Commodity options as an alternative to hedging live cattle

Lowell B. Catlett
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Part of the Agricultural and Resource Economics Commons, and the Agricultural Economics Commons

Recommended Citation

This Dissertation is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help you understand markings or notations which may appear on this reproduction.

1. The sign or “target” for pages apparently lacking from the document photographed is “Missing Page(s)”. If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure you of complete continuity.

2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed the photographer has followed a definite method in “sectioning” the material. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.
CATLETT, LOWELL B.

COMMODITY OPTIONS AS AN ALTERNATIVE TO HEDGING LIVE CATTLE

Iowa State University

Ph.D. 1980

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106
Commodity options as an alternative
to hedging live cattle

by

Lowell B. Catlett

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Department: Economics
   Major: Agricultural Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
   Ames, Iowa

1980
TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION 1

Problem Situation 3

Futures options 3

Dealer and exchange options 4

'Weak' and 'strong' options 4

Fixed and variable striking prices 4

Problem Justification 5

Objectives 7

CHAPTER 2. OPTION USAGE 9

Definitions 9

Buying Calls 11

Buying Puts 13

Double Options 17

Writing Options 22

Writing calls 23

Writing puts 28

Call and Put Strategies 33
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean gross returns</td>
<td>105</td>
</tr>
<tr>
<td>Testable hypothesis for objective 3</td>
<td>107</td>
</tr>
<tr>
<td>Model, Hedging Strategies, and Data Base</td>
<td>107</td>
</tr>
<tr>
<td>Simulation model</td>
<td>108</td>
</tr>
<tr>
<td>Assumptions</td>
<td>109</td>
</tr>
<tr>
<td>Interest, brokerage fees, premiums, and other costs</td>
<td>111</td>
</tr>
<tr>
<td>Producer</td>
<td>112</td>
</tr>
<tr>
<td>Data base</td>
<td>112</td>
</tr>
<tr>
<td>Futures and Option Strategies</td>
<td>114</td>
</tr>
<tr>
<td>Futures strategies</td>
<td>114</td>
</tr>
<tr>
<td>Option strategies</td>
<td>116</td>
</tr>
<tr>
<td>Complete and Partial Feeding Activities</td>
<td>121</td>
</tr>
<tr>
<td>Details of the Model</td>
<td>121</td>
</tr>
<tr>
<td>Tests of significance</td>
<td>125</td>
</tr>
<tr>
<td>Tests of variance equality</td>
<td>126</td>
</tr>
<tr>
<td>Tests of gross mean equality</td>
<td>127</td>
</tr>
<tr>
<td>CHAPTER 6. RESULTS AND INTERPRETATIONS</td>
<td>131</td>
</tr>
<tr>
<td>Full Hedge Strategy</td>
<td>131</td>
</tr>
<tr>
<td>Non-Delivery Month Strategy</td>
<td>139</td>
</tr>
<tr>
<td>Delivery Months Strategy</td>
<td>140</td>
</tr>
<tr>
<td>$1.00 Basis Strategy</td>
<td>141</td>
</tr>
<tr>
<td>$1.50 Basis Strategy</td>
<td>141</td>
</tr>
<tr>
<td>Double Options</td>
<td>142</td>
</tr>
<tr>
<td>Options Comparisons</td>
<td>143</td>
</tr>
</tbody>
</table>
CHAPTER 1. INTRODUCTION

Recorded history sheds very little light on option trading, although scholars generally agree that it has existed for several millennia. The early Phoenician merchants, and later the Romans, traded options on goods in their argosies (9, 79, 87). It is known also that forms of commodity option trading existed in the early European Pieds Poudres fairs (9, 66, 79). Holland had a thriving option trade on tulip bulbs during 1634-1637 (2, 9, 79).

Sir Charles Leonard Woolley uncovered the Tell al Muqayyar in 1923 and found countless clay tablets describing transactions in the city of Ur. Among the clay tablets were records of "payment in kind" for taxes with commodities and records of "rights to buy" certain commodities (79, p. 103). The Sumerians were trading in early forms of options as early as 5,000 B.C. in Ur. Evidence of options, therefore, covers a 7,000 year time span.

Recent history of option trading in the United States shows bewilderment and skepticism. Stock options had been regularly traded prior to 1932. In that year in drawing up the Securities Act the attitude was, "... not knowing the difference between good options and bad options, for the matter of convenience we strike them all out" (87, p. 10). Subsequently, however, the Securities and Exchange Commission did allow the trading of stock-options. The success of the stock-options is evidenced by the recent growth, popularity, and volume of the Chicago Options Exchange (part of the Chicago Board of Trade).
Commodity options, on the other hand, have not fared so well. The Commodity Exchange Act of 1922 forbids trading in options on farm products. Subsequent rulings also outlawed options on any domestically produced commodity regulated by the Commodity Exchange Authority. A catch in the Commodity Exchange Act was found in 1971 regarding international commodities. The so-called international commodities were not under the jurisdiction of the Commodity Exchange Authority. A thriving option business was being conducted by mid-1971 on futures contracts for silver, silver coins, copper, platinum, coffee, cocoa, sugar, and plywood.

The American options proved highly successful in terms of volume, and at least one estimate placed the 1972 dollar volume of option trade between $200 - 400 million (111). The absence of governmental regulation, high volatility of commodity prices in the early 1970s, high volume of trading, and several unscrupulous dealers and underwriters provided the elements to bring the newly established market to a virtual standstill by late 1973. Public interest was sufficiently stirred by commodity options and consequently the 1974 amendments to the Commodity Exchange Act [Section 4c (b)] gave power to the Commodity Futures Trading Commission to regulate the so-called international commodities. Currently the Commodity Futures Trading Commission has suspended all option trading in commodities. London options are also forbidden by the recent ruling (prior to the ban London options were the mainstay of commodity options in the U.S.A.).
Problem Situation

The Commodity Futures Trading Commission was prompted to totally suspend option trading primarily for two reasons: (1) unscrupulous dealers and (2) insufficient economic information for effective regulation. Unscrupulous dealers abounded during the boom days of 1971-1973, but the more recent case involving Alan Abrahams alias Jim Carr of Lloyd, Carr and Company incited the recent total ban on commodity options (75, 82, 98). Lloyd, Carr customers were bilked of approximately 50 million dollars by charging excessive rates and operating a bucket shop (75, 82, 98). Most of the problems of unscrupulous dealers can, of course, be corrected over time by proper licensing and bonding in a fashion similar to the stock-option market. The problem of insufficient information and economic analyses can be corrected only with additional research. Some of the major areas that need further research are described in the sections that follow.

Futures options

A substantial portion of the additional research needs to be focused on the commodity futures options. Historically option trading in commodities has been in conjunction with futures trading because they share common ground. Futures and options both involve a contract to buy or sell at a future date for a price agreed upon in advance. Furthermore, futures contracts have delivery and other contract terms worked out whereas options on actuals (the physical commodity) would entail considerable problems in these areas. The American option market that developed after 1971 and the London option market were options written against
futures contracts. The pilot program that the Commodity Futures Trading Commission had outlined before the recent ban involved only options on futures contracts.

**Dealer and exchange options**

Problems exist in deciding who should be allowed to handle the trading of commodity options. Currently the Commodity Futures Trading Commission favors the futures exchanges as the medium for trading. Recent court rulings in favor of Mocatta Metals, Inc. points to dealers of the actuals also being allowed to handle futures options. This presents tremendous regulatory and pricing problems because of decentralized trading.

**'Weak' and 'strong' options**

A 'weak' option is one which doesn't have the flexibility of resale. A 'strong' option, conversely, is one that can be freely traded. The early American options and London options were 'weak' options. Once an option was bought it could be terminated only by allowing the option to expire or exercising the option via the futures contract. A 'strong' option, once bought, can be resold either for a profit or loss without allowing it to expire or having to exercise it. The Chicago Options Exchange operates with 'strong' stock-options. The Commodity Futures Trading Commission, at present, favors 'weak' commodity options.

**Fixed and variable striking prices**

The striking price of an option is the price at which the option is valued. The stock-option business is based on fixed striking prices.
Different striking prices for a stock are offered simultaneously. The striking prices will be above or below the current market price (called "in-the-money" or "out-of-the-money" respectively) with the difference reflected by the premium or cost. A variable striking price typically is at or near the current market price. There are advantages and disadvantages to each type, but the Commodity Futures Trading Commission leans toward variable pricing.

There are, of course, any number of other research problem areas in commodity options such as stockpiling, premium variations, margins and strategies to name only a few. The fact that so many problem areas exist and the fact that very little work has been done necessitates some attempt at clarification of the issues and resolving some of the problems.

**Problem Justification**

A clarification of the advantages and disadvantages of futures versus actuals in options, dealers versus exchange trading, 'weak' versus 'strong' options, and fixed versus variable striking prices must be resolved before any viable commodity option market can emerge. A review of literature (Chapter 3) shows that even the Commodity Futures Trading Commission is somewhat bewildered by the whole options area, as evidenced by its early pilot program for options and then its recent total ban. Before any useful economic analysis of options can be undertaken the above problem areas must be addressed and clarified to the point of narrowing the controversy to a manageable and useful set of guidelines.
One of the more crucial problems facing the commodity option market, however, is its effect on hedging strategies of producers. If options exist on futures contracts then producers face an additional set of marketing strategies. Commodity options on futures contracts, therefore, may represent an alternative and or a complement to hedging with the actual futures contract.

Farmers have been skeptical and reluctant to use commodity futures in their marketing plans. In a recent survey of farmers in a midwest state it was reported that 83 percent of the respondents never hedged, 11 percent speculated in commodity futures, but only 2 percent hedged on any regular basis (86). Since 11 percent do use the commodity futures market as an investment, it must be believed that at least this percentage understood the operation of the market, yet only 2 percent were willing to use it for marketing their products. It may be that the group that never hedged had the security necessary to assume price risks or were not willing to have a quasi lock-in price for their products, or wanted the opportunity to take advantage of price movements in their favor. Commodity options on futures contracts may allow them to enjoy price movements in their favor at a cost (option premium), but allow them to set a minimum or maximum price floor or ceiling by exercising their option via the futures contracts.

In another study of a cross-section of 8,000 farmers, again it was discovered that very few used the futures market (80). It was felt that a major reason for non-participation is lack of information and misconceptions. Many farmers do not understand the mechanics of
trading and have formulated unfavorable viewpoints of the markets. Others are not willing to commit themselves to a legal agreement that would require them to deliver or accept delivery of a product and at the same time face the possibility of significant margin calls. The commodity option, with its expiration concept, may be viewed as price insurance by many farmers, most of whom are users of other types of insurance, to reduce risks in their farming operations. Viewed as a kind of insurance, the commodity option may have an impact on the variance of prices farmers receive and on the mean returns of their farming operation.

The effect, therefore, of commodity options as an alternative and or a complement to hedging needs to be studied in terms of variance of prices and mean returns.

Objectives

Since commodity options are a relatively new concept to the majority of producers and traders, a development of the theory of option usage involving both puts, calls, doubles, and the writing of options will be presented. Likewise, the research problem areas involving futures versus actuals, dealer versus exchange options, 'weak' versus 'strong' options, and fixed versus variable striking prices will be developed more completely and with greater detail. Commodity option strategies will be developed and compared to hedging strategies involving live beef cattle futures for variance of prices received and mean returns from feedlot enterprises. The three objectives of the study are:
Objective 1: Detail and discuss the theory and mechanics of how puts, calls, and doubles function and how they are purchased and underwritten.

Objective 2: Evaluate the problems of futures options versus actuals options, dealer versus exchange options, 'weak' versus 'strong' options and fixed versus variable striking prices for options.

Objective 3: Develop, compare, and test various hedging and option strategies in live beef cattle futures for a typical midwestern cattle feeder in terms of variance of prices received and mean returns from feeding.

Objective 1 will explain and give examples of how to use puts, calls, and doubles in option trading. The theory and use of underwriting options will be presented and examples given. Objective 2 will be a literature review and discussion of the issues surrounding each of the areas that need further researching. Based on the various advantages and disadvantages of each of the areas plus the likely policy the commodity Futures Trading Commission will follow, a synthetic option market will be outlined to be used to test Objective 3. The purpose of Objective 3 will be to test the economic performance in terms of mean returns and price variance of the synthetic option market against the typical futures markets. From the presentation and analysis of these three objectives, various producer and policy recommendations will be made.
CHAPTER 2. OPTION USAGE

The actual mechanics and workings of commodity options, while not complex, do at least require some basic discussion and definition for clarity. Also, to use properly, strategy concepts need to be formulated to eliminate erratic option usage and poor option performance.

Definitions

Webster describes an option as "the power or right to choose," and "a right to buy or sell designated securities or commodities at a specified price during the period of the contract" (107, p. 593).

Zieg and Zieg define an option in the following fashion (111, p. 21);

When a speculator purchases a commodity option he is purchasing the right to assume a position in the futures at a certain price, called the strike price, and within a certain period of time, running from the purchase date to the declaration date. The option specifies the commodity, the amount or number of contracts, the price at which a futures position is taken if the option is exercised, whether it is an option to take a long or short position in that future, the declaration date on which the option expires, and the premium or charge paid by the buyer to the seller for granting the option.

The following list defines the various terms used in the option trade. The list concentrates on commodity options but the same basic terminology applies to the securities market.

Call option — The right to buy a commodity on a future date for a fixed price.
Put option  -- The right to sell a commodity on a future date for a fixed price.

Double option  -- The right to either buy or sell a commodity on a future date for a fixed price, but not both at the same time.

Striking Price  -- The price at which the option is initially purchased or sold (the fixed price on the option contract).

Exercise Price  -- The market price at the time the option is converted.

Premium  -- The amount the purchaser of a put or call has to pay (cost) for the option or the amount the underwriter receives for granting the option.

Declaration Date  -- The last date on which the option can be exercised or used, after which the option is useless.

Underwriter  -- The person or firm that grants the option. The underwriter is responsible for the option in the event it is exercised.

