Simulation of moving average hedging strategies for winter wheat
by Al Stevens Brogan

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University

Abstract:
This research is an investigation of hedging alternatives for Montana winter wheat producers. Various moving averages are used to make hedging decisions. The results of implementing various decision-rules are simulated using a General Purpose Discrete Simulator program.

The Great Falls, Montana winter wheat basis is analyzed as a function of days remaining to contract maturity for futures contracts on both the Chicago Exchange and Kansas City Exchange. The Kansas City basis is found to be more predictable. It is indicated that within a crop year the December and March bases narrow as contract maturity approaches. This is not true for the September basis. The May basis tends to narrow until December and then widen. These results are incorporated as returns to hedging. The distribution daily price changes is analyzed in a time series framework. Estimated autocorrelation functions indicate that daily futures price changes follow a random walk.

The results of the simulation of moving average decision rules are generally negative. It is concluded that moving averages are not a good criterion for hedging decisions by Montana producers.

STATEMENT OF PERMISSION TO COPY

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or, in his absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature Al Stevens Brogan

Date May 25, 1977

SIMULATION OF MOVING AVERAGE

HEDGING STRATEGIES FOR WINTER WHEAT

by

AL STEVENS BROGAN

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Applied Economics

Approved:

R. Clyde Greer
Chairperson, Graduate Committee

A M Conner
Head, Major Department

Henry L Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 1977

ACKNOWLEDGEMENTS

I am grateful to my major advisor, Dr. R. Clyde Greer, for his support and guidance. I am also grateful to Drs. Oscar Burt, John Marsh, Edward Ward and Professor Maurice Taylor for their advice and assistance.

I would like to thank Farmers Union GTA for the graduate scholarship which funded this work. I would also like to thank Mr. Gale Hansen of Farmers Union GTA in Great Falls and Mr. Kent Norby of Cargill, Inc. in Great Falls for their aid in gathering data.

I am appreciative of the efforts of the typists, June Freswick and especially Evelyn Richard.

I also wish to express my gratitude to my wife, Laura, whose support and encouragement smoothed the rough spots.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This research is an investigation of hedging alternatives for Montana winter wheat producers. Various moving averages are used to make hedging decisions. The results of implementing various decision-rules are simulated using a General Purpose Discrete Simulator program.

The Great Falls, Montana winter wheat basis is analyzed as a function of days remaining to contract maturity for futures contracts on both the Chicago Exchange and Kansas City Exchange. The Kansas City basis is found to be more predictable. It is indicated that within a crop year the December and March bases narrow as contract maturity approaches. This is not true for the September basis. The May basis tends to narrow until December and then widen. These results are incorporated as returns to hedging. The distribution daily price changes is analyzed in a time series framework. Estimated autocorrelation functions indicate that daily futures price changes follow a random walk.

The results of the simulation of moving average decision rules are generally negative. It is concluded that moving averages are not a good criterion for hedging decisions by Montana producers.

Chapter 1

Introduction

Agriculture is an important industry to Montana. Over 40 percent of Montana's income is derived from agriculture. Within the agricultural sector, winter wheat holds an important place. For the four crop years from 1973/74 to 1976/77 the average annual winter wheat production has been 84.2 million bushels. For many producers winter wheat is the most important source of income. Yet these producers can not be sure in advance what return their crop will bring. From 1972 to 1976 prices have fluctuated between $2.00 and $6.00 a bushel. Because of this instability, a few producers have adopted futures trading as part of their marketing activities.

During this period of price volatility many authors, in trade publications, recommended that farmers should hedge. These articles then presented a simplified example of hedging. In this classical sense, hedging involves selling futures contracts to match production and then lifting the hedge when the grain is marketed in the spot market. However, work by Wayne Purcell (1976) indicates that returns can be increased by using a trading hedge based on moving averages.

The mechanics of a trading hedge are simple. A producer hedges grain when a short term moving average is below a longer term moving average and lifts the hedge when the short term average moves above the long term.

Inherent in the consideration of a trading hedge is an assumption about the motive for hedging. Classical hedging assumes that a producer hedges to reduce risk. This view requires that variability of spot market price be greater than the variability of the difference between futures price and spot market price. Trading hedging assumes that a producer hedges to maximize return. In this case, stability of a price difference, or basis, is less important than the predictability of the change in the basis and of the direction of price movements.

