2.33	2.34	2.36	2.39	2.38	2.48	2.75	2.79	2.65
76	2.64	2.36	2.19	2.29	2.40	2.35	2.46	2.36	2.34	2.13	1.86	1.67
77	1.54	1.50	1.67	1.68	1.80	1.81	1.92	2.05	2.10	2.06	1.88	1.76
78	1.70	1.61	1.68	1.87	1.85	1.95	1.91	1.94	2.06	2.21	2.29	2.20
79	2.03	1.88	1.79	1.91	1.98	2.01	1.99	2.04	2.12	2.25	2.46	2.55
80	2.61	2.70	2.94	2.95	3.06	3.04	3.03	3.06	3.02	3.00	3.00	2.67
81	2.42	2.13	2.14	2.21	2.31	2.34	2.35	2.42	2.44	2.44	2.16	2.10
82	2.08	1.93	1.88	1.93	2.13	2.38	2.53	2.78	2.79	2.84	2.90	3.11
83	3.03	2.94	3.00	3.03	3.03	2.95	3.05	3.17	3.25	3.23	3.15	2.98
84	2.85	2.42	2.39	2.50	2.44	2.46	2.49	2.54	2.53	2.54	2.50	2.32
85	2.29	2.05	2.08	2.09	2.18	2.19	2.15	2.14	2.20	2.11	1.92	1.82
86	1.33	1.29	1.32	1.33	1.30	1.29	1.30	1.45	1.57	1.61	1.52	1.38
87	1.37	1.37	1.47	1.59	1.64	1.69	1.78	1.78	1.88	2.33	2.75	2.63
88	2.50	2.43	2.45	2.41	2.46	2.46	2.45	2.39	2.44	2.40	2.29	2.09
89	2.02	2.00	2.07	2.13	2.09	2.10	2.17	2.37	2.46	2.44	2.43	2.31
90	2.07	1.92	1.91	1.95	2.07	2.14	2.23	2.28	2.23	2.17	2.13	2.19

Sep. of 1990 crop year is Sep. of 1990 calendar year.