Straddle  -- A combination of one put and one call purchased simultaneously at the same striking price.

Spread  -- A combination of one put and one call purchased simultaneously but at different striking prices.

Straddle  -- A combination of two calls and one put.

Spread  -- A combination of two puts and one call.
Buying Calls

A call would be purchased if the buyer thought the price of the commodity was going to increase. For example, if a trader noticed on December 1, on Figure 1, that the chart was giving a buy (bull) signal near the 1970 level (point A) he could enter an option to take advantage of the supposed move. He would purchase a July Silver call for a set premium, say

![Figure 1. July Silver (10,000 Troy ounces) bar chart](image)
$1,500, at the striking price of $1.70/ounce for a fixed duration -- say six months. Anytime between December 1 and June 1 he can exercise his July Silver option or allow it to expire. Figure 1 shows that July Silver eventually went to over 200. If at $2.00/ounce the trader "called" his option he would have purchased a July Silver futures contract at $1.70 via his option. He then sells a July Silver futures contract on the futures market for $2.00 and has captured the $.30/ounce difference on a 10,000 Troy ounce contract, the gross gain was $3,000 less $1,500 premium cost, brokerage fees and interest. Throughout the option time duration the traders' only risk was his initial $1,500 premium. He did not receive any margin calls nor would he be liable for any losses greater than $1,500. What if the trader missed the 200 level price? Suppose that he rode the price up to 200 thinking it would go higher, but rode it back down to 170 (point B) hoping it would reverse. At the second 170 level his option time is close to expiration so he must exercise it or let it expire. Since there is no profit from exercising, he lets it expire. He has lost only his $1,500 premium.

The advantages of the call option over a regular futures contract are: First, the traders' maximum liability for an option is his initial premium. He can never lose more than his premium unless his dealer or exchange goes bankrupt. Second, there are no margin calls and consequently no interest cost or opportunity cost except on his initial premium. The principal disadvantage of an option is the necessity of a moderate to large price move before any profit can be realized. On a 10,000 Troy ounce Silver contract with a $1,500 premium, prices must
increase $.15 per ounce to break-even plus brokerage fees and interest. Problems of what the premium should be and the exact striking price are other areas that need attention when buying calls.

The previous example demonstrates a call option on a futures contract where only the futures contract was involved, but no physical commodity. An option on the actuals would be similar but involves ownership of the physical commodity if the option was exercised. If a call on actual silver were exercised, the trader would receive ownership of the actual silver and would liquidate on the cash market rather than the futures market.

Call options are also very useful as a stop loss order. Typically when a speculator is short in the futures market a stop loss order is used to protect against adverse price moves. During a limit-move day or rapid price movements the stop loss order may not get filled or will be filled at different prices. The purchase of a call option can provide a guaranteed stop loss price against a short sale in the futures market. Whether this guaranteed stop loss price is worth more than the more erratic futures market stop loss order depends on the individuals attitude toward risk and the premium value of the call option.

Buying Puts

A put would be purchased if the trader thought prices were going to decrease. Figure 2 shows July Silver in a bear price move. If the trader was chart trading and saw the short signal near the 195 level (point A) he would purchase a put option. At 140 the chart gives a liquidate signal so
the option is "put" (exercised). Again, as with a call option, if prices did not move in the trader's favor (decrease), the total amount the trader could lose would be his premium. If the put option premium was $1,500 then the July Silver price would have to decrease $.15 per ounce to cover the cost of the option. If the put were purchased at $1.95 per ounce, then the price move would have to decrease to $1.80 per ounce to break-even plus brokerage costs.

The variable cost of the option is the brokerage fees (usually $50-60 per contract) with the fixed cost being the premium. The brokerage fees are variable since if the option expired no additional futures transaction fees are incurred. Anytime, therefore, that the variable costs can be covered, the option should be exercised to recover some of the fixed costs. For example, in Figure 2 if the put was purchased at 195 ($1.95 per ounce) but prices had fallen only to 185 by the time the option was ready to expire, the trader should liquidate the option. The fixed cost of the put was the $1,500 premium or .15 per ounce with .01 per ounce additional as interest costs and consider the brokerage fees (variable costs) to represent .02 per ounce. To break-even the price move must be at least .15 + .01 + .02 = .18 per ounce. The brokerage fees incurred when the option is exercised are .02 per ounce, therefore anytime the price move is greater than .02 per ounce a contribution to fixed costs can be realized by exercising the option. Only if the price move were under .02 per ounce would the option be allowed to expire or die.
Figure 2. July Silver (10,000 Troy ounces) bar chart
Figure 3 shows the price moves necessary to break-even, to exercise, and to expire the option.

Speculators will consider placing the option initially only if returns above fixed and variable costs are positive, that is, below the break-even line in Figure 3. On the other hand, traders who use options as "hedges" or "insurance" should consider placing (buying) the option when returns above variable costs are positive, that is, below the exercising line in Figure 3.

Figure 3. July Silver (10,000 Troy ounces) bar charts showing the break-even lines
Put options, like call options, can be used as a stop loss technique against a long position in the futures market. The put can be exercised (a right to sell) and consequently the long position is liquidated. The use of puts and calls as stop loss orders must be tempered with risk attitudes, premium costs, and how 'nervous' the market is to price moves. They should be considered only if the market is erratic enough to give false liquidate signals to normal futures stop loss orders. Calls and puts used as stop orders can eliminate these 'nervous' false liquidate orders.

Double Options

A double option gives the owner the right to buy or sell a commodity futures contract. The buyer cannot do both at the same time, however. The trader must either buy (call) or sell (put) but he cannot use the double to do both — that has to be done in the futures market or the cash market. The double was very popular during the brief domestic commodity option market from 1971-73 because it offered tremendous potential. To use puts and calls separately, the trader must be willing and or able to predict the direction of price movements. If the prediction is wrong, he loses his premium, if the prediction is right he recovers all, less, or more than his premium. With a double option the necessity of predicting the direction of price is removed. If prices move up the call can be exercised, or if they move down the put can be exercised.
This flexibility has a cost, however. Usually the premium for a double is the sum of a put and call purchased separately. If a trader wants to purchase a double option, additional volatility in price moves must occur for the option to be profitable. Figure 4 shows March Sugar in a period of congestion between 650 and 850. No clear chart buy or sell signals are visible; thus, the trader could purchase a double option if he felt the March Sugar contract would be volatile enough to cover the premium. If the double was purchased for $3,000 and struck at 700 for a 6-month option the trader can take advantage of the time factor. Usually doubles are not exercised until the last of the contract time unless a profit move has definitely changed. This allows for the full flexibility of the double. Of course, if a substantial profit can be achieved before expiration, the double is usually exercised. In Figure 4, prices decline to less than 550 but finally rebound to nearly 1050. If the trader had purchased a put he would have lost his option premium if he held it past the 550 point. Thus, afforded the trader the luxury of not having to predict price direction, only volatility.

Tables 1 and 2 show how a double option on Cocoa performed over a seven-year period and how a Sugar double option performed over a ten-year period. The results do not include any "hedging" techniques and thus are biased downward.

These performance results are reported by Zieg and Zieg (111) but they do not correspondingly report any offsetting results. Since
Figure 4. March Sugar (112,000 U.S. Pounds) bar chart
Table 1. Performance of a cocoa double option held to maturity and liquidated on the profit side (111, p. 91)

<table>
<thead>
<tr>
<th>Contract Year</th>
<th>Striking Price</th>
<th>Price Exercised</th>
<th>Gross Return(^a)</th>
<th>Premium</th>
<th>Net Profit or Loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>3.50 ¢</td>
<td>7.20</td>
<td>$4,150</td>
<td>$705</td>
<td>+ 490%</td>
</tr>
<tr>
<td>1964</td>
<td>4.75</td>
<td>8.60</td>
<td>4,310</td>
<td>905</td>
<td>+ 376%</td>
</tr>
<tr>
<td>1965</td>
<td>7.00</td>
<td>2.40</td>
<td>5,150</td>
<td>1,410</td>
<td>+ 265%</td>
</tr>
<tr>
<td>1966</td>
<td>3.00</td>
<td>2.12</td>
<td>990</td>
<td>605</td>
<td>+ 64%</td>
</tr>
<tr>
<td>1967</td>
<td>3.00</td>
<td>2.15</td>
<td>950</td>
<td>605</td>
<td>+ 57%</td>
</tr>
<tr>
<td>1968</td>
<td>2.00</td>
<td>1.64</td>
<td>520</td>
<td>425</td>
<td>+ 22%</td>
</tr>
<tr>
<td>1969</td>
<td>3.00</td>
<td>3.84</td>
<td>940</td>
<td>605</td>
<td>+ 55%</td>
</tr>
<tr>
<td>1970</td>
<td>3.30</td>
<td>3.40</td>
<td>110</td>
<td>665</td>
<td>- 83%</td>
</tr>
<tr>
<td>1971</td>
<td>3.50</td>
<td>4.70</td>
<td>1,350</td>
<td>705</td>
<td>+ 92%</td>
</tr>
<tr>
<td>1972 (1)</td>
<td>4.60</td>
<td>7.46</td>
<td>3,200</td>
<td>1,350</td>
<td>+ 137%</td>
</tr>
</tbody>
</table>

\(^a\) Annual average gross return $2,167, annual average investment $798, annual average net profit $1,369, and annual average percentage return 172 percent.
Table 2. Performance of a sugar double option held to maturity and liquidated on the profit side (I11, p. 92)

<table>
<thead>
<tr>
<th>Contract Year</th>
<th>Striking Price</th>
<th>Price Exercised</th>
<th>Gross Return$^a$</th>
<th>Premium</th>
<th>Net Profit or Loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>25.00 $c$</td>
<td>19.20</td>
<td>$1,740</td>
<td>$1,800</td>
<td>- 3%</td>
</tr>
<tr>
<td>1966</td>
<td>14.00</td>
<td>24.50</td>
<td>3,150</td>
<td>1,800</td>
<td>+ 75%</td>
</tr>
<tr>
<td>1967</td>
<td>26.00</td>
<td>28.00</td>
<td>600</td>
<td>1,800</td>
<td>- 67%</td>
</tr>
<tr>
<td>1968</td>
<td>27.00</td>
<td>43.50</td>
<td>4,950</td>
<td>1,800</td>
<td>+ 175%</td>
</tr>
<tr>
<td>1969</td>
<td>28.00</td>
<td>40.00</td>
<td>3,600</td>
<td>1,800</td>
<td>+ 100%</td>
</tr>
<tr>
<td>1970</td>
<td>41.00</td>
<td>27.50</td>
<td>4,050</td>
<td>1,800</td>
<td>+ 125%</td>
</tr>
<tr>
<td>1971</td>
<td>28.50</td>
<td>23.50</td>
<td>1,500</td>
<td>1,800</td>
<td>- 17%</td>
</tr>
</tbody>
</table>

$^a$Annual average gross return $2,800, annual average investment $1,800, annual average net profit $1,000 and annual average percentage return 55 percent.

Assumptions under which they were generated are not known, no attempt is made to produce contrary results. They are presented to show the upside potential that doubles possess and as an example of the techniques used to generate double option business during the life of the American option market. Doubles offer upside (profit) potential only on very volatile price moves and correspondingly the downside (loss) potential exists during less erratic price movements. The maximum loss, of course, is limited to the premium amount.
Zieg and Zieg list two principal trading strategies for double options based on past price moves. The first strategy, called the Comparison Rule, says that the double premium should be compared to the average range over an equivalent period and if the premium is equal to or greater than this past range, the option should be rejected (111, p. 107). Since the Comparison Rule does not distinguish between relative profit levels, a rule for ranking the most profitable-looking options was developed called the Value Premium Ratio. The VPR is the futures price range for one-half the double's life length divided by the premium cost of the double option. This ratio is based on the assumption that the last months of a futures price move are more representative than older moves of the future potential of price moves (thus the 1/2 — the time is divided in half). Ranking of the VPR ratios shows the relative profitability of the options. Any ratio less than two is rejected with the higher ratios meaning higher relative profitability (111, p. 111). Zieg and Zieg do not report any examples of the ratios use or performance.

Writing Options

In addition to buying puts and calls the possibility also exists to write (grant) options. There can be no buying of options unless someone is granting (selling) the puts and calls. Although an infinite array of option granting strategies exist for both puts and calls, only the basic strategies involving 'naked' and 'covered' options will be discussed in this section. 'Covered' calls and puts are options that
are written when the actual commodity is owned in sufficient quantity and quality to 'cover' the option. Likewise a 'naked' option does not have the physical backing of the commodity.

More complicated strategies concerning 'weak' and 'strong' options, fixed and variable striking prices, and dealer and exchange options will be discussed in Chapter 4.

Writing calls

The simplest and least risky type of call writing involves a covered call. An individual purchases a futures contract on a commodity, say corn (5,000 bushels of #2 yellow). Thus, he actually has the commodity futures contract and an option written against it would be 'covered'. The commodity futures contract could be held waiting for a price rise, but the possibility also exists for a price decrease. As an alternative to this uncertain situation, the futures contract holder could write an option against the contract.

If the individual purchased the futures contract in corn at the market price (say $2/bushel); he has committed the margin requirements for the contract (approximately $1,000/contract). Figure 5 shows the price chart for the March '78 corn contract and the point (Point A) where the contract was purchased. Since no clear technical or fundamental signals are observed as to which direction price will move, writing an option is a possible alternative.

The individual writes a call at a striking price of $2/bushel - 90 days; this gives the buyer of the call the option of 'calling' his
futures contract anytime during the next 90 days for $2/bushel. He receives a premium for writing the call from the buyer, say 10 percent ($1,000). By writing a call against his futures contract he has truncated the upside potential of price increases by the amount of the premium, and reduced the loss from price decreases by the amount of the premium. For example, after 45 days if the price of the March '78 corn contract had risen to $2.30/bushel (point B in Figure 5) the buyer "calls" the option to be exercised at $2/bushel. The writer must deliver the long futures contract for $2/bushel. The buyer takes the long futures contract at $2/bushel and offsets the position by selling a futures contract for $2.30/bushel. He has made 30¢/bushel - 20¢/bushel premium, or 10¢/bushel in added revenue (ignoring brokerage fees, handling costs, and opportunity costs), see Table 3.