These concepts have been examined in the professional literature. Holbrook Working (1953a; 1953b) and Roger Gray (1960) have demonstrated the faults associated with classical hedging. However, their work is not generally applicable to the special problems encountered by a producer who is spatially separated from a futures market and whose product does not generally move toward the delivery points of a futures contract, the position in which a Montana producer finds himself. All wheat futures delivery points are east of Montana. Ochsner (1974) concluded that in recent years over 50 percent of Montana's wheat crop has been exported from the west coast. Very little Montana wheat is shipped east. Montana producers do not have the information needed to determine the applicability of new concepts in hedging to their situation.

Objectives

The general purpose of this study is to investigate some of the specific opportunities and problems faced by a Montana producer who wishes to use the futures market. Specifically the study is addressed to:

1. describing the theory of hedging,
2. reviewing the theory of speculative price changes,
3. choosing a futures market appropriate for Montana winter wheat producers,
4. determining a distribution of daily future price changes, and
5. simulating the results a producer might expect for moving average trading strategies.

The theoretical considerations are presented in Chapter 2. The development of the theory of hedging is discussed. Some ideas and evidence concerning price changes in speculative markets are presented.

The choice of a market is investigated in Chapter 3. Predictability of basis movement is stressed as a criterion. Basis is analyzed as a function of time.

The distribution of daily price changes is the subject of Chapter 4. Time series analysis is applied to price changes, and the results are presented.

The simulation model used to test hedging strategies is described in Chapter 5. Moving averages are used as a decision criterion. The results of Chapters 3 and 4 are implemented in the simulation.

The results of the simulation model are presented in Chapter 6. The conclusions of the study and suggestions for further research are discussed.

Chapter 2

THEORETICAL CONSIDERATIONS

Hedging Theory

There are four concepts of hedging, each based on differing assumptions regarding hedgers' motives. These concepts are classified as risk elimination, risk reduction, arbitrage, and portfolio management. These concepts are examined individually.

The risk elimination concept of hedging holds that hedging is effective only if all risk associated with price fluctuations of a commodity is eliminated. In other words, any gains or losses in the cash market due to price changes are exactly offset by respective losses or gains in the futures market. This view of hedging is very naive and is characteristic of much of the work done in the early part of the twentieth century (Hardy and Lyon, 1923; Taylor, 1913; Boyle, 1920).

Obviously, the risk elimination criterion requires a constant spread between cash and futures prices for hedging to be effective. Even cursory examination indicates that cash and futures prices do not move exactly in parallel. This observation, coupled with the fact that successful business operations do hedge leads to the next concept of hedging, that of risk reduction.

The risk reduction concept of hedging is an outgrowth of the earlier, naive view. The examination which indicates that cash and futures prices do not move exactly parallel does show a similarity of price movements (Gruen, 1960). A simple test of hedging under this view is to calculate the ratio of expected changes in the cash price-futures price difference to the expected changes in cash price. If this ratio is less than one, then hedging can be deemed to be effective (Snape and Yamey, 1965). This test was used in several studies before and after Snape and Yamey's article (Howell, 1948, 1962; Howell and Watson, 1938; Graf, 1953; Brogan, 1973). Graf, especially, concluded that the returns to hedging were negative. Again, the results of this risk reduction concept of hedging were in conflict with the business-man's view of hedging. This disparity led directly to Holbrook Working's formulation of the third concept of hedging, arbitrage hedging.

The arbitrage concept of hedging rests on Working's contention that hedging is done for at least one of four reasons. These are that hedging:

1. facilitates buying and selling decisions;
2. gives greater freedom;
3. provides a reliable basis for conducting storage; and
4. reduces risk (Working, 1953a, p. 560-561).

According to Working this view of hedging changed the criterion for effective hedging from minimum basis fluctuation to predictable basis fluctuation (Working, 1953b).

change in the basis was the size of the basis at the beginning of a period (Working, 1953a). He regressed the change in the basis from September to December against the value of the basis on September 1. The resulting equation was $Y = 0.861 X + 2.87$. Unfortunately, this approach seems to be begging the question. The futures price and cash price must approach each other in the maturity month, differing at most by the cost associated with making or accepting delivery of the commodity. If the futures price exceeds the cash price by more than delivery costs, then a trader could sell a contract, purchase the commodity, and deliver against the contract. An opposite set of transactions would be to the trader's benefit if the cash price exceeded the futures price by more than the acceptance costs.

Roger Gray adopted Working's concept of hedging and then maintained that the effectiveness of hedging depends upon a market being a balance between traders desiring long positions and those desiring short positions. He maintained that a market was in balance if the average value of the basis was equal to zero. A basis equal to zero implied a low cost of hedging (Gray, 1960). It was argued that this criterion was similar to the previously discarded criteria of risk reduction and risk elimination and did not receive further attention.