Table A.5: Corn, U.S. - Price received by farmers.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
49	1.16	1.09	1.02	1.13	1.15	1.16	1.19	1.26	1.34	1.36	1.44	1.44
50	1.44	1.37	1.37	1.45	1.54	1.60	1.60	1.62	1.64	1.62	1.63	1.65
51	1.65	1.64	1.61	1.68	1.68	1.65	1.65	1.68	1.70	1.73	1.73	1.73
52	1.71	1.53	1.45	1.50	1.48	1.43	1.46	1.46	1.49	1.46	1.47	1.48
53	1.50	1.34	1.33	1.41	1.42	1.43	1.44	1.45	1.47	1.49	1.50	1.53
54	1.53	1.45	1.37	1.39	1.40	1.40	1.36	1.36	1.40	1.40	1.40	1.30
55	1.24	1.14	1.09	1.15	1.16	1.18	1.20	1.32	1.39	1.42	1.43	1.45
56	1.43	1.19	1.21	1.22	1.23	1.19	1.20	1.21	1.23	1.22	1.23	1.23
57	1.15	1.06	0.99	0.98	0.93	0.96	1.00	1.12	1.15	1.19	1.18	1.18
58	1.13	1.04	0.94	1.02	1.02	1.04	1.06	1.13	1.15	1.16	1.13	1.13
59	1.09	0.99	0.98	0.96	0.98	0.99	1.00	1.05	1.07	1.08	1.09	1.07
60	1.06	0.99	0.87	0.91	0.96	1.00	1.01	0.97	1.02	1.03	1.05	1.04
61	1.04	1.02	0.94	0.95	0.95	0.96	0.97	0.99	1.03	1.03	1.04	1.02
62	1.04	1.03	0.99	1.04	1.07	1.09	1.10	1.10	1.11	1.16	1.19	1.19
63	1.21	1.11	1.05	1.09	1.12	1.11	1.13	1.15	1.17	1.16	1.12	1.12
64	1.17	1.13	1.07	1.16	1.18	1.20	1.21	1.23	1.26	1.25	1.22	1.18
65	1.18	1.10	1.04	1.13	1.19	1.20	1.17	1.19	1.21	1.20	1.27	1.34
66	1.35	1.29	1.26	1.29	1.28	1.26	1.28	1.26	1.25	1.26	1.21	1.11
67	1.12	1.04	0.98	1.03	1.04	1.06	1.06	1.06	1.09	1.07	1.04	0.99
68	1.01	0.96	1.04	1.05	1.08	1.09	1.09	1.12	1.19	1.18	1.18	1.18
69	1.15	1.12	1.07	1.09	1.12	1.14	1.13	1.15	1.18	1.21	1.24	1.27
70	1.38	1.34	1.29	1.36	1.42	1.43	1.43	1.41	1.38	1.43	1.36	1.19
71	1.11	1.00	0.97	1.08	1.09	1.09	1.10	1.13	1.15	1.13	1.14	1.15
72	1.22	1.19	1.20	1.42	1.39	1.35	1.37	1.42	1.61	1.99	2.03	2.68
73	2.15	2.17	2.18	2.39	2.59	2.76	2.68	2.41	2.45	2.57	2.91	3.37
74	3.30	3.45	3.32	3.27	3.07	2.86	2.67	2.68	2.66	2.68	2.72	2.95
75	2.76	2.62	2.33	2.37	1.44	1.46	1.46	1.44	1.47	1.64	1.64	1.48
76	1.49	1.46	1.45	1.51	1.58	1.63	1.64	1.64	1.52	1.29	1.02	0.93
77	0.94	1.04	1.10	1.13	1.18	1.22	1.17	1.19	1.24	1.16	1.08	1.06
78	1.06	1.08	1.15	1.19	1.22	1.25	1.27	1.29	1.29	1.35	1.33	1.24
79	1.29	1.31	1.41	1.31	1.39	1.37	1.34	1.38	1.43	1.48	1.50	1.53
80	3.01	2.99	3.10	3.19	3.19	3.22	3.25	3.24	3.24	3.17	3.14	2.87
81	2.55	2.45	2.34	2.39	2.54	2.44	2.46	2.55	2.60	2.57	2.50	2.30
82	2.15	1.98	2.13	2.26	2.36	2.56	2.71	2.95	3.03	3.04	3.13	3.35
83	3.32	3.15	3.17	3.15	3.15	3.11	3.21	3.32	3.34	3.36	3.30	3.13
84	2.90	2.65	2.55	2.56	2.64	2.62	2.67	2.70	2.68	2.64	2.60	2.44
85	2.29	2.11	2.21	2.29	2.33	2.32	2.29	2.30	2.39	2.32	2.00	1.73
86	1.45	1.40	1.47	1.50	1.48	1.42	1.47	1.52	1.66	1.69	1.60	1.47
87	1.49	1.56	1.62	1.72	1.77	1.83	1.86	1.88	1.95	2.41	2.72	2.65
88	2.60	2.58	2.51	2.53	2.60	2.59	2.60	2.56	2.58	2.52	2.47	2.27
89	2.29	2.22	2.24	2.27	2.31	2.32	2.37	2.51	2.62	2.63	2.62	2.51
90	2.32	2.19	2.16	2.22	2.27	2.32	2.39	2.42	2.38	2.31	2.27	2.33

Sep. of 1990 crop year is Sep. of 1990 calendar year.