Figure 5. Bar chart for March 1978 corn (CBT)
Table 3. Example of a call option writer and buyer strategy during rising prices

<table>
<thead>
<tr>
<th>Writer</th>
<th>Buyer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner of the long futures contract writes a call option</td>
<td>Purchases call option</td>
</tr>
<tr>
<td>$2 per bushel</td>
<td>Striking Price</td>
</tr>
<tr>
<td>$1,000 or .20¢ per bushel (5,000 bushels)</td>
<td>Premium</td>
</tr>
<tr>
<td>Writer delivers long futures contract at $2 per bushel</td>
<td>Price increases to $2.30 per bushel</td>
</tr>
<tr>
<td>Buyer received .20¢ per bushel above what he paid for the futures contract or $1,000 less brokerage fees plus interest</td>
<td>Buyer offsets long futures at $2.30 per bushel by selling a futures contract</td>
</tr>
<tr>
<td></td>
<td>Buyer received .30¢ per bushel from futures transaction less .20¢ per bushel premium cost less brokerage fees and interest</td>
</tr>
</tbody>
</table>
The writer, on the other hand, has confined his revenue to the amount of the premium, or 20¢/bushel. The writer sacrifices the right to "winners" (price increases greater than the premium) for the premium amount. On an annualized basis, however, the writer received in advance an 800 percent return on his $1,000 investment (45 days) or 400 percent for the full run of the option (90 days). (He received $1,000 in premium for his $1,000 investment -- annually that's 100 percent, but for 45 days it's 8 times that.)

On price downsides the writer faces two possible actions. First, if prices fall the writer can sell the futures contract (offset his long position) when the option expires (any price decrease would preclude a profit-taking buyer from wanting to exercise the option). If the price decrease is less than the premium, then the writer has a net positive position from the transaction (ignoring brokerage fees, handling costs, and opportunity costs). The premium has therefore reduced the effect of downside price movements. The second action the writer might want to consider would be to keep the futures contract and write a new call option at the lower striking price. If the price fell to $1.80/bushel (point C in Figure 5), the writer was protected (net zero) by his premium (20¢/bushel). He now writes a new call option for 90 days, striking price of $1.80/bushel, and a premium of 10 percent (18¢/bushel). Thus, by continuous writing the grantor can limit losses and establish a quasi-floor on price decreases. Table 4 illustrates this example.
Table 4. Call option writer and buyer strategies under falling prices

<table>
<thead>
<tr>
<th>Writer</th>
<th>Buyer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner of the long futures contract writes a call option</td>
<td>Purchases call option</td>
</tr>
<tr>
<td>$2 per bushel</td>
<td>Striking Price</td>
</tr>
<tr>
<td>$1,000 or .20¢ per bushel (5,000 bushels)</td>
<td>Premium</td>
</tr>
<tr>
<td>Sell futures contract</td>
<td>Price decreased to $1.80 per bushel at expiration date</td>
</tr>
<tr>
<td>$2 - $1.80 = .20¢ loss per bushel less brokerage fees and interest</td>
<td></td>
</tr>
<tr>
<td>Rewrite Option</td>
<td></td>
</tr>
<tr>
<td>$1.80 per bushel</td>
<td>Striking Price</td>
</tr>
<tr>
<td>$900 or .18¢ per bushel (5,000 bushels)</td>
<td>Premium</td>
</tr>
</tbody>
</table>
Commodity futures price movements are typically asymmetric due to trends in most agricultural products; therefore, the writer can judiciously determine when opportune times exist to stop writing or continue writing additional covered calls. The duration of futures contracts (typically no longer than a year) places additional constraints on the writer's strategies.

Writing naked calls necessarily involves more risks than covered calls. If the buyer exercises the option, the writer must deliver the futures contract. The writer, therefore, must go into the futures market and purchase the contract to deliver. Suppose a grantor writes a 90 day call on a March corn contract for $2/bushel with a 10 percent premium. In 20 days, the price has increased to $2.30/bushel so the buyer "calls" the option. Since the call was naked, the writer goes into the futures market and pays $2.30/bushel for a long contract and delivers to the buyer for $2/bushel. The grantor lost 30¢/bushel on the futures transaction but received 20¢/bushel premium, for a net loss of 10¢/bushel. If the call had been covered the net gain in revenue would have been 20¢/bushel instead of a 10¢/bushel loss with the naked call.

On the other hand, ownership of the futures contract entails handling costs, margin requirements, brokerage fees, and opportunity costs. Because of these costs, naked call writing appeals more to speculators than commodity owners or managers (Table 5).

Writing puts

Writing covered puts in commodities involves a twist in logic. The writer of a put is saying that he will deliver a short futures position
Table 5. Writer and buyer strategies for naked call options

<table>
<thead>
<tr>
<th>Writer</th>
<th>Buyer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naked call option written</td>
<td>Call purchased</td>
</tr>
<tr>
<td>$2 per bushel</td>
<td>$2 per bushel</td>
</tr>
<tr>
<td>$1,000 or .20¢ per bushel (5,000 bushels)</td>
<td>$1,000 or .20¢ per bushel (5,000 bushels)</td>
</tr>
<tr>
<td>Writer must deliver a long futures contract at $2 per bushel so he enters the futures market and pays $2.30 per bushel</td>
<td>Buyer calls the option</td>
</tr>
<tr>
<td>Price increased to $2.30 per bushel</td>
<td>Buyer takes long futures called at $2 per bushel and offsets by selling at $2.30 per bushel - a gross gain of .30¢ per bushel less premium, interest and brokerage fees</td>
</tr>
<tr>
<td>Long futures delivered to buyer</td>
<td></td>
</tr>
<tr>
<td>Writer lost .30¢ per bushel on transaction plus a gain of .20¢ from the premium and interest less brokerage fees</td>
<td></td>
</tr>
</tbody>
</table>
(a sell contract) to the buyer of the put. Thus, if the buyer of the put exercises his option, the grantor must deliver a short futures contract. For the writer of the put to have his position covered implies that he must sell (at the time the option is written) a contract on the futures market.

Consider, as an example, an individual who writes a put on a March corn futures contract. The put is written with a striking price of $2/bushel - 90 days, at a premium of 10 percent. The buyer has the right in the next 90 days of "putting" to the writer, that is exercising the option. In the physical market this would involve the actual transfer by the buyer of the commodity to the writer. In the securities market the buyer 'puts' to the writer the stock which the writer must take at the striking price. The twist of logic in options on commodity futures occurs when the buyer 'puts' his option. The buyer does not put anything to the writer when he exercises the option. The writer delivers a short (Sell) futures contract to the buyer. The writer, therefore, actually 'puts', not the buyer.

The buyer is actually hoping for a price decrease with the put. If the price of the March corn futures drops to $1.70/bushel during the next 60 days, the buyer exercises his option. The writer delivers a sell futures contract purchased at $2/bushel to the buyer. The buyer then buys a futures contract at $1.70/bushel to offset for a gain of 30¢/bushel - 20¢/bushel premium or a net revenue gain of 10¢/bushel (ignoring brokerage fees, handling costs, and opportunity costs). The writer's gain was only the 20¢/bushel premium. Thus, the maximum gain
from writing a put when the put is exercised in a downward market is the amount of the premium. The writer had to establish margin for the sell futures contract of approximately $1,000. He received $1,000 in premium from the buyer, for a 600 percent annualized rate in advance for 60 days or 400 percent for the full 90 days (Table 6).

A price increase would result in the option not being exercised. It also results in a loss for the writer if he offsets his sell futures contract. The grantor may, therefore, keep the sell contract and reissue a new put option after 90 days. How much the writer makes or loses in a rising market depends on the amount of the price increase, when the futures contract is offset, and if a new put is issued.

Writing naked puts would mean the grantor does not have a sell futures contract to cover the option. If the buyer exercises the option the writer must enter the futures market and sell a futures contract to deliver to the buyer. In the previous example, the writer of the option would have to go into the futures market and sell a contract for $1.70/bushel, and make up the difference between it and the striking price ($2/bushel). Thus, the writer lost 10c/bushel with the naked put rather than making 20c/bushel had it been covered.

If the naked put is not exercised, however, then huge annualized returns exist for the writer. The naked put writer does not have the initial margin requirement that covered writers have. If the option is not exercised, he has gained $1,000 in premiums for no initial investment. The annualized premium would be infinite with a zero investment, but for a $1 investment, the annualized rate would be 4,000 percent.
Table 6. Writer and buyer strategies for put options

<table>
<thead>
<tr>
<th>Writer</th>
<th>Buyer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A put option is written against a short futures contract</td>
<td>A put option is purchased</td>
</tr>
<tr>
<td>$2 per bushel</td>
<td>Striking Price</td>
</tr>
<tr>
<td>$1,000 or .20¢ per bushel (5,000 bushels)</td>
<td>Premium</td>
</tr>
<tr>
<td>Writer must deliver a short futures contract at $2 per bushel</td>
<td>Price decreases to $1.70 per bushel</td>
</tr>
<tr>
<td>Writer has a gross gain of .20¢ per bushel plus interest less brokerage fees</td>
<td>Buyer offsets short futures by buying a contract for a gross gain of .30¢ per bushel less premium, interest, and brokerage fees</td>
</tr>
</tbody>
</table>
These exorbitant annualized returns serve to show only the possible returns. It is very possible a writer can experience large losses, also. For instance, if a grantor held on to a sell futures contract and continues writing puts in a rising market he faces the possibility of large losses when he offsets the futures contract. A naked option writer faces the possibility of large losses if the option is exercised during substantial price moves. Losses under these conditions can be just as large on an annualized basis as the gains mentioned previously.

Call and Put Strategies

The basic strategies of puts and calls were outlined in the previous sections. Detailed strategies usually center around margin requirements, exercise costs (brokerage fees), current tax laws, individuals attitude toward risk, and the individuals own financial situation. Auster (2, p. 38) provides a very detailed set of strategies for securities that can be modified for commodity options. The Chicago Board of Trade (9, p. 20) offers strategy sets for securities that have possible application to commodity options. These two sources can provide a flavor for detailed strategies. No attempt will be made in this thesis to develop rigorous strategies concerning margins, tax laws, etc., because of the unknown values of these variables.

Table 7 shows a basic strategy matrix for put and call grantors. A call writer will only face the "call" of the option when price increases enough to cover brokerage and handling costs. For small increases, all price decreases, and stable prices the call remains
Table 7. Basic strategy matrix for commodity option writers on futures contracts

<table>
<thead>
<tr>
<th>Price Movement</th>
<th>Calls</th>
<th>Puts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price Increase</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater than exercise costs</td>
<td>Deliver long futures contract to buyer, and: 1. Take no further action 2. Reissue a new call</td>
<td>Option not exercised 1. Offset short futures if covered and take no further action 2. Reissue a new put</td>
</tr>
<tr>
<td>Less than exercise costs</td>
<td>Option not exercised 1. Reissue a new call 2. Offset long futures if covered and take no further action</td>
<td>Option not exercised 1. Offset short futures if covered and take no further action 2. Reissue a new put</td>
</tr>
<tr>
<td><strong>Price Decrease</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater than exercise costs</td>
<td>Option not exercised 1. Offset long futures if covered and take no further action 2. Reissue a new call</td>
<td>Deliver short futures contract to buyer, and: 1. Take no further action 2. Reissue a new put</td>
</tr>
<tr>
<td>Less than exercise costs</td>
<td>Option not exercised 1. Offset long futures if covered and take no further action 2. Reissue a new call</td>
<td>Option not exercised 1. Offset short futures if covered and take no further action 2. Reissue a new put</td>
</tr>
<tr>
<td><strong>Stable Prices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option not exercised 1. Reissue a new call 2. Offset long futures if covered and take no further action</td>
<td>Option not exercised 1. Reissue a new put 2. Offset short futures if covered and take no further action</td>
<td></td>
</tr>
</tbody>
</table>

*aLess than enough to exercise options is defined as only the amount to cover brokerage and handling fees for the option and futures contracts.*
unexercised. The put, likewise, remains unexercised except during price declines greater than brokerage and handling fees. Brokerage and handling fees, therefore, provide a threshold for option exercising. If a call buyer purchased the option at a striking price of $2/bushel, then the buyer would call the option only if prices increased enough to cover incurred costs. The buyer has to pay brokerage fees for the option plus brokerage fees for the futures contract if he exercises the option. He also has to put up margin on the futures contracts if the option is exercised. If these costs amount to say 5c/bushel then the threshold level becomes $2.05/bushel for calls and $1.95 for puts. Securities option writers typically take advantage of this by reissuing calls and puts on the underlying stock. Less than 40 percent of securities options are exercised because of the threshold effect and contrary price moves (16, p. 91).
CHAPTER 3. REVIEW OF LITERATURE

Although commodity options have existed for at least 7,000 years, very little information on their use is available. Most of the recorded information concerning commodity options has been generated since 1971. Stock options on the other hand, have been richly represented in the literature since the 1930s. The literature is also well-endowed with discussions of hedging on commodity futures and with the regulation of commodity markets via the Commodity Exchange Authority and more recently the Commodity Futures Trading Commission.

Commodity Futures Trading Commission

The United States Department of Agriculture (USDA) regulated the futures markets and commodity markets via the Commodity Exchange Authority (CEA) before 1974 (97, p. 61). In 1974, the Commodity Futures Trading Act created the independent Commodity Futures Trading Commission (CFTC). This law also had a "sunset" provision which forced re-evaluation of the new commission after 1978 (97, p. 60). Although the Securities Exchange Commission and the Treasury Department fought for part of the CFTC's power, the 1978 congressional hearings re-authorized the CFTC substantially as it was prior to 1978 (98, p. 34).