Two additional corollaries were developed by Working under the arbitrage concept of hedging, anticipatory hedging and selective hedging. Both of these concepts may be especially useful in the case of primary producers. Anticipatory hedging consists of taking a position in the futures market opposite of an anticipated position in the cash market. A wheat farmer, for instance, may hedge a portion of his crop before it is harvested or before it is planted, in anticipation of having the crop in the future. Selective hedging involves a determination of the size of a futures position conditioned on an expected price change. That is, an individual may take a larger futures position if the cash price is expected to move unfavorably and vice versa.

A fourth, and less fully developed, concept of hedging is that of portfolio management. The portfolio management concept of hedging is a relatively new point of view. This concept stems from investment analysis where the purpose is to balance assets which have various returns and risks associated with them. The original formulation of a mathematical model for portfolio selection was done by Markowitz (1952). This approach has been applied to commodities and commodity futures by Johnson (1960), Telser (1955), and Stein (1961) with varying results.

The basic model consists of a column vector of expected returns and a matrix of variances and covariances. The total position can be described by a row vector of amounts held of each asset. The problem then be expressed in either of two ways, to maximize expected returns subject to a given level of risk or to minimize risk subject to a given level of return. If X is the expected return matrix, V the variance-covariance matrix, and A the asset matrix, then the first alternative can be expressed as the problem:

Maximize AX subject to

$$AVA' \leq C$$

while alternative two is expressed as

Minimize AVA' subject to

$$AX \geq D$$

In the case of commodities, the possible assets are unhedged stocks, hedged stocks and stocks marketed by forward sale. While the model seems to be an especially neat formulation of hedging, certain problems exist. First, the variance-covariance matrix must generally be of a subjective nature. Secondly, the expected return vector is difficult to determine. A final problem arises from the inherent assumption that variance is the best measure of risk. This approach seems to be a step backwards emphasizing risk to the neglect of the other factors developed by Working.

Price Change Theory

Futures prices change daily and even within the trading day. These short run price movements have long been a subject of study by economists and statisticians and an area of conflict between academicians and traders. This section presents summaries of the various theories and the evidence which has accumulated, dealing particularly with random walk, anticipatory prices, and random shock hypotheses.

The random walk hypothesis is the take-off point for most analyses of the behavior of short run price movements. This hypothesis was first presented by Louis Bachelier in 1900 (Bachelier, 1900). According to Bachelier, the price of a commodity in time period t was equal to the price in period (t-1) plus a random element, i.e.,

$$p_t = p_{t-1} + \varepsilon_t.$$

It is the distribution of ε_t which is important. Bachelier's first contention was that $E(\varepsilon_t) = 0$. The argument to support this contention is straightforward. If the expected price change is other than zero, then traders would take positions appropriately. For example, if the expected price change is greater than zero, then traders would buy, confident that they could sell at a higher price in the future. However, this buying activity in period (t-1) would force the (t-1) price to that level where the expected price change was zero. A similar analysis holds for expected price changes less than zero.

Bachelier's second contention concerning the ε_t's was that they were independently distributed and normal. This conclusion was reached by solving the integral equation of the probability of any price in period t given the price in period (t-1). This solution is dependent upon three assumptions concerning the probability density function:

a. it is differentiable with respect to t,

b. it has first and second partials with respect to price in period t, and

c. it has finite mean and variance (Cootner, 1964, p. 4.).

As a consequence of Bachalier's work, many economists have studied and tested price series for randomness with mixed results. While Kendall (1953) and Alexander (1961) concluded that price changes were random, Larson (1960) found that price changes followed a moving average process. Smidt (1965) and Stevenson and Bear (1970) rejected random walk as an explanation of futures price behavior. Two alternatives, martingale and stable paretian, to the random walk hypothesis have been developed but the evidence is far from conclusive. The martingale and stable paretian models each disregard one of the assumptions of random walk. The martingale model assumes $E(\varepsilon_t) = 0$ but does not assume independence of the ε_t's. The stable paretian hypothesis does not assume that the distribution has a finite variance. The lack of a second moment has serious implications. If the second moment does not exist, then standard statistical techniques are not appropriate. Further discussion of these problems can be found in articles by Mandelbrot (1963, 1966), in Cootner's book (1964), and in a U.S.D.A. bulletin by Mann and Heifner (1976). The latter, especially, rejected random walk and martingale models as well as the Gaussian hypothesis.