Table A.6: Wheat, S.D. - Price received by farmers.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
49	1.92	1.92	1.94	1.95	1.93	1.92	1.99	1.99	2.04	2.00	2.07	2.02
50	1.94	1.91	1.91	2.03	2.11	2.23	2.10	2.12	2.08	2.06	2.05	2.03
51	2.02	2.08	2.16	2.17	2.16	2.14	2.15	2.12	2.09	2.10	2.05	2.07
52	2.07	2.10	2.15	2.14	2.12	2.08	2.14	2.12	2.13	2.00	2.01	1.85
53	1.99	1.99	2.05	2.06	2.04	2.10	2.09	2.06	2.04	1.98	2.03	2.12
54	2.22	2.25	2.28	2.26	2.26	2.24	2.28	2.19	2.25	2.25	2.16	2.02
55	2.07	2.06	2.05	2.04	2.05	2.03	2.01	2.07	2.05	2.02	2.03	2.00
56	1.99	1.99	2.07	2.05	2.04	2.04	2.03	2.02	1.96	1.96	1.98	1.89
57	1.92	1.96	1.97	1.96	1.93	1.95	1.99	1.99	1.99	2.01	1.85	1.66
58	1.72	1.74	1.75	1.76	1.75	1.76	1.76	1.78	1.79	1.80	1.80	1.81
59	1.82	1.85	1.88	1.85	1.85	1.85	1.86	1.86	1.86	1.86	1.80	1.74
60	1.75	1.76	1.78	1.79	1.80	1.79	1.78	1.78	1.81	1.83	1.95	1.94
61	2.00	2.05	2.05	2.11	2.13	2.11	2.11	2.12	2.11	2.07	2.13	2.02
62	2.03	2.06	2.11	2.10	2.10	2.10	2.11	2.12	2.08	2.09	1.90	1.79
63	1.91	2.00	1.98	1.99	1.99	1.96	1.87	1.92	1.90	1.72	1.40	1.34
64	1.40	1.44	1.45	1.45	1.46	1.45	1.43	1.43	1.45	1.40	1.44	1.38
65	1.40	1.44	1.46	1.49	1.51	1.53	1.52	1.48	1.50	1.56	1.77	1.75
66	1.77	1.66	1.63	1.66	1.61	1.56	1.64	1.56	1.63	1.55	1.50	1.44
67	1.42	1.44	1.41	1.42	1.43	1.44	1.45	1.42	1.40	1.34	1.31	1.23
68	1.28	1.33	1.37	1.36	1.37	1.38	1.37	1.35	1.36	1.33	1.34	1.27
69	1.34	1.40	1.42	1.44	1.44	1.42	1.41	1.41	1.40	1.44	1.41	1.44
70	1.52	1.56	1.55	1.52	1.52	1.50	1.44	1.44	1.41	1.42	1.34	1.27
71	1.28	1.31	1.33	1.35	1.36	1.33	1.34	1.34	1.35	1.35	1.30	1.44
72	1.64	1.74	1.78	2.08	2.10	1.84	1.90	1.96	1.98	2.30	2.40	4.22
73	4.34	3.95	4.00	4.61	5.12	5.38	4.99	4.08	3.67	4.07	4.60	4.40
74	4.46	4.93	5.08	4.77	4.35	4.10	3.86	3.97	3.74	3.56	3.98	4.25
75	4.46	4.40	3.94	3.77	3.82	4.02	3.97	3.84	3.83	4.00	3.92	3.21
76	3.03	2.81	2.65	2.55	2.62	2.65	2.62	2.61	2.46	2.21	2.09	2.15
77	2.16	2.41	2.60	2.47	2.57	2.64	2.69	2.84	2.88	2.76	2.61	2.63
78	2.79	2.86	2.95	2.85	2.65	2.85	2.80	2.85	3.11	3.35	3.60	3.50
79	3.70	3.97	3.83	3.65	3.52	3.71	3.72	3.73	3.90	4.06	4.20	4.37
80	4.45	4.50	4.83	4.54	4.47	4.46	4.25	4.21	4.33	4.18	3.78	3.62
81	3.57	3.56	3.66	3.59	3.56	3.48	3.55	3.54	3.56	3.54	3.46	3.37
82	3.43	3.42	3.50	3.41	3.34	3.34	3.48	3.75	3.83	3.74	3.66	3.74
83	3.60	3.71	3.59	3.59	3.50	3.51	3.66	3.80	3.89	3.78	3.56	3.52
84	3.48	3.45	3.44	3.38	3.38	3.45	3.47	3.56	3.51	3.42	3.05	3.05
85	3.27	3.37	3.53	3.54	3.60	3.50	3.48	3.60	3.36	2.81	2.26	2.22
86	2.33	2.38	2.47	2.53	2.47	2.40	2.42	2.57	2.61	2.51	2.27	2.35
87	2.41	2.60	2.58	2.60	2.68	2.74	2.54	2.77	2.92	3.26	3.46	3.53
88	3.62	3.60	3.60	3.66	3.75	3.85	3.94	3.94	3.96	3.90	3.75	3.70
89	3.62	3.57	3.61	3.65	3.62	3.48	3.39	3.48	3.48	3.32	2.67	2.55
90	2.46	2.45	2.44	2.40	2.26	2.40	2.50	2.58	2.63	2.54	2.43	2.53