Prior to 1974, the so-called international commodities that the CEA did not have the authority to regulate developed option trading. The 1974 Act that established the CFTC brought the so-called international
commodities and options under its control. Schneider reported that the CFTC has the authority to (1) ban options on the so-called international commodities or (2) if regulation can correct the past abuses, to adopt the necessary regulation (95, p. 44).

Option regulation

When American options began in 1971, new interest was also generated in the London commodity options. Reiss lists the size and types of both London and American option contracts that existed in late 1972 (92, p. 16) (Table 8).

Table 8. Futures and options specifications 1972

<table>
<thead>
<tr>
<th>Commodity</th>
<th>London Futures and Options</th>
<th>American Futures and Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>10,000 Troy ounces</td>
<td>5,000 Troy ounces</td>
</tr>
<tr>
<td>Sugar</td>
<td>50 Long Tons (112,000 pounds)</td>
<td>112,000 pounds</td>
</tr>
<tr>
<td>Copper</td>
<td>25 Metric Tons (55,115 pounds)</td>
<td>25,000 pounds</td>
</tr>
<tr>
<td>Cocoa</td>
<td>10 Metric Tons (22,046 pounds)</td>
<td>30,000 pounds</td>
</tr>
<tr>
<td>Coffee</td>
<td>5 Metric Tons (11,023 pounds)</td>
<td>37,500 pounds</td>
</tr>
<tr>
<td>Rubber</td>
<td>15 Metric Tons (33,069 pounds)</td>
<td>33,000 pounds</td>
</tr>
<tr>
<td>Tin</td>
<td>5 Metric Tons (11,023 pounds)</td>
<td>Not Traded</td>
</tr>
<tr>
<td>Lead</td>
<td>25 Metric Tons (55,155 pounds)</td>
<td>Not Traded</td>
</tr>
<tr>
<td>Zinc</td>
<td>25 Metric Tons (55,155 pounds)</td>
<td>Not Traded</td>
</tr>
</tbody>
</table>
Zieg and Zieg reported the following list as of early 1973
(111, p. 31) (Table 9).

Table 9. Futures and options specifications 1973

<table>
<thead>
<tr>
<th>Commodity</th>
<th>London Futures and Options</th>
<th>American Futures and Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>10,000 Troy ounces</td>
<td>10,000 Troy ounces</td>
</tr>
<tr>
<td>Sugar</td>
<td>50 Long Tons (112,000 pounds)</td>
<td>112,000 pounds</td>
</tr>
<tr>
<td>Copper</td>
<td>25 Metric Tons (55,015 pounds)</td>
<td>30,000 pounds</td>
</tr>
<tr>
<td>Cocoa</td>
<td>5 Long Tons (11,200 pounds)</td>
<td>30,000 pounds</td>
</tr>
<tr>
<td>Coffee</td>
<td>5 Long Tons (11,200 pounds)</td>
<td>37,500 pounds</td>
</tr>
<tr>
<td>Rubber</td>
<td>5 Long Tons (11,200 pounds)</td>
<td>Not Traded</td>
</tr>
<tr>
<td>Platinum</td>
<td>Not Traded</td>
<td>50 Troy ounces</td>
</tr>
<tr>
<td>Plywood</td>
<td>Not Traded</td>
<td>69,120 pounds</td>
</tr>
</tbody>
</table>

The size and type of options changed substantially in the early years of the new market. As with any new market, experience had to be gained but it was slow in coming and the new market began to falter. As Zieg and Zieg report (111, pp. 26, 27):

... the relatively low moral integrity of many salesmen and underwriters - nurtured by the lack of regulations, controls, and safeguards; inexperienced clerical and managerial personnel; accounting systems designed for one-tenth of the peak volume at best; and the inefficiencies as well as capital and managerial drain, resulting from many firms opening new offices daily, brought the industry to a near standstill by early 1973.
The situation was further complicated when the securities commissioners of a handful of states -- including California, the home state for most underwriters and dealers - seeing the potential risks to investors of such practices, filed civil and/or criminal suits against a number of firms. The firms retaliated with counter suits for damages. Tempers flared, more suits and counter suits were filed, and the confused investors, totally baffled by the situation, stopped payment on their checks and made runs on the cash reserves of the dealers. The final result was chaos, corporate bankruptcies, and investor losses.

The industry stumbled along for several months trying to reorganize and overcome the adverse effects of the 1973 burst. Jobman reports that the options firms formed the National Association of Commodity Options Dealers (NASCOD) (74, p. 22). Roy Kavanaugh, chairman of the board of First Western Commodity Options, Inc. and spokesman for the new association was quoted as indicating that NASCOD wanted to take an active part in regulating the industries and establishing industry standards and guidelines (74, p. 22). Kavanaugh also stated (in December, 1976), "a year from now (1977), I can see the options business in a completely different posture, and in three years it'll really be a vital financial force, no doubt about it" (75, p. 12). Armed with new strength from the 1974 Amendments to the Commodity Exchange Act, the CFTC seemed to have a different view.

Pilot program

The CFTC began in earnest in late 1975 and early 1976 to respond to the needs of the options market. In November, 1976, the CFTC proposed the following regulations (96, p. 28):
1. London option firms will have to segregate 90 percent of customer funds in the U.S.

2. Futures commission merchants (FCM) will not have to provide full details of option price, premium and commissions to the prospective customer 24 hours in advance as earlier proposed regulations stated. But the FCM, to comply with the revised disclosure section of the new rules, will still be required to give the potential customer more generalized information at the time the deal is being negotiated and would have to provide a customer with a confirmation statement of all details within 24 hours of the option being struck. Dealers will not have to make a summary disclosure statement on each transaction with a customer if they have previously given that customer a breakout statement on fees, charges, premiums, markups, risks, etc. in that transaction.

3. Any FCM dealing in commodity options will still have to maintain a $50,000 pool of working capital.

4. All commodity dealers will still have to be FCM's and will still have to be registered with the CFTC by the previously designated date of January 17, 1977.

The above regulations were proposed to go into effect on November 22, 1976 (96, p. 28). They were, however, delayed until about December 13, 1980. Currently (January, 1980), the regulations are still in effect because of the total ban.
Jarecki reports and lists comparisons between the current dealer options, London options, and the proposed exchange option program as of July, 1977 in Table 10 (72, p. 51).

The CFTC opened a "hotline" that interested parties could call concerning options and the new proposed pilot program. The line received calls at the rate of one a minute as interest in options soared (76, p. 10).

The proposed regulations went into effect on January 1, 1977 but several suits and petitions forced the CFTC to rethink its regulations. The CFTC won a major battle against these suits and petitions when the Supreme Court refused to hear a petition concerning the CFTC's right to regulate options (76, p. 12).

Even so, the CFTC decided to change its regulation on August 30, 1977. The CFTC issued its set of rule changes called "Part B of the Options Regulations," which would, according to Sarnoff (93, p. 38), (a) finalize the rules for trading of London options in the U.S. and (b) set guidelines for trading of listed domestic commodity options on American commodity exchanges.

Sarnoff summarizes the new rule changes and the pilot American exchange options as follows (93, p. 39):

1. Permits vending of London options to Americans only by broker/dealers who are members of the International Commodity Clearing House (ICCH) and vending of metal options only if customers are
Table 10. Comparing U.S. exchange options, domestic dealer options, and London options

<table>
<thead>
<tr>
<th>TRADING MECHANICS</th>
<th>U.S. EXCHANGE OPTIONS</th>
<th>DOMESTIC DEALER OPTIONS</th>
<th>LONDON OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location &amp; Method</td>
<td>Open outcry in central marketplace</td>
<td>Office-to-office</td>
<td>Some on exchanges; some office-to-office</td>
</tr>
<tr>
<td>Trading Hours</td>
<td>Specified and limited, approx. 10 am - 2:30 pm</td>
<td>Normal business hours, 9 am - 5 pm</td>
<td>Normal U. K. business hours (8 am - 12 Noon, New York time)</td>
</tr>
<tr>
<td>Continuous Price Dissemination</td>
<td>Customer's broker can receive continuous prices on a ticker or screen or by direct line telephone from exchange floor.</td>
<td>Customer's broker can receive continuous quotes on a screen or by direct line telephone from dealer. He also receives opening and closing price details from dealer daily.</td>
<td>Customer's broker obtains quotes from U. S. wholesaling broker, London broker, or London dealer by telephone. No continuous quotes available.</td>
</tr>
</tbody>
</table>

aSource: (72, p. 51).
Table 10. (Continued)

<table>
<thead>
<tr>
<th>TRADING MECHANICS</th>
<th>U.S. EXCHANGE OPTIONS</th>
<th>DOMESTIC DEALER OPTIONS</th>
<th>LONDON OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade Price Dissemination</td>
<td>Trade-by-trade price runs without trade time available.</td>
<td>Trade-by-trade price runs with trade time available.</td>
<td>Estimated but not necessarily traded &quot;settlement&quot; prices published. No price runs available.</td>
</tr>
<tr>
<td>Trading Time &amp; Place and Market Features (cont.)</td>
<td>Volume and open interest published daily.</td>
<td>Volume and open interest published daily.</td>
<td>Volume and open interest available on ICCH.</td>
</tr>
<tr>
<td>TRADING MECHANICS</td>
<td>U.S. EXCHANGE OPTIONS</td>
<td>DOMESTIC DEALER OPTIONS</td>
<td>LONDON OPTIONS</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------</td>
<td>-------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Contract Terms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract &amp; Trading Terms</td>
<td>Well-defined, easily understood contracts with fixed striking price and fixed maturity date.</td>
<td>Well-defined, easily understood contracts with fixed striking price and fixed maturity date.</td>
<td>Contract terms vary. All have variable striking prices, some have fixed maturity dates, some do not.</td>
</tr>
<tr>
<td>Assignability</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TRADING MECHANICS</td>
<td>U.S. EXCHANGE OPTIONS</td>
<td>DOMESTIC DEALER OPTIONS</td>
<td>LONDON OPTIONS</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------</td>
<td>-------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Contract Terms</td>
<td>Nature of Option</td>
<td>Right to convert</td>
<td>Right to convert</td>
</tr>
<tr>
<td></td>
<td>Buyer's Right</td>
<td>contract to a futures</td>
<td>contract to a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>contract (which he</td>
<td>futures contract</td>
</tr>
<tr>
<td></td>
<td></td>
<td>must then margin or</td>
<td>(which he must</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sell)</td>
<td>then margin or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>sell)</td>
</tr>
<tr>
<td>Can Be Liquidated By Offset</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 10. (Continued)
Table 10. (Continued)

<table>
<thead>
<tr>
<th>TRADING MECHANICS</th>
<th>U.S. EXCHANGE OPTIONS</th>
<th>DOMESTIC DEALER OPTIONS</th>
<th>LONDON OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer's Costs</td>
<td>Premium plus single, defined, moderate brokerage</td>
<td>Premium plus single, defined, moderate brokerage</td>
<td>Premium plus U.K. broker's (not always moderate) commission markup</td>
</tr>
<tr>
<td>Premium Payments</td>
<td>Possibly margined</td>
<td>Paid in full</td>
<td>Paid in full</td>
</tr>
<tr>
<td>Customers Premium funds</td>
<td>Held in dollars in U.S. bank</td>
<td>Held in dollars in U.S. bank</td>
<td>Currently paid to grantor who deposits sterling or (more frequently) asks a U.K. bank to issue a sterling denominated guarantee to ICCH</td>
</tr>
<tr>
<td>Customer's Profits</td>
<td>Can be calculated in dollars and are paid in dollars</td>
<td>Can be calculated in dollars and are paid in dollars</td>
<td>Can only be calcu</td>
</tr>
</tbody>
</table>
**Table 10. (Continued)**

<table>
<thead>
<tr>
<th>TRADING MECHANICS</th>
<th>U.S. EXCHANGE OPTIONS</th>
<th>DOMESTIC DEALER OPTIONS</th>
<th>LONDON OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs; Disposition and Protection of customer funds (cont.)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Striking Price Currency</td>
<td>Dollars</td>
<td>Dollars</td>
<td>Sterling</td>
</tr>
<tr>
<td>Protection of Customer's Premiums</td>
<td>Margin deposits with clearinghouse segregated in U.S. bank</td>
<td>Customer's funds held in U.S. banks segregated from general funds of dealer and broker</td>
<td>Customer's funds held either by grantor or (Part B) foreign commodity exchange in U.K.</td>
</tr>
<tr>
<td>Protection of Customer's Profits</td>
<td>Customer's profit is segregated for his benefit either with clearinghouse or in his account with broker</td>
<td>Customer's profit is transferred daily to account segregated for customer's benefit</td>
<td>- - -</td>
</tr>
</tbody>
</table>
Table 10. (Continued)

<table>
<thead>
<tr>
<th>Legal Framework and Constraints</th>
<th>TRADING MECHANICS</th>
<th>U.S. EXCHANGE OPTIONS</th>
<th>DOMESTIC DEALER OPTIONS</th>
<th>LONDON OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Law</td>
<td></td>
<td>United States</td>
<td>United States</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>CFTC Jurisdiction</td>
<td>Yes, along entire chain</td>
<td>Yes, along entire chain</td>
<td>Only at FCM level; no influence over rules</td>
<td></td>
</tr>
<tr>
<td>Protection of Customer from Fraud</td>
<td>Customer's broker must be registered FCM</td>
<td>Customer's broker must be registered FCM</td>
<td>Customer's broker must be registered FCM if customer if in U.S.</td>
<td></td>
</tr>
<tr>
<td>CFTC Recourse to Unwarranted Changes in Contract or Trading Terms</td>
<td>Can nullify</td>
<td>Can nullify</td>
<td>Cannot nullify; can only withdraw &quot;rec</td>
<td></td>
</tr>
<tr>
<td>Ability to Time-Stamp Orders Within One Minute</td>
<td>Probably not</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Books and Records Available to CFTC</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>TRADING MECHANICS</td>
<td>U.S. EXCHANGE OPTIONS</td>
<td>DOMESTIC DEALER OPTIONS</td>
<td>LONDON OPTIONS</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Model and Data For</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Computerized Trading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input to Data</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Gathering for Pilot Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
provided with a contract signed by a ring-dealing member of
the London Metal Exchange (LME).