It is evident that the random walk model is not a completely satisfactory explanation of futures price movements. An alternative explanation was offered by Holbrook Working (1958). Working developed an anticipatory market model based on classes of traders which explained the gradual effect of new information on prices. The ε_t in any period is affected not only by the new information but also by the series of past information. Donald Gordon in a discussion of Working's paper objected to the division of traders into classes and then demonstrated that such a division was not a necessary component of the theory of anticipatory prices.

Working's theory can be put into the framework of time series analysis according to the following finite random shock formula:

$$Z_t = \mu_t + \Psi_1 \mu_{t-1} + \Psi_2 \mu_{t-2} + \ldots + \Psi_n \mu_{t-n}$$

where Z_t is the price change and the μ_i's are random variables which are measurements of new developments and new information.

To apply time series analysis it is necessary to assume that the μ_i's are independently, identically distributed. With this assumption, the process becomes a linear discrete stochastic process (Nelson, 1973). This can be approximated as an autoregressive process of order p as follows:

$$Z_t = \pi_1 Z_{t-1} + \pi_2 Z_{t-2} + \ldots. + \pi_p Z_{t-p} + \mu_t \qquad (1)$$

where the π_i's are functions of the original Ψ_i's, and the Z_{t-i}'s are previous observations.

It is apparent that a theory of the behavior of futures price changes can be devised which is consistent with concepts of market efficiency but does not require the independence of successive price changes. A later section will be devoted to the approximation of equation 1 from observed futures market price changes.

Chapter 3

THE BASIS

No examination of futures market can be deemed adequate without an investigation of the basis. However, this necessary introduction of basis also introduces confusion. Arthur (1971, p 64-69) identifies four concepts of basis ranging from the general "a spread or difference of the price relating to actual grain, above or below the price of a futures contract for such product." to the specific opportunity basis which "calls for the quotations at which I either close out my position on both sides or have the opportunity to close out my positions."

Technically, then, basis even in the general sense refers to the difference between a specific futures contract price and a cash price. In this exposition, however, the term basis is used to refer to the price difference between any futures price and a Great Falls, Montana cash price. When a more specific interpretation is needed, the general term will be modified by including market and contract maturity month such as Kansas City - July basis or Chicago - May basis. When there is no room for ambiguity, the market designation may be dropped.

Methodology

As Working's view of hedging emphasizes, it is the predictability of basis movements which is important. A concentric idea, however, is that a hedger should only be interested in the predictability of the basis when he is in a position to take advantage of favorable basis movements. Thus, the Montana producer is interested in basis prediction only for that period after probable harvest or from August to contract expiration dates within a crop year. While the results of this study may have implications for the timing of sales within a crop year, the optimum selling date is a question beyond the scope of this study. The producer cannot gain from favorable basis movements unless the crop is in hand and can be sold. Thus, for Montana producers, there are four relevant contract months, September, December, March and May. July is excluded on the presumption that the crop harvested in any year will not be held beyond the date beginning of the next harvest season. It is further assumed that a producer will not maintain an open position beyond the first trading day in the month of contract termination.

Some authors argue that it is important for a producer to predict the value of the basis. It is their contention that a producer should hedge only when the futures price adjusted by the predicted basis represents a return great enough to cover all costs. This attitude is consistent with risk reduction, but is a step away from dynamic hedging and aggressive marketing by the producer. Two situations clearly illustrate the fallacy inherent in such a static strategy. In the first case, commodity prices may be so low that costs cannot be covered and still be dropping. In this situation, it is obvious that a producer may hedge to minimize a loss. In the second case, commodity prices may be high enough to cover all costs, and yet still be rising. In this eventuality, it is clearly to the producer's disadvantage to hedge. Therefore, to effectively implement an aggressive marketing program a producer must be able to predict the direction of price movements and basis movements. The former problem will be dealt with in a later chapter while the latter will be dealt with here.

At any point in time the basis is made up of several components including a constant term representing locational differences, a yearly term representing peculiarities of a particular season or crop year, a daily term representing storage costs from the present to contract maturity, and an error term. This suggests the following linear model.

$$B_{ti} = \beta_o + \beta_{1i}Y_i + \beta_2 D_t + \varepsilon_t$$

where B_{ti} is the basis on day t of year i

β_o is a constant

β_{1i} is a vector (1 x i) of coefficients

Y_i is a matrix (i x 1) of zero - one values

β_2 is a coefficient of daily change

D_t is the number of days to contract maturity, and

ε_t is an error term.