Sep. of 1990 crop year is Sep. of 1990 calendar year.

Table A.7: Wheat, U.S. - Price received by farmers.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
49	1.87	1.89	1.90	1.93	1.92	1.93	1.98	2.01	2.24	1.93	1.99	1.97
50	1.94	1.90	1.94	2.02	2.09	2.21	2.12	2.14	2.11	2.08	2.05	2.05
51	2.07	2.10	2.19	2.22	2.20	2.18	2.20	2.18	2.13	2.06	1.98	2.04
52	2.09	2.07	2.13	2.12	2.10	2.05	2.10	2.08	2.06	1.88	1.87	1.86
53	1.92	1.94	2.00	2.01	2.03	2.06	2.09	2.06	2.00	1.91	2.00	2.03
54	2.07	2.08	2.12	2.12	2.14	2.13	2.12	2.09	2.13	2.06	1.97	1.90
55	1.92	1.94	1.94	1.95	1.95	1.95	1.97	2.03	2.00	1.93	1.90	1.93
56	1.95	1.98	2.05	2.07	2.09	2.07	2.07	2.05	1.98	1.91	1.91	1.90
57	1.90	1.92	1.93	1.94	1.90	1.92	1.96	1.95	1.93	1.70	1.64	1.64
58	1.68	1.73	1.74	1.73	1.71	1.74	1.76	1.77	1.77	1.69	1.70	1.75
59	1.72	1.76	1.79	1.79	1.78	1.80	1.82	1.82	1.82	1.72	1.67	1.71
60	1.72	1.74	1.76	1.77	1.79	1.81	1.80	1.74	1.76	1.72	1.73	1.83
61	1.87	1.88	1.88	1.89	1.88	1.88	1.89	1.92	1.98	1.99	1.98	2.00
62	1.99	1.97	2.00	2.02	2.01	2.04	2.04	2.09	2.04	1.86	1.75	1.77
63	1.84	1.94	1.95	1.97	2.00	1.99	1.85	1.94	1.88	1.40	1.33	1.33
64	1.36	1.36	1.39	1.39	1.38	1.37	1.36	1.34	1.33	1.28	1.31	1.34
65	1.33	1.35	1.38	1.40	1.41	1.43	1.41	1.39	1.44	1.59	1.74	1.70
66	1.71	1.59	1.60	1.61	1.57	1.49	1.59	1.55	1.58	1.49	1.37	1.41
67	1.39	1.43	1.39	1.39	1.40	1.42	1.42	1.36	1.36	1.24	1.19	1.19
68	1.22	1.26	1.29	1.26	1.27	1.28	1.28	1.28	1.28	1.22	1.15	1.19
69	1.24	1.28	1.29	1.30	1.29	1.30	1.28	1.32	1.31	1.23	1.23	1.31
70	1.41	1.43	1.45	1.41	1.40	1.41	1.39	1.40	1.43	1.46	1.34	1.28
71	1.26	1.30	1.31	1.34	1.33	1.34	1.34	1.36	1.38	1.33	1.32	1.51
72	1.73	1.89	1.97	2.38	2.38	1.97	2.06	2.15	2.15	2.43	2.47	4.45
73	4.62	4.22	4.20	4.78	5.29	5.52	4.96	3.98	3.52	3.57	4.04	4.24
74	4.32	4.85	4.87	4.65	4.11	3.95	3.65	3.69	3.47	2.92	3.33	3.89
75	4.11	4.02	3.58	3.41	3.43	3.66	3.65	3.50	3.43	3.46	3.33	2.97
76	2.88	2.59	2.46	2.39	2.43	2.47	2.43	2.37	2.19	2.03	2.04	2.13
77	2.16	2.30	2.46	2.47	2.53	2.59	2.67	2.82	2.82	2.81	2.81	2.88
78	2.92	2.99	3.04	3.01	2.99	2.99	2.97	3.01	3.20	3.72	3.89	3.74
79	3.87	3.98	3.94	3.81	3.74	3.78	3.64	3.58	3.69	3.69	3.81	3.94
80	3.99	4.19	4.32	4.22	4.21	4.17	4.09	4.07	3.95	3.70	3.62	3.62
81	3.65	3.77	3.85	3.80	3.78	3.70	3.67	3.68	3.64	3.39	3.26	3.34
82	3.38	3.43	3.48	3.51	3.57	3.57	3.66	3.75	3.73	3.50	3.34	3.61
83	3.65	3.60	3.54	3.48	3.50	3.40	3.49	3.63	3.66	3.46	3.28	3.43
84	3.43	3.43	3.45	3.38	3.38	3.38	3.38	3.43	3.30	3.09	2.93	2.89
85	3.01	3.09	3.23	3.25	3.19	3.16	3.28	3.37	3.01	2.47	2.25	2.26
86	2.28	2.30	2.43	2.49	2.53	2.58	2.57	2.63	2.66	2.44	2.32	2.36
87	2.54	2.62	2.69	2.70	2.75	2.79	2.74	2.79	2.99	3.37	3.50	3.61
88	3.74	3.84	3.88	3.94	4.02	4.03	4.07	4.03	4.01	3.85	3.78	3.74
89	3.72	3.75	3.72	3.79	3.71	3.56	3.48	3.49	3.40	3.08	2.79	2.58
90	2.46	2.42	2.39	2.40	2.42	2.43	2.53	2.60	2.64	2.55	2.49	2.63