2. Permits trading of both puts and calls (no doubles) on domestic
commodity exchanges approved for such trading — but those
exchanges would be initially barred from trading both kinds of
options on the same commodity.

3. Permits trading on physical commodity options such as those
proposed by the American Stock Exchange Commodity branch (The
American Commodity Exchange).

4. Permits trading of dealer options, such as Mocatta Options, on
precious metals only — if the CFTC is satisfied appropriate
safeguards can be established by approved dealers as a substi­
tute for clearing mechanism.

5. Domestic commodity exchanges slated to trade options include:

   Chicago Board of Trade -- Ginnie Mae (puts)
   Chicago Mercantile Exchange -- Gold (calls)
   New York Comex -- Copper, Gold, Silver (calls)
   New York Coffee and Sugar Exchange -- Coffee, Sugar (calls)
   New York Cocoa Exchange -- Cocoa (calls)
   American Commodity Exchange -- Gold, Silver (calls)

Thus, by mid-1977 the CFTC seemed to have a comprehensive set of
regulations for the existing domestic and London option market and a
pilot program for domestic options on regular futures exchanges.

However, Schneider reported in May, 1977, that the CFTC was still leaning
very heavily toward requiring economic justification for each option contract — similar to the existing requirement for futures contracts (95, p. 46).

The CFTC during mid-1977 encountered various problems concerning the regulation of options. Schneider reports that the James Carr situation was the "straw that broke the camel's back" (98, p. 35). Schneider further reports that although Carr was in violation of the CFTC's ruling concerning registration, the CFTC was rebuffed in court in attempts to stop Lloyd, Carr and Company from trading options. Meanwhile, Lloyd, Carr grew to become one of the largest option dealers in the country. The company dissolved, however, after it was found that its founder Jim Carr was wanted by the FBI on several counts (98, pp. 36, 37).

Throughout the Lloyd, Carr problem the CFTC was facing limited resources, the courts' reluctance to act, adverse newspaper publicity, and pressure from Congress to do something. When the Lloyd, Carr scandal broke, the CFTC felt pressure to drop the whole option business (98, p. 37). They acted by banning London and domestic dealer options as of March 8, 1978. The ban was still in effect as of June, 1980 (76, p. 10).

The CFTC still has a pilot program for domestic options on exchanges that was scheduled to go into effect by late summer, 1980 (98, p. 35). The most recent pilot program, as reported by Schneider (98, p. 35), is as follows:
1. Tightly controlled pilot program of up to three years.

2. Both put and call options on the same commodity can be traded on the same exchange (that represents a shift in original thinking).

3. Commodities and the designated exchanges for various options have not been selected but will come from the following suggested list of commodities eligible for the pilot program: sugar, lumber, plywood, cocoa, iced broilers, silver, copper, gold, platinum, GNMA's, Canadian dollars, Deutschmarks, Swiss francs, British pounds and T-bills. Applications will apparently have to be submitted and approved on an individual basis.

4. For options to be traded on an exchange, the exchange must be designated as a contract market for that commodity — in other words, silver options could be traded only where silver futures are traded.

5. Margining of premiums will probably not be allowed although a final decision has not been made.

6. Dual trading and cross trading of options will be allowed.

7. Time sequencing of option orders will be required.

8. The reporting level is 25 option contracts.

9. "Cold calls" — telephone solicitations to offer options to new customers will still be prohibited.

10. Exchanges are not required to adopt segregation requirements for their members.
11. Options and underlying futures trading areas do not have to be physically separated as originally suggested.

Currently all option trading is banned, but the pilot program for exchange options appears to have some promise of being started during 1980. Schneider has a more pessimistic view as reported in March, 1980 "... a domestic commodity options program could remain in limbo for some time" (98, p. 35).

Stock Options

History of stock option usage

Although history records the early options as being written against commodities, the securities markets have made the largest contribution to option development. Thomas and Morgan report that a well-organized and rather sophisticated market in puts and calls existed in London during the 1690s (104, p. 21). Stock options fell into early disrepute, according to Thomas and Morgan, and Barnard's Act of 1733 was passed which made stock options illegal (104, p. 61).

Duguid indicates that the Barnard Act of 1821 almost caused the split of the London Stock Exchange (32, pp. 121-122). The Stock Exchange Committee outlined a new rule to ban options trading (already illegal) but "a large number of members rose in arms against the innovation" (35, p. 122). Malkiel and Quandt report that the Barnard Act was repealed in 1860 (83, p. 9).

Thomas and Morgan write that option trading on stocks continued after the repeal of the Barnard Act in England but were banned during
World War II and 1958 (104, pp. 219, 224, 236). Stock options also existed in France, West Germany, and Switzerland, but London was the most important option exchange in the world for a long period of time (104, pp. 47, 141).

Options on stocks in the United States enjoyed a somewhat more stable climate than in Europe. Duguid reports that the first mention of stock options in the United States was in 1790 (32, p. 10). Stock options have never been banned in the United States despite several attempts to do so, especially during the 1930s. A Congressional investigation during 1932-33 found that several of the financial abuses of the 1920s were strongly related to the use of stock options (32, pp. 37-41). Malkiel and Quandt relate the incidents that surrounded the Congressional hearing concerning the use of "pools" and "wash" sales by option dealers to manipulate stock prices (83, p. 11). Malkiel and Quandt further report on option regulation (83, p. 12):

By 1934, following President Roosevelt's message to Congress of February 9 asking for legislation to regulate the stock exchange, the movement against stock options became even more intense. The Fletcher-Rayburn bill called for an outright ban on all stock options. Represented by Herbert Filer, the put and call brokers, whose very existence was threatened by the measures, protested vigorously, stressing the hedging uses of options and the beneficial functions these instruments served. The option dealers prevailed, and the Securities Act of 1934 did not forbid the use of options although the Securities and Exchange Commission was empowered to regulate them.

The Put and Call Brokers and Dealers Association (PCBDA) was formed in 1934 as an outgrowth of the Congressional hearings. The PCBDA sets rules and regulations and has thus far done the job well-enough to
prevent the Securities and Exchange Commission from having to set its own regulations (83, p. 12). The stock option market in the U.S. is thus self-regulated.

Stock option usage has increased dramatically since the 1930s (although not in comparison to the 1929-1933 boom period (83, p. 12)). Table 11 shows the growth of the stock option trade (83, p. 13).

Table 11. Volume of puts and calls sold and relation to total volume on the NYSE, 1937-1968

<table>
<thead>
<tr>
<th>Year</th>
<th>Puts</th>
<th>Calls</th>
<th>Total</th>
<th>Ratio of Total Option Volume to NYSE Reported Volume (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1937</td>
<td>754</td>
<td>1,492</td>
<td>2,246</td>
<td>.55</td>
</tr>
<tr>
<td>1940</td>
<td>459</td>
<td>746</td>
<td>1,205</td>
<td>.58</td>
</tr>
<tr>
<td>1945</td>
<td>801</td>
<td>1,307</td>
<td>2,108</td>
<td>.56</td>
</tr>
<tr>
<td>1950</td>
<td>1,064</td>
<td>1,567</td>
<td>2,631</td>
<td>.50</td>
</tr>
<tr>
<td>1955</td>
<td>2,246</td>
<td>3,766</td>
<td>6,012</td>
<td>.93</td>
</tr>
<tr>
<td>1960</td>
<td>3,133</td>
<td>5,428</td>
<td>8,561</td>
<td>1.12</td>
</tr>
<tr>
<td>1965</td>
<td>4,873</td>
<td>10,383</td>
<td>15,256</td>
<td>.98</td>
</tr>
<tr>
<td>1968</td>
<td>8,187</td>
<td>22,099</td>
<td>30,286</td>
<td>1.03</td>
</tr>
</tbody>
</table>

In the early 1970s about 3 percent of the NYSE volume had options written against the stock (83, p. 14).

The Securities and Exchange Commission reports that stock option volume is related to the bullish or bearish activity of the stock market
because of profit potential, as illustrated below in Figure 6 (83, p. 21):

Figure 6. Stock price movements as compared to the volume of options traded, 1942-1960 (83, p. 15)

Prior to 1973, stock options were traded over the counter by individual dealers. The Chicago Board of Trade founded the first exchange for the sole purpose of trading stock options in the name of
the Chicago Board Options Exchange (CBOE) (16, p. 91). By mid-1977, option volume was such that it amounted to approximately 50 percent of the volume of the NYSE (16, p. 94). Exchange trading of options, therefore, seems to be a contributing factor in the phenomenal 47-49 percent growth (as a percent of NYSE volume) in option trading.

Option pricing models

The literature is rich with option theory and models of the behavior of option values. For the sake of brevity, since an exhaustive review would require several volumes, only the models widely accepted in the field will be discussed. Early empirical models and non-behavioristic models will not be reviewed but are listed (6, 7, 10, 35, 41, 46, 51, 56, 64).

Since model notation differs, a uniform notation as developed by Smith (100, pp. 6, 7) will be used. The symbols are:

- \( t \) - current date
- \( t^* \) - expiration date of the option
- \( T \) - time to expiration (\( t^* - t \))
- \( B \) - price of a default-free discount bond with a face value of one dollar
- \( C \) - price of an American call option at \( t \)
- \( c \) - price of a European call option at \( t \)
- \( k \) - expected average rate of growth in the call price \( \left[ e^{kT} = E \left( C^* / C \right) \right] \)
- \( P \) - price of an American put option at \( t \)
- \( p \) - price of a European put option at \( t \)
r - risk-free interest rate
S - stock or commodity price at t
\( \rho \) - expected average rate of growth in the stock or commodity price
\( [e^{\rho t} = E(S^*/S)] \)
X - exercise price of option
\( V_a \) - value of portfolio A at t

Starred variables such as \( C^*, c^*, S^* \), refer to prices at \( t^* \). Also, American options can be exercised before maturity \( (t^*) \) whereas European options cannot.

The following equilibrium conditions as developed by Merton (85, pp. 141-183) and outlined by Smith (100, pp. 7-14) are used as a comparison point for the various option pricing models and are presented without the accompanying mathematical proofs for brevity (for the mathematical proofs see the above references).

1. Call prices are non-negative
2. At the expiration date, \( t^* \), the call will be priced at the maximum of either the difference between the stock price and the exercise price, \( S^* - X \), or zero.
3. At any date before expiration an American call option must sell for at least the difference between the stock price and the exercise price.
4. If two American calls differ only as to expiration date, then the one with the longer term to maturity, \( T_1 \), must sell for no less than that of the shorter term to maturity, \( T_2 \).
5. An American call must be priced no lower than an identical European call.

6. If two options differ only in exercise price, then the option with the lower exercise price must sell for a price which is no less than the option with the higher exercise price to avoid dominance.

7. The common stock is at least equivalent to a perpetual call (i.e. $T = \infty$) with a zero exercise price.

8. An American call on a non-dividend paying stock, will not be exercised before the expiration date.

9. A perpetual option on a non-dividend paying stock must sell for the same price as the stock.

10. The call price is a convex function of the exercise price.

11. If the call price can be expressed as a differentiable function of the exercise price, the derivative must be negative and be no larger in absolute value than the price of a pure discount bond of the same maturity.

12. With dividend payments on the stock, premature exercise of an American call may occur.

**The Bachelier model** Bachelier advanced the first stock-option pricing model in 1900 (4, p. 47). The Bachelier model assumed "that the stock price is a random variable, price changes are independent and identically distributed, and that

$$\text{Prob}\{S \leq S^* | S = s\} = \Phi (S^* - s, T), \quad (1)$$
where $F$ is the cumulative distribution function of the stock price changes" (4, p. 47). Bachelier stated that (1) implies,

$$F(S^* - S_0T) = N \left( \frac{S^* - (S + \mu T)}{\sigma \sqrt{T}} \right)$$

(2)

where $\mu$ - mean expected price change per $t$

$\sigma$ - standard deviation in $t$

$N$ - cumulative standard normal distribution

Therefore Bachelier's model implies that

$$C = E(C*) \equiv \int_{-\infty}^{\infty} (S^* - X) N'(S^*) dS^*$$

(3)

with $N'(S^*)$ as the normal density function for $S^*$. Smith (100, p. 48) further describes the model as:

$$C = \int_{-\infty}^{\infty} -S \left| \frac{\sigma \sqrt{T}}{\sigma \sqrt{T}} \right| (z \sigma \sqrt{T} + S - X) N' (z) dz,$$

(4)

where $z \equiv (S^* - S) \sigma \sqrt{T}$, and

$$C = S \cdot N \left[ \frac{S - X}{\sigma \sqrt{T}} \right] - X \cdot N \left[ \frac{S - X}{\sigma \sqrt{T}} \right]$$

$$+ \sigma \sqrt{T} \cdot N' \left[ \frac{X - S}{\sigma \sqrt{T}} \right]$$

(5)

where $N \{ \}$ is the cumulative standard normal and $N' \{ \}$ the standard normal density function.

Smith lists the major objections to Bachelier's early model as (100, p. 49):
1. The assumption of arithmetic Brownian Motion in the description of expected price movements implies both a positive probability of negative prices for the security and option prices greater than their respective security prices for large T;

2. The assumption that the mean expected price change is zero, suggesting both no time preference and risk neutrality;

3. The implicit assumption that the variance is finite, thereby ruling out other members of the stable - Paretian family except the normal.

What the Bachelier model really says is that the price of the call is a function of the variability of the security price over the life of the option. However, under an arithmetic Brownian Motion assumption the model tends to over or under estimate the value of the call because of the drift (skewed) nature of some securities' price over time.