This general model can be estimated using ordinary least squares if there are (i + 1) years of data available. As specified the model parameters estimates have the following interpretation. β_o is the location difference which is constant over time. The β_{1i}'s are inter-year differences representing a difference from the base year. β_2 is the expected daily basis change.

For each futures exchange there are ten possible contract-trading period combinations when the Montana producer may hedge his crop and expect to gain from basis change. The combinations are:

1. a September contract may be used in the August trading period;
2. a December contract may be used in the August and September to December trading periods;
3. a March contract may be used in the August, September to December and December to March trading periods; and
4. a May contract may be used in the August, September to December, December to March, and March to May trading periods.

Data used to estimate the model are Chicago and Kansas City wheat futures closing quotations from July 1, 1971 to June 30, 1976 and prices paid for ordinary winter wheat at Great Falls, Montana for the same period. The estimations results are discussed below.

Regression results for the September contract are presented in Table 1. The starting date for this regression is the first trading day in August and ending date is the first trading day in September.

Table 1

Estimation of the Basis Model for the September

Contract during the August-September Period

	Chicago	Kansas City
Variable		
D	-.1677 E-2 (.1241 E-2)*	-.3135 E-2 (.1542 E-2)
Y	.9437 E-1 (.3973 E-1)	-.3264 (.4072 E-1)
Y_2	.1203 E-2 (.3946 E-1)	-.8265 E-1 (.4160 E-1)
Y_3	.4658 E-1 (.4031 E-1)	.6199 E-1 (.4149 E-1)
Intercept	.3938	.5410
R^2	.1422	.5669
St. Error of the estimate	.1347	.1391

*The numbers in parentheses are the standard errors of the regression coefficients.

For both exchanges the estimated coefficient on days remaining to contract maturity is negative. In the Chicago equation, the coefficient is insignificant. The most probable explanation for these coefficients being negative is that prices offered Montana producers are being depressed during a harvest "glut" while Midwest prices have achieved post harvest stability. The estimated coefficients on the year dummy variables represent a difference from the base year contract of September 1971.

A standard error of the estimate criterion would favor the Chicago market while an R-squared criterion would favor Kansas City. In either case, the producer should expect an unfavorable basis movement through the month of August for the September contract.

The December basis was estimated for trading period beginning in August, after harvest, and September, after the September contract expired. The results are presented in Table 2.

In all four cases, the coefficient on days remaining to contract maturity is significant and has the expected sign. The coefficients on the year dummy variables indicate a difference from the base year. While these results are useful for estimating basis predictability, they are not useful for estimating the absolute value of the basis. These results suggest that there are significantly different inter-year demand and/or supply forces which determine the absolute value of the basis. Identification of these latter forces is beyond the scope

Table 2

Estimation of the Basis Model for the December Contract

	August-December		September-December	
	Chicago	Kansas City	Chicago	Kansas City
Variable				
D_t	.1126 E-2 (.1832 (E-3)*	.1148 E-2 (.1739 E-3)	.1871 E-2 (.2339 E-3)	.1853 E-2 (.1680 E-3)
Y_1	.2593 E-1 (.2068 E-1)	.9814 E-1 (.1956 E-1)	-.9400 E-2 (.1974 E-1)	.6814 E-1 (.1395 E-1)
Y_2	-.1356 (.2056 E-1)	-.1705 (.1939 E-1)	-.1085 (.1966 E-1)	-.1025 (.1384 E-1)
Y_3	-.6948 E-2 (.2063 E-1)	.2705 E-1 (.1944 E-1)	-.6560 E-1 (.1958 E-1)	-.3504 E-1 (.1378 E-1)
Y_4	.7756 E-3 (.2056 E-1)	.1510 (.1939 E-1)	-.7193 E-1 (.1936 E-1)	.9178 E-1 (.1373 E-1)
Intercept	.3773	.2948	.3786	.2837
R^2	.2182	.4645	.2542	.5523
Std. Error of the estimate	.1336	.1260	.1095	.0771

*The numbers in parentheses are the standard errors of the regression coefficients.

of this work.

For both contract-trading period combinations, the Kansas City-December basis model has a lower standard error of the estimate and higher R-squared than the Chicago-December basis model. This implies that if a producer is to use a December contract to hedge he should choose the Kansas City exchange.