Sep. of 1990 crop year is Sep. of 1990 calendar year.

Table A.8: Oats, S.D. - Price received by farmers.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
49	0.53	0.53	0.59	0.62	0.62	0.62	0.63	0.66	0.72	0.74	0.70	0.61
50	0.65	0.64	0.73	0.77	0.79	0.86	0.81	0.80	0.78	0.71	0.70	0.67
51	0.68	0.75	0.86	0.88	0.86	0.78	0.79	0.76	0.69	0.69	0.67	0.73
52	0.77	0.74	0.76	0.76	0.72	0.65	0.69	0.66	0.65	0.62	0.64	0.65
53	0.61	0.64	0.65	0.68	0.70	0.68	0.69	0.70	0.69	0.66	0.58	0.57
54	0.62	0.64	0.67	0.66	0.66	0.64	0.63	0.62	0.61	0.65	0.52	0.47
55	0.50	0.52	0.53	0.56	0.54	0.54	0.53	0.52	0.54	0.53	0.61	0.64
56	0.63	0.63	0.66	0.68	0.69	0.65	0.64	0.64	0.63	0.58	0.54	0.49
57	0.50	0.51	0.52	0.52	0.50	0.49	0.50	0.51	0.49	0.49	0.48	0.44
58	0.46	0.47	0.49	0.52	0.51	0.52	0.51	0.52	0.53	0.53	0.56	0.57
59	0.57	0.59	0.60	0.62	0.63	0.61	0.60	0.61	0.60	0.58	0.54	0.51
60	0.51	0.51	0.50	0.51	0.51	0.51	0.50	0.50	0.53	0.54	0.58	0.54
61	0.57	0.57	0.58	0.60	0.61	0.58	0.58	0.60	0.60	0.57	0.56	0.50
62	0.52	0.54	0.57	0.59	0.58	0.58	0.58	0.58	0.57	0.58	0.55	0.53
63	0.55	0.56	0.57	0.58	0.59	0.58	0.57	0.58	0.58	0.57	0.54	0.54
64	0.56	0.58	0.58	0.61	0.62	0.62	0.62	0.62	0.62	0.60	0.56	0.54
65	0.54	0.55	0.56	0.58	0.60	0.60	0.60	0.59	0.59	0.59	0.60	0.60
66	0.62	0.62	0.63	0.64	0.65	0.64	0.64	0.63	0.64	0.64	0.63	0.58
67	0.59	0.59	0.59	0.60	0.62	0.63	0.64	0.64	0.64	0.63	0.56	0.51
68	0.53	0.54	0.56	0.58	0.59	0.61	0.59	0.59	0.59	0.55	0.53	0.50