The Sprenkle model Smith (100, p. 16) reports that the Sprenkle model removes the first two objections of the Bachelier model. The basic Sprenkle model is of the form (100, p. 16):

---

1. Arithmetic Brownian Motion without drift implies that the probabilities of the stock price either rising or falling by one dollar are equal, independent of the level of stock price. Geometric Brownian Motion without drift implies that the probabilities of the stock price either rising or falling by one percent are equal, independent of the stock price.
\[ E(C^*) = \int_{x}^{\infty} (S^* - L) L'(S^*) \, dS^* \] 

(6)

where \( L'(S^*) \) is a log-normal density function of security prices at maturities or reduces to

\[ E(C^*) = e^{\rho T} S \cdot N \left\{ \frac{\ln (S/X) + [\rho + (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \] 

(7)

\[ = X \cdot N \left\{ \frac{\ln (S/X) + [\rho - (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \] 

(8)

Sprenkle also allowed for risk as:

\[ C = e^{\rho T} S \cdot N \left\{ \frac{\ln (S/X) + [\rho + (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \] 

(9)

\[ = -(1 - k) X \cdot N \left\{ \frac{\ln (S/X) + [\rho - (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \] 

(10)

where \( k \) is the risk aversion parameter. Smith (100, p. 17) reports the model is still flawed because it lacks an allowance for the time value of money.

The Boness model

Boness (15, pp. 163-175) doesn't allow for risk aversion but does provide for the time value of money, as:

\[ C = e^{-\rho T} \int_{x}^{\infty} (S^* - X) L'(S^*) \, dS^* \] 

(11)

or in Smith's form (100, p. 18);

\[ C = S \cdot N \left\{ \frac{\ln (S/X) + [\rho + (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \] 

(12)

\[ = e^{-\rho T} X \cdot N \left\{ \frac{\ln (S/X) + [\rho - (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \] 

(13)
The Samuelson model  
Samuelson provides for both positive time preference for money, risk, and growth of option prices (100, p. 18), as:

\[
c = e^{(\rho - k)T} S \cdot N \left\{ \frac{\ln (S/X) + [\rho + (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \tag{14}
\]

or solved as,

\[
c = e^{-kT} S \cdot N \left\{ \frac{\ln (S/X) + [\rho - (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \tag{15}
\]

Black and Scholes (13, p. 640) as well as Smith (100, p. 20) argue Samuelson's model does not provide for complete market equilibrium.

The Black–Scholes model  
The most widely regarded general equilibrium call pricing model seems to be the one developed by F. Black and M. Scholes in 1972.

The basic Black–Scholes model takes the form (100, p. 22):

\[
c = e^{-rT} E (c^*) \tag{16}
\]

or solved as,

\[
c = S \cdot N \left\{ \frac{\ln (S/X) + [r + (\sigma^2/2)]T}{\sigma \sqrt{T}} \right\} \tag{18}
\]

Thus, the Black–Scholes model shows that the price of a European call is a function of the following variables: the stock price, the exercise price, the maturity time, the risk-free interest rate, and the instantaneous variance rate on the stock price. All of the variables are
observable except the last (100, p. 23). This has made the Black–Scholes one of the more popular models for empirical studies (12, 13, 33, 100, 106).

Smith further shows how the Black–Scholes model fits the Merton general equilibrium requirements (100, p. 24), as:

1. As the stock price rises, so does the call price,

\[
\frac{\partial c}{\partial S} = N \left\{ \ln \left( \frac{S}{X} \right) + \frac{r + \sigma^2}{2 \sigma \sqrt{T}} \right\} > 0 \quad (20)
\]

2. As the exercise price rises, the call price falls,

\[
\frac{\partial c}{\partial X} = -e^{-rT} N \left\{ \ln \left( \frac{S}{X} \right) + \frac{r - \sigma^2}{2 \sigma \sqrt{T}} \right\} < 0 \quad (21)
\]

3. As the time to expiration increases, the price of the call falls,

\[
\frac{\partial c}{\partial T} = Xe^{-rT} N \left[ \frac{6}{2\sigma^2 T} N \left\{ \ln \left( \frac{S}{X} \right) + \frac{r - \sigma^2}{2 \sigma \sqrt{T}} \right\} \right] > 0 \quad (22)
\]

4. As the riskless rate of interest rises, the call price rises,

\[
\frac{\partial c}{\partial r} = T \cdot Xe^{-rT} N \left\{ \ln \left( \frac{S}{X} \right) + \frac{r - \sigma^2}{2 \sigma \sqrt{T}} \right\} > 0 \quad (23)
\]

5. As the variance rate rises, so does the call price,

\[
\frac{\partial c}{\partial \sigma} = Xe^{-rT} N \left\{ \ln \left( \frac{S}{X} \right) + \frac{r - \sigma^2}{2 \sigma \sqrt{T}} \right\} \frac{\sqrt{T}}{2\sigma} \quad (24)
\]
Many extensions of the Black–Scholes model exist (see Smith (100, pp. 25-51)) as well as many tests plus a general model for puts that is very similar to the general call model (again see Smith (100, p. 34)).

Commodity Options

Unlike stock options, commodity options have had very little recorded research. It is interesting to note that history reveals commodity options as the forerunner in option trading, and subsequently the mainstay of options until the advent of organized securities markets. Interest in commodity options dropped dramatically by the late seventeenth century and was revived only recently (1970s).

With the revival in domestic commodity option trading in 1971, several articles appeared describing how to use the new option market and specifically the London options. London options were available for trading for several years prior to 1971 but traded only by a few people. Reiss presented one of the first articles on trading London options in 1973 (92, p. 15). Reiss stressed the "... unlimited opportunity for gains with a fixed, relatively moderate risk," (92, p. 15). The article contains information on buying options, selling options, doubles, tax considerations, stop orders, and how to get started trading (92, pp. 16-17). The same article was rerun in Commodities in 1976 due to popular demand (92, p. 15).
Jobman discusses how to evaluate commodity option firms and different trading approaches (74, p. 21). The ten criteria that Jobman stresses to use when trying to decide on an option dealer are (74, p. 20):

1. What's the premium or markup?
2. Does the firm shop around for costs?
3. What kind of market research does the firm do?
4. What kind of service will you get?
5. What training is given brokers?
6. What's the broker like?
7. How does the firm watch your account?
8. What's the execution time?
9. Is the firm reputable, reliable, financially sound?
10. Is the firm a member of NASOCD, FIA, etc.?

Jobman further cautions the prospective buyer about using the amount of the premium as the sole criteria for picking a firm (44, p. 22).

Most and Steur report on the American Stock Exchange's proposal to offer commodity options on gold and silver bullion via the actual commodities rather than futures contracts (88, p. 32). They also list some strategies and outline how industrial users can benefit from options on the actuals (88, p. 55).

The Mocatta-type options are explained by Jarecki (73, pp. 31, 34, 35). He indicates how the dealer options started and how they operate and can be used by hedgers. Jarecki later explained through an example how Mocatta actually underwrote and sold options (72, pp. 50–54).
Sarnoff explains how to gain from granting or underwriting options and gives various schemes for doing so via various sophisticated strategies (93, pp. 34, 40-43).

Miller details how to avoid many of the pitfalls of commodity option dealers and explains the risk involved (87, p. 3).

Option pricing models

The only accepted pricing model for commodity options known to currently be in use is the Black model. Black summarizes his model as (12, p. 170):

\[
w(x, t) = e^{r(t - t^*)} \left[ xN(d_1) - C^N(d_2) \right]
\]

where

- \( w \) = option price
- \( x \) = futures price
- \( t \) = time period
- \( t^* \) = expiration time
- \( C^* \) = exercise price of option
- \( r \) = riskless rate of return

\[
d_1 = \left[ \ln \frac{x}{C^*} + \frac{s^2}{2} \frac{(t^* - t)}{t^* - t} \right] / \sqrt{s \sqrt{(t^* - t)}}
\]

\[
d_2 = \left[ \ln \frac{x}{C^*} - \frac{s^2}{2} \frac{(t^* - t)}{t^* - t} \right] / \sqrt{s \sqrt{(t^* - t)}}
\]

This model is essentially the same as the securities option model for European type options that Black and Scholes developed (13, p. 177). The model simply says that the commodities option price is a
function of the futures price and the time period involved. The exact specification of the equation involves the statistical distribution assumptions of the futures price over time, i.e., its distribution moments. Black also points out that the model as developed does not work for options that can be exercised before maturity (American options) (12, p. 178).

Gardner uses Black's model to formulate a similar model, as (53, p. 989):

$$\frac{V}{P_t} = e^{-rt} N \left( \frac{\sigma}{2} - \frac{\ln \left( \frac{P^*}{P_t} \right)}{\sigma t} \right)$$

(26)

where

- $\frac{V}{P_t}$ = value of option relative to expected price
- $P^*/P_t$ = exercise price relative to the expected price
- $t$ = time period
- $r$ = riskless rate of return

Gardner points out that Black's model was derived under random changes in the commodity price with changes distributed log-normally. The time series of agricultural commodity prices, however, is not random because of seasonal factors which securities lack (53, p. 989).

Gardner also gives an example of how if the futures price $P_t$ is known then $P^*$ and $V$ can be generated and the log standard deviation of expected price, $\sigma$, can be calculated. To illustrate, assume $P_t=$ $3.00$ and
an option to buy at \( P^* = $3.30 \) sells for \( V = $0.30 \) with \( r \) at 0.05 for a 6-month option. Thus equation (26) will give \( \sigma \) value of 0.36. This changes to 0.22 if \( V = $0.15 \) (53, p. 990).

Gardner also states that if the futures price and the exercise (striking) price are equal then the option equation shows \( \sqrt{\frac{V}{P}} \) depends only on \( \sigma \). Furthermore, observation of an option premium does not imply an estimate of a futures price (53, p. 990). Gardner does say that if two options are observed then inference can be made above the first two moments of the futures price distribution. His example shows that if the striking price of both a put and call option are equal, then (53, p. 990):

\[
\int_0^{P^*} Pr (P) \cdot (P - P^*) \, dP = \int_{P^*}^{\infty} Pr (P) \cdot (P^* - P) \, dP \quad (27)
\]

or

\[
\int_0^{\infty} Pr (P) \cdot PdP = \int_0^{\infty} Pr (P) \cdot P^*dP \quad (28)
\]

reducing to

\[
E (P) = P^* \text{ expected price } = \text{ striking price} \quad (29)
\]

Dunning provides one of the few explanations of how the Black model is practically used (33, pp. 44, 45). Eurocharts Information Service, London, England, has computerized the data for several years of the London commodity options and applied the Black model to calculate option values. The model is used by hedgers to determine whether or not to continue holding the option and, also, if the option should be purchased in the first place. Dunning uses a simple example as follows (33, p. 45):
Current price (May) of

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>September cocoa</td>
<td>2000 BP</td>
</tr>
<tr>
<td>Exercise price of option in May</td>
<td>2000 BP</td>
</tr>
<tr>
<td>Premium</td>
<td>200 BP</td>
</tr>
<tr>
<td>Interest rate (riskless)</td>
<td>$R_1$</td>
</tr>
<tr>
<td>Duration</td>
<td>4 months</td>
</tr>
</tbody>
</table>

The Black model yields the value of the option as 250 British pounds, or 50 British pounds more than the premium. Thus, the firm should buy the option. Later in June the same option is:

Current spot price

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>September cocoa</td>
<td>2250 BP</td>
</tr>
<tr>
<td>Exercise price of option</td>
<td>2000 BP</td>
</tr>
<tr>
<td>Interest Rate (riskless)</td>
<td>$R_2$</td>
</tr>
<tr>
<td>Duration</td>
<td>3 months</td>
</tr>
</tbody>
</table>

The model gives a value of 300 British pounds. This is compared with the foregone cash (50 British pounds) from not exercising the option in May and the premium 200 British pounds, or 250 British pounds cost to hold the option. Thus, the holding cost is 50 British pounds less than the expected value and the firm should continue holding the option.

The principal problem in using the Black option pricing model is the seasonality factor that Gardner pointed out (53, p. 989). Black's model assumes random prices over the life of the option, that is,
prices are just as likely to increase as decrease. Use of the present Black model may generate biased option values. The literature does not contain any commodity option pricing models that overcome the problem of seasonality.

Commodity Futures Hedging Strategies

Hedging and futures markets have enjoyed a prolific representation in the literature since Holbrook Working began researching them in the late 1920s and early 1930s. Most of the research was confined to the traditional storable commodities such as wheat, corn and soybeans. With the introduction on November 30, 1964, of futures contracts for live beef cattle, new research was generated on non-storable commodities.

Powers conducted a study to find if the introduction of live beef cattle and pork bellies futures had any influence on the cash prices. His results showed that cash prices stabilized (random element reduced) somewhat after the introduction of the non-storable futures contracts (89, pp. 460-464). Taylor and Leuthold conducted a similar study and found that annual variability of cash prices was reduced but not significantly; however, weekly and monthly variability were significantly reduced (103, p. 372). Leuthold, in a separate study, concluded that futures prices for live beef cattle estimated spot cash prices as well as corn futures did for cash corn prices, despite the differences in storability (81, p. 382).

Scheer found that hedging with live hog contracts could reduce risk and increase profitability. If the hedge was terminated, in a non-
contract month, however, profit was reduced due to greater basis variation in non-contract months versus contract months (94, pp. 78-80).

Leuthold evaluated the following eleven different hedging strategies for Illinois cattle feeders to determine the variance and mean returns (81, p. 15).