The results of the March basis model estimations are presented in Tables 3 and 4. In five of the six cases the coefficients on days remaining to contract maturity are positive and significant. For the sixth case, the Chicago-March basis for the period December to March the coefficient is not significantly different from zero. This is also the only case where the Chicago basis model has a higher R-squared than the Kansas City model. However, in every case the Kansas City-March basis model has a lower standard error of the estimate than the Chicago-March basis model.

The implications of these results are similar to those of the December models. A producer who chooses to hedge with a March contract should also choose the Kansas City exchange. Furthermore, depending upon the period, the producer can expect to benefit by a cent per bushel move in the basis every five to twenty days.

In a like manner, the May basis was estimated for both Chicago and Kansas City. The results of these regressions, with starting dates of August, September, December and March are presented in Tables 5, 6, 7,

Table 3

Estimation of the Basis Model for the Chicago-March Contract

Variable	August-March	September-March	December-March
D_t	.9903 E-1 (.8764 E-4)*	.1065 E-2 (.9547 E-4)	.1864 E-3 (.1497 E-3)
Y_1	-.3530 E-1 (.1727 E-1)	-.6747 E-1 (.1607 E-1)	-.1724 (.1258 E-1)
Y_2	-.1945 (.1721 E-1)	-.1664 (.1604 E-1)	-.1132 (.1258 E-1)
Y_3	-.2318 E-1 (.1712 E-1)	-.6907 E-1 (.1587 E-1)	-.2557 (.1236 E-1)
Y_4	-.2254 E-2 (.1711 E-1)	-.6842 E-1 (.1587 E-1)	-.2132 (.1241 E-1)
Intercept	.3618	.3792	.4994
R^2	.3004	.2809	.6392
St. Error of the estimate	.1457	.1247	.0688

*The numbers in parentheses are the standard errors of the regression coefficients.

Table 4

Estimation for the Basis Model for the Kansas City-March Contract

Variable	August-March		September-March		December-March	
D_t	.1068 E-2	(.8166 E-4)*	.1195 E-2	(.8018 E-4)	.5183 E-3	(.1430 E-3)
Y_1	.4050 E-1	(.1603 E-1)	.1096 E-1	(.1344 E-1)	-.7371 E-1	(.1191 E-1)
Y_2	-.2045	(.1593 E-1)	-.1934	(.1336 E-1)	-.1540	(.1186 E-1)
Y_3	.4987 E-1	(.1589 E-1)	.3742 E-2	(.1327 E-1)	-.1395	(.1171 E-1)
Y_4	.1431	(.1595 E-1)	.9517 E-1	(.1333 E-1)	-.2004 E-1	(.1186 E-1)
Intercept	.2545		.2607		.3534	
R^2	.5362		.5505		.4941	
Std. Error of the estimate	.1353		.1043		.0652	

*The numbers in parentheses are the standard errors of the regression coefficients.

Table 5

Estimation of the Basis Model for the Chicago-May Contract

During the Periods of August-May and September-May

Variable	August-May	September-May
D_t	.7255 E-3 (.7961 E-4)*	.7124 E-3 (.9244 E-4)
Y_1	-.6932 E-1 (.2016 E-1)	-.9815 E-1 (.2070 E-1)
Y_2	-.3233 (.2010 E-1)	-.2925 (.2067 E-1)
Y_3	-.3079 E-1 (.2007 E-1)	-.6196 E-1 (.2057 E-1)
Y_4	.4798 E-1 (.1999 E-1)	.3566 E-2 (.2048 E-1)
Intercept	.3288	.3466
R^2	.3516	.2925
Std. Error of the estimate	.1936	.1866

*The numbers in parentheses are the standard errors of the regression coefficeints.

Table 6

Estimation of the Basis Model for the Chicago-May Contract

During the Periods December-May and March-May

	December-May	March-May
Variable		
D_t	-.1358 E-3 (.8147 E-4)*	-.3544 E-3 (.2643 E-3)
Y_1	-.1799 (.1122 E-1)	-.2015 (.1514 E-1)
Y_2	-.2280 (.1122 E-1)	-.1905 (.1514 E-1)
Y_3	-.2228 (.1116 E-1)	-.2459 (.1533 E-1)
Y_4	-.8359 E-1 (.1111 E-1)	-.9852 E-1 (.1505 E-1)
Intercept	.4517	.5683
R^2	.5552	.6164
St. Error of the estimate	.0801	.0702

*The numbers in parentheses are the standard errors of the regression coefficients.