69	0.51	0.53	0.53	0.53	0.56	0.56	0.55	0.57	0.57	0.56	0.52	0.53
70	0.58	0.57	0.60	0.60	0.63	0.62	0.61	0.60	0.62	0.62	0.53	0.51
71	0.54	0.55	0.57	0.59	0.60	0.60	0.60	0.59	0.59	0.60	0.58	0.57
72	0.60	0.62	0.66	0.75	0.72	0.70	0.70	0.70	0.71	0.73	0.69	1.04
73	1.01	1.03	1.05	1.15	1.26	1.36	1.32	1.16	1.22	1.22	1.29	1.49
74	1.55	1.64	1.68	1.67	1.56	1.53	1.40	1.48	1.53	1.46	1.38	1.41
75	1.42	1.33	1.38	1.41	1.43	1.44	1.42	1.42	1.47	1.69	1.69	1.50
76	1.53	1.46	1.44	1.50	1.59	1.62	1.60	1.54	1.48	1.18	0.87	0.82
77	0.76	0.98	1.03	1.07	1.14	1.06	1.09	1.14	1.21	1.08	0.94	0.89
78	1.00	1.06	1.14	1.16	1.16	1.21	1.21	1.22	1.25	1.28	1.18	1.06
79	1.14	1.15	1.24	1.31	1.32	1.28	1.24	1.26	1.29	1.36	1.44	1.45
80	1.47	1.58	1.86	1.92	1.90	1.97	2.00	2.01	2.01	1.96	1.82	1.70
81	1.67	1.71	1.91	1.94	1.91	1.94	1.93	1.96	1.96	1.74	1.40	1.24
82	1.19	1.18	1.25	1.37	1.37	1.35	1.41	1.51	1.47	1.50	1.37	1.37
83	1.57	1.62	1.65	1.72	1.75	1.71	1.67	1.71	1.73	1.73	1.59	1.52
84	1.49	1.48	1.52	1.64	1.62	1.56	1.52	1.49	1.40	1.32	1.11	1.03
85	1.01	1.01	1.03	1.12	1.12	1.06	1.04	1.07	1.05	1.03	0.81	0.82
86	0.97	1.01	1.26	1.36	1.41	1.36	1.38	1.41	1.63	1.51	1.30	1.41
87	1.50	1.63	1.70	1.82	1.79	1.82	1.71	1.82	1.87	2.88	2.80	2.65
88	2.37	2.65	2.40	2.41	2.54	2.14	2.38	2.14	1.96	1.70	1.53	1.43
89	1.34	1.39	1.45	1.49	1.44	1.37	1.40	1.38	1.38	1.26	1.08	1.00
90	0.99	1.06	1.08	1.08	1.09	1.02	1.06	1.11	1.08	1.03	1.04	1.07

Sep. of 1990 crop year is Sep. of 1990 calendar year.