1. Unhedged - sell on cash market

2. Fully hedged - hedge every animal for every feeding period

3. Hedge if the break-even value is less than the futures price

4. Hedge if the break-even plus $.50/cwt. is less than the futures price

5. Hedge if cash price is less than futures price

6. Hedge if cash price plus $1.00/cwt. is less than futures price

7. Hedge if break-even is greater than cash price

8. Hedge if animals are to be marketed in the months of September, October, November, and December

9. Hedge if animals are to be marketed in the months of August, September, October, November, December, and January

10. Hedge if animals are to be marketed in the delivery months

11. Hedge if animals are to be marketed in the non-delivery months

Leuthold found that the first strategy had the highest variance and the second strategy the lowest. He found that strategies 4-7 had lower variances than the first with higher net returns (81, p. 18). also surveyed Illinois farmers and found very few actually used the futures market for live beef cattle (81, p. 24).
Holland, Purcell, and Hague suggested that cattle feeders use a net of selective hedging strategies. They list five hedging strategies that generate higher returns than not hedging or hedging in an unorganized manner (67, pp. 123-128):

1. Hedge if animals are to be marketed in the months September, October, November, and December
2. Hedge if the target price (localized futures price) is less than the net mean return from no hedging
3. Hedge if the target price (localized futures price) is greater than the net mean return from not hedging
4. Hedge if the expected net revenue is less than the mean net return without a hedge and the target price (localized futures price) is greater than zero
5. Hedge if prices decrease more than $1/cwt. during the feeding period

Erickson simulated nine hedging marketing strategies for cattle feeders (40, p. 17):

1. Unhedged - Sell on cash market
2. Fully hedged - hedge all animals every feeding period
3. Hedge if the cash price plus $1/cwt. is less than the futures price
4. Drop the hedge if the cash price plus $1.50/cwt. is greater than the futures price.
5. Hedge only in the delivery months
6. Hedge only in the non-delivery months

7. If the break-even price is less than the futures price plus $1/cwt. don't hedge

8. Do not feed if the break-even price is greater than the futures price

9. If the break-even price is less than the futures price, hedge half of the production

Thus, Erickson's simulation allows for a non-feeding strategy. Results of the nine strategies showed that only strategies 7 and 8 exhibited positive net returns (both allow for non-feeding) (40, p. 19).

Although numerous studies exist on livestock hedging strategies, they generally all generated results that had common ground. First, hedging usually results in a decrease in variance but not always an increase in net returns; and second, usually selective hedging strategies produce higher net returns than full hedges or routine hedges.
CHAPTER 4. RESEARCH PROBLEMS

A viable commodity options market must resolve several key issues. The major issues include the following: 1) should options be on futures contracts or on the physical commodity, 2) should options be traded on organized exchanges (such as the Chicago Options Exchange for securities) and/or by dealers in the actual commodity (such as Mocatta, Inc.), 3) should options be developed to be resold ('strong') or should they not be freely traded ('weak'), and 4) should striking prices on options be fixed at certain levels or should striking prices be variable.

Resolution of these issues is crucial to how the option market functions. Since no option market exists currently, assumptions about these issues must be made to establish a basis for the theoretical model and analysis. Each of these issues or problem areas is discussed in this chapter in some detail to provide information for decisions about analytical assumptions.

Futures Versus Actuals

Options on futures contracts function as detailed in Chapter 2. The procedures for buying and writing both puts and calls for actuals do not materially differ from futures contracts. For example, if the buyer of a call exercises his option he receives a long futures contract at the designated striking price. If the option was on the actuals he would receive the physical commodity instead of the long futures
contract. In the latter case he is long the cash commodity compared to being long the futures contract in the former, but a long position nonetheless. The writer, likewise, either delivers a long futures contract or the actual commodity if the option was written against the actuals.

The major difference between the futures contract options and options on the actuals involves the put. As outlined in Chapter 2, when a put writer has the option exercised by the buyer, he delivers a short (sell) futures contract. If he wrote a put against the actuals, he receives the actual commodity if the put is exercised. The put on actuals, therefore, functions the way puts on securities work. In fact, this is one of the justifications AMEX lists for proposing using actuals rather than futures contracts (88, p. 55). The writer essentially is agreeing to accept a certain amount of the commodity at the designated striking price. The buyer of the put when it is exercised is short the actual commodity if it is against the actuals because he is selling to the writer. Likewise, if the put was on futures contracts he would receive a short futures contract and be short in the futures market. The buyer is in a short position regardless of the type of market.

Since both futures and actuals options leaves the buyer either in a short or long position if exercised, the question of which one to use can be more objectively analyzed by looking at the advantages and disadvantages of each.
Table 12 shows the relative advantage or disadvantage of each activity for options on futures contracts and actuals. Options on futures contracts relative to actuals are: 1) easier to deliver if exercised because it is merely an accounting transfer and broker call, 2) provisions for grade, delivery points, and contract size are more uniform and already in use, 3) more liquid and easier to transact orders, and 4) traded on organized, regulated exchanges.

Options on actuals relative to futures contracts are: 1) more readily accepted by the general public because an option on a futures contract is difficult to understand, 2) more flexible for small producers or odd lots for contract size, delivery points, and grades, and 3) less costly in terms of margin deposits, margin calls, and brokerage fees (88, p. 55).

These advantages and disadvantages, for the most part, don't differ enough to provide a clear choice of which should be used. The main difference involves the primary function of each market. The actuals market is a resource providing or resource releasing market. It is used primarily by participants that either need the commodity or need to get rid of the commodity. Options on actuals, therefore, have in the past been typically granted or bought by participants that handle the physical commodity. They are essentially using the option as a price or risk shifting mechanism, but often times it is used as an assurance of a market -- either a source of sale or purchase. To illustrate, Mocatta
Table 12. Advantages and disadvantages of options on futures contracts and actuals

<table>
<thead>
<tr>
<th>Activity</th>
<th>Options On Futures</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of delivery if exercised</td>
<td>High&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Low&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Liquidity and ease of transactions</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Public understanding and acceptance</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Extent to which individual needs and small lots are served</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Organization and regulation of trading mechanisms</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Costs of margin accounts, margin calls, and brokerage fees</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Number of different types of commodities that can be traded</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Uniformity of grade, delivery points, and contract size</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

<sup>a</sup> The terms High and Low are not used as absolutes but rather as a relative comparison between the two options.

Metals, Inc. (72, p. 50) used options on actuals to establish a market for palladium. A foreign government was attempting to sell palladium for $70 per ounce when the market price was $66 per ounce. Mocatta purchased the palladium with the right to double purchase quantity anytime within the next year. Mocatta then sold options to industrial counterparts, metal merchants, and brokers who then sold them...
to the public. A year later, four tons of palladium moved into the United States at $70 per ounce, instead of the then market price of $135/ounce for a balance of payment savings of $8 million.

AMEX in proposing in 1977 options on actuals listed three advantages to industrial users: 1) provides a means of producing a return (premium) on non-income producing inventory, 2) permits hedging of price risks on a not-as-yet ascertained quantity of goods, and 3) price insurance (88, p. 55).

Options on futures contracts attract a different clientele. Futures markets are used almost exclusively as price shifting markets (usually no more than 2 percent of the contracts are ever fulfilled by actual delivery (9, p. 7)). Option buyers and writers, therefore, want price insurance and price shifting protection with respect to cash and futures prices. This group constitutes a much larger population than actuals users. In 1978, the value of agricultural commodities at the farm was approximately $75 billion and the marketing value was another $150 billion, whereas futures contracts on only a select group of these commodities was over $1 trillion (105). This $225 billion dollar farm and marketing sector provides a larger volume need for options because they need price protection in addition to actual physical markets.

The Commodity Futures Trading Commission in early option trading proposals favored options on futures contracts partly because of the advantages and disadvantages discussed earlier, volume considerations,
and because of the problems of dealer versus exchange options (discussed in the following section). Undoubtedly when and if commodity options are allowed to be traded both futures contracts and actuals will be used. Currently, options on any futures contract are banned by the Commodity Futures Trading Commission. Some options on actuals are, however, being written by dealers such as Mocatta Metals, Inc.

Dealers Versus Exchanges

Closely related to the issue of futures versus actuals is the problem of dealers versus exchanges for trading options. In fact, the alternatives here are not clear-cut. Typically dealers have handled options on the actuals such as Mocatta Metals, Inc., but they also handled options on futures during their brief life in the early 1970s. Indeed, the scandal involving "Goldstein - Samuelson" (98, p.35) that wrote both actuals and futures options prompted early Commodity Futures Trading Commission rulings against dealers. Currently, the Commodity Futures Trading Commission's proposal would allow dealer options on the actuals if the dealer also traded the underlying commodity. By the same token, early exchange trading proposals for options involved only futures contracts with AMEX being the exception.

The two key issues concerning the controversy over exchange and dealer trading are in general: 1) Centralized pricing and 2) Regulation and control.

Centralized pricing has certain advantages from an economic theory standpoint. The more centralized the market place, the more
concentrated are the buyers and sellers and presumably the greater the understanding of supply and demand conditions. Many buyers and sellers and perfect knowledge of supply and demand are the two principle assumptions of a perfectly competitive market. However, centralized pricing has problems from a realistic and location theory standpoint. Centralized pricing of futures contracts has had a tendency over the years to diminish knowledge of local supply and demand conditions. A good example of this was the back hauling that occurred from Iowa to Chicago during the building of the interstate highway system through Iowa. Steel haulers competed for back hauls to Chicago for Iowa corn. Because of the centralized trading of corn futures in Chicago, the relative price in Iowa had little effect on the Chicago price. Only when the relative difference (basis) between the Chicago and Iowa price became large did the futures price respond. That is, the centralized trading responded to regional differences very slowly. Centralized futures markets, while fairly price effective in their own geographical areas (Chicago, New York, etc.), have been less effective from a pricing standpoint in the spatial, temporal, and form dimensions. The potential for arbitrage to be the stabilizer between markets is severely reduced when all pricing is centralized. This deficiency is reflected in the basis values which can vary widely such as occurred for corn and soybeans in the fall of 1973. Also, while more buyers and sellers are preferred from the viewpoint of competition, there is also a lower threshold on the number needed for a viable (active) market. The
Minneapolis and Kansas City Futures Exchanges stand as examples of markets that rival Chicago in pricing performance but with significantly fewer buyers and sellers.

The cost of regulation and control is lower for exchange trading. Certain economics of size prevail in centralized regulation both in time and money expenditures. The old Commodity Exchange Authority and the Commodity Futures Trading Commission have considerable experience, investment, and expertise in regulating exchange trading of commodity futures. The cost of licensing, regulating, and overseeing a totally new dealer network is a major disadvantage of dealer trading. It has been argued that dealers should be free of most of the regulation and control just as other market places (county elevators, wholesale markets, and other trading centers). The aftermath of the early option market, the Lloyd, Carr scandal, and the Goldstein - Samuelson problem, cause serious doubts as to market performance if dealers are not regulated.

Indeed, the Commodity Futures Trading Commission lists centralized pricing and the cost of dealer regulation as the major criteria for supporting exchange trading (97, p. 60). The only serious challenger of the Commodity Futures Trading Commission's ban on dealers, Mocatta Metals, Inc. (Metals Quality Corporation, Rosenthal and Co., and Powdex have also challenged the Commodity Futures Trading Commission's ruling against dealers) argues that, "Logic and fairness require continuation of a business that has existed without problems" (72, p. 50).
'Weak' Versus 'Strong' Options

'Weak' options are options that cannot be retraded. They must either expire or be exercised. 'Strong' options can be retraded and, like futures contracts, usually are never exercised. The current securities option trading on the Chicago Options Board is in 'strong' options.

A 'weak' option functions the way options were described in Chapter 2. If a buyer of a call finds the price movement is enough to justify exercising the call, he does so. Likewise, if the price movement was against him, he would simply let the option expire. The writer of the call is also limited in what he can do. Once he writes the call, he has to wait for it to be exercised or expires. He does not have the right to purchase his call and nullify the option.

If a 'strong' option was available, the buyer could do one of two things. He could exercise the call (treat it as a 'weak' option) or he could reenter the option market and sell the call option. The writer of the call also has the same privilege. If he sees the option may be exercised he can reenter the market and purchase his obligation and offset his option.

As an example of a 'strong' option (Table 13), consider a naked writer who grants a 90 day call in December Live Cattle at $55/cwt for a premium of $5.50/cwt (assuming a 10 percent premium). After 60 days the price of December Live Cattle has moved to $59/cwt with definite technical and fundamental bullish signals. Rather than wait for the option to be "called" at $55/cwt, the writer could purchase his call
Table 13. 'Strong' option example for buyer and writer

<table>
<thead>
<tr>
<th>Writer</th>
<th>Buyer</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Naked' 90 day call is granted on December Live Cattle</td>
<td>Striking Price $55 per cwt.</td>
</tr>
<tr>
<td>Received $5.50 per cwt.</td>
<td>Premium $5.50 per cwt.</td>
</tr>
<tr>
<td>Writer enters market and buys a call at a premium of $5.90 per cwt.</td>
<td>60 days later Price at $59 per cwt.</td>
</tr>
<tr>
<td>Writer has a net loss of $.40 per cwt. plus commissions minus interest</td>
<td>90 days later Price at $63 per cwt.</td>
</tr>
<tr>
<td>If writer did not repurchase after 60 days then he must enter the futures market and pay $63 for the contract. He delivers it to the buyer at $55 for a net loss of $8 less premium and interest plus commissions.</td>
<td>Buyer calls at $63 - gets a futures contract at $55 for a gain of $8 less premium, interest, and commissions</td>
</tr>
</tbody>
</table>
back for $59/cwt. at a premium of $5.90/cwt. (again, assuming a 10 percent premium), for a net loss of $.40/cwt. Why would a writer take a $.40/cwt. loss rather than hold the option? Since it was a naked call and all signals were bullish he had a potential for a loss much greater than $.40/cwt. If at the end of 90 days December Live Cattle had advanced to $63/cwt., the buyer would call his option. The writer must deliver a long December Live Cattle futures contract — at $55/cwt. He, therefore, must enter the futures market and purchase a contract at $63/cwt. for a loss of $8/cwt. He received $5.50/cwt. in premium for writing the call for a net loss of $2.50/cwt. (plus brokerage and miscellaneous costs) rather than $.40/cwt. if he would have purchased the call back at an earlier date. Of course, if his bullish prediction was wrong then he sacrificed a $5.50/cwt. gain for a $.40/cwt. loss because the option would not have been exercised.

If the call was covered, the strategy would change. The writer would probably not repurchase his call. If it was exercised, he would deliver the long futures contract purchased at $55/cwt. He received the $5.50/cwt. premium but suffered a $2.50/cwt. opportunity loss by writing the call.