Table 7

Estimation of the Basis Model for the Kansas City-May Contract

During the Periods August-May and September-May

Variable	August-May		September-May	
D_t	.5718 E-3	(.5800 E-4)*	.5540 E-3	(.5870 E-4)
Y_1	-.5759 E-1	(.1468 E-1)	-.9362 E-1	(.1315 E-1)
Y_2	-.4113	(.1460 E-1)	-.3672	(.1308 E-1)
Y_3	-5816 E-2	(.1462 E-1)	-.3747 E-1	(.1306 E-1)
Y_4	.1671	(.1456 E-1)	.1420	(.1300 E-1)
Intercept	.2680		.2790	
R^2	.6608		.6801	
St. Error of the estimate	.1410		.1185	

*The numbers in parentheses are the standard errors of the regression coefficients.

Table 8

Estimation of the Basis Model for the Kansas City-May Contract During the Periods December-May and March-May

Variable	December-May		March-May	
D_t	-.4677 E-3	(.8466 E-4)*	-.1262 E-2	(.2334 E-3)
Y_1	-.1953	(.1165 E-1)	-.2435	(.1328 E-1)
Y_2	-.3229	(.1162 E-1)	-.2497	(.1328 E-1)
Y_3	-.1467	(.1159 E-1)	-.1852	(.1354 E-1)
Y_4	.8827 E-1	(.1153 E-1)	.1168	(.1321 E-1)
Intercept	.3880		.4184	
R^2	.7580		.8564	
Std. Error of the estimate	.0832		.0616	

*The numbers in parentheses are the standard errors of the regression coefficients.

and 8.

These results show that in three of the four cases the Kansas City market is clearly preferable using either the R-squared or the standard error of the estimate criterion. In the fourth case, the period beginning in December the Chicago-May basis has a slightly lower standard error than that of Kansas City. Overall, the Kansas City market is to be preferred. Far more important, however, is the fact that the coefficient on days to contract maturity is negative and significant for Kansas City for the periods beginning in December and March. A possible cause of this is that while prices are rising through the crop year, new crop expectations are affecting the May futures price. This is especially plausible when it is remembered that harvest in the extreme southern portion of the winter wheat producing area begins in early May. The implication of this is that while a producer who chooses to hedge with the Kansas City-May contract may expect a favorable basis movement of between five and six thousandths of a cent per day in the period August through December, that producer should also expect an unfavorable basis movement of between four and twelve thousandths of a cent per day in the December through May period.

Conclusions

In nearly all cases the Kansas City market is preferable to Chicago. Therefore, the time series analysis in the next chapter will focus on the Kansas City futures market. Furthermore, the December and March contracts offer the greatest probability of a favorable basis movement for any period after August. These expected movements will be incorporated as a return to hedging in the simulation model described in Chapter 5.

Chapter 4

SHORTRUN FUTURES PRICE CHANGES

The various theories of price changes in speculative markets were discussed in Chapter 2. The results of applying these theories to the Kansas City Board of Trade wheat contracts for the period July 1971 through June 1976 are presented in this chapter. Specifically, if the price changes follow an autoregressive, moving average framework, the series can be identified through the autocorrelation function and the partial autocorrelation function. For instance, if the series is a moving average process of order q so that $Z_t = \mu_t + \Psi_1\mu_{t-1} + \ldots \Psi_q\mu_{t-q}$, then the autocorrelation function will have spikes at lags 1 through q and then be cut off. The partial correlation function will decrease gradually to zero (Nelson, 1973, p. 89). If the series is from the autoregressive process of order p such that $Z_t = \mu_t + \phi_1 Z_{t-1} + \ldots \phi_p Z_{t-p}$, then the autocorrelation function will tail off according to the Yule-Walker equations while the partial autocorrelation function will have spikes at lags 1 through p and then be cut off (Nelson, 1973, p. 89). Similarly, the most complicated possibility, a mixed autoregressive-moving average process of orders p and q can be identified through the autocorrelations and partial autocorrelations. In this case the model is $Z_t = \mu_t + \phi_1 Z_{t-1} + \phi_1 Z_{t-1} + \ldots + \phi_p Z_{t-p} + \Psi_1\mu_{t-1} + \ldots + \Psi_q\mu_{t-q}$. The autocorrelation function will have an irregular pattern at lags 1 through q and then tail off according to Yule-Walker equations. The partial autocorrelation function will gradually decrease to zero (Nelson, 1973, p. 89).