Table A.9: Oats, U.S. - Price received by farmers.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
49	0.61	0.62	0.66	0.70	0.70	0.71	0.72	0.75	0.79	0.80	0.76	0.71
50	0.73	0.74	0.81	0.85	0.88	0.92	0.91	0.91	0.89	0.83	0.78	0.76
51	0.78	0.82	0.91	0.95	0.94	0.89	0.89	0.87	0.82	0.78	0.76	0.80
52	0.84	0.83	0.85	0.84	0.82	0.77	0.78	0.76	0.75	0.71	0.70	0.72
53	0.71	0.73	0.75	0.77	0.78	0.78	0.78	0.78	0.77	0.74	0.67	0.68
54	0.71	0.73	0.76	0.77	0.77	0.76	0.74	0.73	0.72	0.70	0.60	0.55
55	0.56	0.59	0.61	0.63	0.62	0.62	0.62	0.62	0.63	0.63	0.65	0.68
56	0.68	0.69	0.72	0.74	0.75	0.73	0.72	0.71	0.70	0.66	0.62	0.58
57	0.60	0.61	0.61	0.62	0.61	0.61	0.62	0.62	0.59	0.62	0.58	0.54
58	0.56	0.56	0.57	0.59	0.59	0.60	0.59	0.60	0.60	0.61	0.61	0.61
59	0.62	0.65	0.67	0.68	0.69	0.68	0.68	0.68	0.68	0.69	0.63	0.58
60	0.60	0.60	0.59	0.59	0.60	0.60	0.59	0.58	0.60	0.63	0.64	0.60
61	0.64	0.64	0.64	0.66	0.67	0.65	0.65	0.66	0.67	0.68	0.62	0.57
62	0.60	0.62	0.63	0.64	0.65	0.65	0.66	0.65	0.64	0.67	0.62	0.58
63	0.62	0.63	0.63	0.64	0.65	0.64	0.63	0.63	0.63	0.63	0.59	0.58
64	0.61	0.62	0.63	0.64	0.66	0.66	0.66	0.67	0.68	0.68	0.63	0.60
65	0.60	0.62	0.62	0.63	0.64	0.65	0.65	0.65	0.66	0.67	0.66	0.64
66	0.65	0.66	0.66	0.68	0.68	0.67	0.68	0.68	0.69	0.72	0.67	0.62
67	0.64	0.65	0.65	0.66	0.67	0.69	0.69	0.69	0.69	0.69	0.61	0.53
68	0.56	0.58	0.60	0.61	0.63	0.64	0.62	0.61	0.62	0.63	0.58	0.53
69	0.55	0.57	0.58	0.58	0.59	0.59	0.58	0.59	0.60	0.61	0.58	0.57
70	0.61	0.61	0.63	0.65	0.67	0.68	0.66	0.63	0.66	0.71	0.63	0.56
71	0.57	0.58	0.60	0.62	0.64	0.64	0.64	0.64	0.64	0.67	0.66	0.62
72	0.65	0.67	0.70	0.81	0.81	0.78	0.77	0.77	0.80	0.90	0.86	1.13
73	1.09	1.14	1.13	1.20	1.32	1.44	1.40	1.24	1.27	1.30	1.37	1.55
74	1.57	1.68	1.70	1.70	1.62	1.58	1.46	1.51	1.54	1.49	1.45	1.44
75	1.45	1.41	1.40	1.42	1.44	1.46	1.46	1.44	1.47	1.64	1.64	1.48
76	1.49	1.46	1.45	1.51	1.58	1.63	1.64	1.64	1.52	1.29	1.02	0.93
77	0.94	1.04	1.10	1.13	1.18	1.22	1.17	1.19	1.24	1.16	1.08	1.06
78	1.06	1.08	1.15	1.19	1.22	1.25	1.27	1.29	1.29	1.35	1.33	1.24
79	1.29	1.31	1.41	1.31	1.39	1.37	1.34	1.38	1.43	1.48	1.50	1.53
80	1.63	1.65	1.84	1.92	1.98	2.01	2.08	2.05	2.05	1.99	1.84	1.72
81	1.74	1.78	1.88	1.94	1.97	1.99	2.02	1.99	1.99	1.88	1.57	1.39
82	1.35	1.32	1.40	1.44	1.46	1.48	1.49	1.54	1.54	1.51	1.46	1.45
83	1.55	1.62	1.67	1.73	1.81	1.88	1.81	1.82	1.84	1.80	1.68	1.62
84	1.60	1.69	1.64	1.72	1.74	1.69	1.68	1.68	1.60	1.59	1.31	1.16
85	1.10	1.08	1.17	1.20	1.18	1.16	1.14	1.13	1.21	1.10	0.90	0.86
86	0.99	1.10	1.32	1.44	1.46	1.47	1.45	1.50	1.57	1.52	1.29	1.40
87	1.49	1.60	1.62	1.76	1.76	1.85	1.78	1.82	1.72	2.68	2.86	2.54
88	2.57	2.56	2.42	2.46	2.43	2.46	2.40	2.24	2.14	1.82	1.53	1.47
89	1.38	1.47	1.48	1.53	1.47	1.43	1.39	1.44	1.46	1.37	1.15	1.06
90	1.08	1.14	1.16	1.18	1.13	1.13	1.16	1.16	1.16	1.08	1.08	1.09