The identification of a time series model is hampered by the fact that the autocorrelation function and the partial autocorrelation function are unknown. However, these functions can be estimated. An estimate for the jth coefficient of the autocorrelation function is

$$r_j = \frac{\frac{1}{T}\sum_{t=1}^{T-j}\left[\left(z_t - \frac{1}{T}\sum_{t=1}^{T} z_t\right)\left(z_{t+j} - \frac{1}{T}\sum_{t=1}^{T} z_t\right)\right]}{\frac{1}{T}\sum_{t=1}^{T}\left[\left(z_t - \frac{1}{T}\sum_{t=1}^{T} z_t\right)^2\right]}$$

(Nelson, p. 71).

Once a model has been identified and estimated, the adequacy of the model can be tested using a portmanteau test (Box and Jenkins, 1976, p. 290-291). A special case of this test can be applied to check whether the series is white noise. If daily futures price changes comprise a series of independent random variables then

$$Q = n \sum_{j=1}^{K} r_j^2 ,$$

where n is number of observations and r_j is the sample autocorrelation of the jth lag, will be distributed approximately $\chi^2(K)$ where K is the number of autocorrelations (Box and Jenkins, 1976, p. 291). If Q is larger than the tabled Chi-square value at a selected confidence level the series is not white noise.

The autocorrelation function for twenty-five Kansas City wheat contracts was estimated using the above formula. The calculated autocorrelation functions are presented in Appendix A. The estimated means, standard deviations, and Chi-square statistics for 24 degrees of freedom are presented in Table 9. At the 97.5 percent confidence level, the Chi-square coefficient for 24 degrees of freedom is 39.4. For 17 of 25 contracts the Chi-square statistic is below this level. Therefore, in these cases, a conclusion of independent random price changes with mean zero is not rejected. Since, in all contract months, the most recent contract is characterized by white noise this distribution will be used in the simulation model.

The above conclusion is at odds with the conclusion of Mann and Heifner (1976). In their work, nonparametric tests indicate serial dependence in futures price changes. However, they did not deal with Kansas City wheat contracts. Furthermore, while such serial dependence may exist, the results of this study suggest that the dependence is so weak that the information content is trivial and is not useful for decision making.

Table 9

Distribution of Daily Price Changes of Kansas City Wheat Contracts

Contract	Mean	Standard Deviation	Chi-Square
March 1972	-.1048E-3	.7189E-2	19.81
March 1973	.4495E-2	.4094E-1	14.92
March 1974	.1668E-1	.1226	53.59
March 1975	-.2143E-2	.1216	27.96
March 1976	.1595E-2	.6871E-1	30.92
May 1972	.1017E-3	.7523E-2	23.28
May 1973	.3823E-2	.3923E-1	26.48
May 1974	.5749E-2	.1329	40.41
May 1975	-.6095E-2	.8649E-1	43.95
May 1976	.9080E-3	.7060E-1	29.18
July 1972	.3318E-3	.8938E-2	23.30
July 1973	.3410E-2	.4570E-1	56.78
July 1974	.6031E-1	.1289	31.78
July 1975	-.6283E-2	.7375E-1	21.32
July 1976	-.5217E-3	.6078E-1	20.95
September 1972	.2784E-2	.1689E-1	67.84
September 1973	.1290E-1	.7772E-1	57.39
September 1974	.3125E-2	.1193	26.14
September 1975	-.3947E-2	.7286E-1	13.45
September 1976	.6207E-3	.5487E-1	19.38
December 1971	-.2024E-3	.7778E-2	18.43
December 1972	.4922E-2	.2328E-1	116.52
December 1973	.1260E-1	.1039	41.63
December 1974	-.1094E-2	.1093	33.07
December 1975	-.1952E-2	.7005E-1	25.07

Chapter 5

THE SIMULATION MODEL

Introduction

In this chapter the results of the previous two chapters are combined into a simulation model. The model will be used to test wheat hedging strategies which are based on moving averages. The output of the simulation program will satisfy the original goal of this study, that is, to estimate a distribution of returns for hedging activities which incorporate various trading rules and stopping or marketing dates. A simplified diagram is presented in Figure 1. The program is found in Appendix B.

The simulation will be done using a General Purpose Discrete Simulation (GPDS) model which interfaces with a Fortran subroutine. This program first generates a price change according to an assumed white noise distribution. From the price change a new daily price is determined. Following this the program calculates a pair of moving averages for each decision strategy. At this stage, the program initiates or maintains a hedged position if a short term moving average is less than a corresponding long term moving average. After a hedge has been initiated, the program closes the position when the relationship of the moving averages is reversed. When a hedge position is closed the program calculates the returns to the hedging activity.