Sep. of 1990 crop year is Sep. of 1990 calendar year.

Table A.10: Selected measures of changes in grain price seasonality over time.

Marketing Year	S.D.						U.S.					
	Corn		Wheat		Oats		Corn		Wheat		Oats	
	A 1/	CV 2/	A	CV	A	CV	A	CV	A	CV	A	CV
72	39.09	1.08	50.39	1.01	30.62	0.82	42.79	0.97	49.30	1.03	32.94	0.71
73	53.23	0.79	56.62	0.78	37.04	0.69	52.87	0.71	60.13	0.73	36.94	0.66
74	57.66	0.51	64.55	0.52	40.16	0.49	56.27	0.56	70.28	0.48	37.59	0.53
75	34.25	0.55	35.36	0.21	27.93	0.63	48.57	0.47	42.18	0.16	22.88	0.69
76	29.37	0.33	34.86	0.22	33.50	0.56	49.21	0.52	39.04	0.20	27.54	0.63
77	32.54	0.28	32.16	0.15	41.47	0.44	49.40	0.40	31.88	0.15	30.94	0.51
78	37.06	0.17	32.07	0.28	41.33	0.34	33.40	0.38	31.25	0.29	33.40	0.36
79	34.87	0.32	27.06	0.33	30.58	0.35	22.56	0.25	22.80	0.39	22.56	0.28
80	28.97	0.47	27.22	0.31	25.76	0.21	17.66	0.80	19.42	0.43	21.00	0.27
81	22.24	0.67	19.44	0.21	31.25	0.37	13.82	0.93	14.75	0.28	24.50	0.39
82	26.89	0.73	16.71	0.18	31.25	0.33	25.40	0.88	15.09	0.20	23.81	0.42
83	25.13	0.75	10.90	0.74	26.20	0.57	23.94	0.91	12.68	0.63	22.77	0.54
84	27.25	0.63	13.18	0.69	26.89	0.41	25.71	0.79	12.94	0.70	23.53	0.39
85	17.90	0.76	22.91	0.46	29.00	0.60	18.33	0.53	21.67	0.49	28.66	0.47
86	22.21	0.74	23.98	0.34	40.66	0.37	22.15	0.49	23.20	0.35	36.49	0.40
87	39.91	0.77	32.11	0.30	49.69	0.37	37.31	0.67	29.93	0.32	47.69	0.41
88	36.16	0.74	20.98	0.49	58.53	0.34	31.71	0.76	20.15	0.51	53.92	0.38

1/ 3-year moving average difference between the highest and lowest price index within the marketing year.

2/ 3-year coefficient of variation for the marketing year.