For a price decline, the strategy reverses for the writer. If the call was written naked, he would let the option expire and would have a net positive position of $5.50/cwt. less commissions. If the call was covered, however, and prices started moving down with strong technical and fundamental bearish signals he would consider purchasing the call
back. If after 30 days December Live Cattle was trading at $53/cwt. the
writer could purchase his call for $53/cwt. at a premium of $5.30 for
a net gain of $.20/cwt. He sacrifices the $5.50/cwt. premium for a
$.20/cwt. gain because of the potential of greater losses. If he lets
the call expire in 90 days and prices have fallen to $46/cwt. he must
sell a futures contract for $46/cwt. to offset his 'covered' long for a
loss of $9/cwt. (plus brokerage and miscellaneous costs). He received
$5.50/cwt. premium for a net loss of $3.50/cwt.

Buyers, likewise, enjoy the same flexibility of repurchase as
writers. If the buyer of the $55/cwt. call on December Live Cattle
found prices at $59/cwt. 60 days later and technical and fundamental
signals did not show any more increases, he might consider selling his
call. If he sells his call at $59/cwt. receiving a $5.90/cwt. premium,
he has a net positive position of $.40/cwt. If prices had increased to
$63/cwt. the writer by offsetting suffers an opportunity cost similar to
the covered call writer.

If the price had decreased to $51/cwt. with further indications of
a decline the buyer could sell at $51/cwt. and a premium of $5.10/cwt.
and have a net negative position of $.40/cwt. If he let it expire, he
would have had a net negative position of $5.50 cwt. (his full premium).

These foregoing examples assumed that the premium value was 10
percent regardless of a price increase or decrease. Obviously this is
not necessarily true. An option's value or premium reflects time and
volatility (price value) (106, p. 18). The less time, the less
value the option has (time decay). The more volatile, the greater the
chance (probability) for gain. By keeping the premium at 10 percent, it is assumed the loss in time decay value is offset exactly by the gain in volatility value. Although this typically doesn't happen, it does not invalidate the examples but merely adds simplicity.

These examples point to one of the main advantages of 'strong' options over 'weak' options — that of allowing both buyers and writers the chance to reduce losses through different strategies. This is especially important for grantors who write naked options. By the same token it places a greater realization of opportunity costs upon the grantors and buyers.

A 'strong' options market necessitates having enough liquidity so that writers and buyers can repurchase their obligations. Obviously if a writer wanted to purchase his call back some buyer must be willing to sell his call option. This process requires enough volume to generate a smooth process or else the 'strong' option rapidly looses its appeal and effectiveness. In a viable liquid form the 'strong' option market is completely analogous to the short and long offsetting concepts of the futures market.

If the 'strong' option market is highly liquid, then fewer options will be exercised or let expire. This has been one of the overriding concerns of futures exchanges. They fear that a strong liquid option market would reduce futures volume and adversely affect that market. The fears are not groundless. The option exchanges for securities seem
to have had a negative effect on volume on the major stock exchanges (16, p. 102). The extent and nature of the effect is not fully known.

A 'strong' option market necessitates specially educated traders because of the additional strategies and possibilities. This could have the effect of forcing more speculators and fewer hedgers to use the market, at least initially.

Fixed Versus Variable Striking Prices

Fixed striking prices are not truly fixed. Fixed pricing refers to setting various prices such as $55/cwt., $60/cwt., or $65/cwt. for a futures contract such as December Live Cattle. The striking price could be any of the above prices (say $55/cwt.) even though the current trading price for December Live Cattle is different, say $58/cwt., the premium would then reflect the difference. If a buyer wanted a call on December Live Cattle he could get a $55/cwt. "in-the-money" option. His premium would be 10 percent plus the "in-the-money" amount, or $5.50/cwt. plus $3/cwt. for a total premium of $8.50/cwt. The buyer could have elected to buy a call at $60/cwt. This is an "out-of-the-money" call if the trading price is $58/cwt. The buyer would pay $6.00/cwt. minus $2.00/cwt., or $4.00/cwt. net premium for the "out-of-the-money" call. If the trading price is at one of the fixed striking prices, then the buyer could elect to buy an "at-the-money" call. If the trading price is $55/cwt. then an "at-the-money" $55/cwt. call would have a premium of only 10 percent, or $5.50/cwt.
In the securities option market a new option with a different striking price is introduced when the value of the stock reaches a midway point between two fixed levels (normally these levels are in multiples of five). If the stock traded at $50 but declined to $47.50, a new $45 option would be allowed to be traded. If it advanced to $52.50, then a $55 option would be allowed.

The fixed striking price system allows for a large number of possible strategies for both writer and buyer.

A covered grantor (writer) may wish to minimize the risk of having the commodity "called" away by the option being exercised. An effective way to do this would be for the writer to write an "out-of-the-money" call. If December Live Cattle are trading at $55/cwt. the grantor could write a call on the $60/cwt. option. His premium would be 10 percent of $55/cwt. or $5.50/cwt. minus $5.00/cwt. ("out-of-the-money") for a net of only $.50/cwt. This option would be less likely to be called than an "at-the-money" or an "in-the-money". The writer could further reduce the risk of the call being exercised by making the duration short, i.e., 30 days or 60 days.

A covered writer may believe prices for December Live Cattle are going to be bearish. To take full advantage of this he could write an "in-the-money" call at $50/cwt. He would receive 10 percent of $50/cwt. or $5.00/cwt. plus $5.00/cwt. ("in-the-money") for a total premium of $10/cwt. The price of December Live Cattle would have to fall below
$45/cwt. before the writer would incur a net loss. Even if the writer's bearish prediction proved wrong and the call was exercised the grantor still had a net positive position of $5.00/cwt.

Option buyers likewise can use the "in-the-money", "out-of-the-money", and "at-the-money" contracts for different risk attitudes, price expectations, and commodity needs. For example, a risk averse buyer during a moderate bull market could buy a $45/cwt. call on December Live Cattle when the market price is $50/cwt. and rising. He has purchased an "in-the-money" option and pays 10 percent of $50/cwt. or $5.00/cwt. plus $5.00/cwt ("in-the-money") for a $10/cwt. premium. He has, therefore, purchased a $5.00/cwt. ("in-the-money") risk premium because he could liquidate the call immediately and lose only his $5.00 premium, not the full $10.00 premium.

Put option strategies for fixed striking prices for writers and buyers are similar but opposite in most cases.

Fixed striking prices for options have the advantage of offering numerous different strategies. Because of this flexibility in strategy design, however, they have the disadvantage of requiring additional training and education. This eliminates otherwise potential option users.

A variable striking price uses the current market as a guide for "striking" or setting the option price. If a buyer wanted a call on December Live Cattle and the market price was $55/cwt., the striking price would be as close to $55/cwt. as could be executed. In the
futures market a market order is typically never filled at the then market price because of trading lags. This would be true, also, for variable striking prices for commodity options.

The uses and strategies of variable striking prices for buyers and grantors were covered in Chapter 2. All of the examples in that chapter assumed variable striking prices.

With the variable striking price for an option being, for all practical purposes, the current market price a measure of simplicity and ease of use is gained over fixed striking prices. It also eliminates several potential strategies and flexibility of use.

Option Markets

The short lived United States commodity option market from 1971–1973 and the proposed new option market by the Commodity Futures Trading Commission differ somewhat concerning the issues of striking prices, trading, and reselling.

Table 14 shows the comparison between the early United States commodity options market and the currently proposed options market by the Commodity Futures Trading Commission.

The proposed Commodity Futures Trading Commission's option market is basically a trial market to determine weaknesses, viability, and regulation needs. Revisions in the Commodity Futures Trading Commission's proposed market presumably could be made after the trial period.
### Table 14. Comparison between the CFTC's commodity option market and the early U.S. market, 1971-1973

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Futures versus actuals contracts</td>
<td>Futures</td>
<td>Futures (some actuals by certain dealers)</td>
</tr>
<tr>
<td>Dealer versus exchange trading</td>
<td>Dealers only</td>
<td>Exchange trading (some dealer trading)</td>
</tr>
<tr>
<td>'Weak' versus 'Strong' options</td>
<td>'Weak'</td>
<td>'Weak'</td>
</tr>
<tr>
<td>Fixed versus variable striking prices</td>
<td>Variable</td>
<td>Variable</td>
</tr>
</tbody>
</table>
Several of the possible option market trading methods are not easily separable. Strong options need fixed striking prices to complement the flexibilities of retrade and strategy development. Without retrading, fixed striking prices pose severe trading problems and become less useful. Strong options with variable pricing, however, are possible and would increase the development of trading strategies. These are possible combinations and modifications that could occur after the Commodity Futures Trading Commission's trial period -- depending on the success of the new market.

The option market that will be assumed for this thesis will be the one proposed by the Commodity Futures Trading Commission. The CFTC's proposed market will be used for two reasons: 1) Since the CFTC will control what kind of market will exist, an analysis using their proposal has more immediate relevance and use, and 2) the CFTC's proposed market is simple, more easily modeled, and offers the possibility of more powerful statistical inferences.
CHAPTER 5. HEDGING THEORY AND METHODOLOGY

This chapter deals with the theoretical development of options, hedging, and the simulation model used for the numerical analysis. The simulation model and the procedure for option and hedging calculations are described. The data base and the precise option and hedging strategies are developed and illustrated.

Hedging Theory

Hedging with commodity futures involves shifting the risk of unknown future spot price movements to traders willing to absorb the risk. Typically this is a speculator but it could also be another opposite position hedger.

The effectiveness of a hedge can be measured by how well these price risks are eliminated. Blau's study in 1945 (14, p. 8) illustrates the point with Venn diagrams. (see Figure 7).

A totally effective hedge (all price change risk eliminated) would be when both cash and futures risks offset each other -- Position I. This perfect hedge, while possible, is highly improbable. The perfect hedge has the possibility of existing only when the cash and futures are mirror images in regard to quality, quantity, type, kind, etc., (66, p. 71). This has never been the case in any futures - cash relationship over a period of time (66, p. 75).
where: \( \alpha = \) non-hedgable cash risks (grade change, natural disasters, shipping loss, etc.)
\( \beta = \) offsetting value (price change) risks
\( \gamma = \) non-hedgable futures risk (exchange problems, contract problems, regulations, etc.)

Figure 7. Venn diagram representation of cash and futures risk transfer

A more correct theoretical development of hedging allows for the recognition of the differences between the cash and futures market — Position II. Only to the extent that \( \beta > \gamma + \alpha \) will hedging reduce value change risk. Blau argues that \( \gamma \) can be eliminated by such things as contract standardization for liquidity and efficient exchanges — Position III. This, however, is not theoretically correct. Blau
acknowledges this by stating that standardization of contracts reduces flexibility of exchange and therefore cannot negate the total effect of \( \gamma \), but he does not develop the idea further. More correctly, then, the theory of hedging involves a diagram such as illustrated in Figure 8.

\[
\alpha \cap \beta \subsetneq \gamma
\]

Position IV

\[
\begin{align*}
\beta & \geq \gamma + \alpha \\
\gamma & \leq \alpha
\end{align*}
\]

Figure 8. Venn diagram of an effective hedge

This theoretical concept more completely reflects the present state of the art on hedging. Hedging comprises exchanging the risk of cash and futures price movements for basis movements, i.e., \( d\beta \) for \( d\alpha + d\gamma \). For this definition, however, \( \alpha \) must be redefined and explained. Non-hedgable cash risks (\( \alpha \)) embrace both individual and aggregate risks. Individual cash risks include loss of grade (rodents, moisture, and foreign matter), shipping and drying losses, etc. Aggregate cash risks would entail large natural disasters, transportation bottlenecks, and other factors that would be reflected in prices both in the cash and futures markets.
Individual risks for one point in time can be assumed small and constant, $\delta$. Hedging risk would thus be $(1-\delta)\alpha + \gamma$, or basis risk. Over time this is $d(1-\delta)\alpha + d\gamma$, or basis change as illustrated in Figure 9.

\[
\delta + (1-\delta) = \alpha
\]

Figure 9. Venn diagram of individual and aggregate risks in the cash market

The risk in hedging then becomes whether

\[
\delta > (1-\delta)\alpha + \gamma \text{ or } d\delta > d(1-\delta)\alpha + d\gamma \tag{30}
\]

offsetting risk (cash and futures price movements) $d\delta$ is greater than basis change $d(1-\delta)\alpha + d\gamma$.

An example may prove useful. Assume a producer has 38 head of cattle averaging 700 lbs./animal on feed. He plans to market in approximately 150 days when the animals will weigh between 1,000 - 1,100 lbs. To protect against the possibility of a price decrease during the next 150 days, the futures market can be used.
Table 15. Hedging table for a cattle feeder where basis change = 0

<table>
<thead>
<tr>
<th>Cash</th>
<th>Futures</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 1. Cattle on feed (cash spot at $60/cwt.)</td>
<td>Jan. 1. Sell 1 contract (40,000 lbs.) June fat cattle at $69/cwt.</td>
<td>$9.00/cwt.</td>
</tr>
</tbody>
</table>

On May 1 when the cattle have reached market weight, the producer will lift the hedge.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$2/cwt.</td>
<td>- $2/cwt.</td>
</tr>
</tbody>
</table>

Net = 0

The producer received $60/cwt. net -- the futures market completely exchanged the risk of the cash price change (Position V, where \(d(l-\delta) = dy = 0\)). This is not the same as Position I where \(\alpha = \gamma = 0\), but rather where risks in futures and cash exist but the levels remain constant over some time.

Basis changes due to the eroding of time, as time decays the probability of futures risk \(\gamma\) and aggregate cash risk \(l-\delta\) decreases, resulting in a decrease in basis -- theoretically because of time moving
the cash and futures together during expiration. With an eroding basis (often called an "improvement in basis" for short hedgers) the example becomes:

Table 16. Hedging table for a cattle feeder with the basis narrowing

<table>
<thead>
<tr>
<th>Cash</th>
<th>Futures</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 1. Cattle on feed (cash spot at $60/cwt.)</td>
<td>Jan. 1. Sell 1 contract (40,000 lbs.) June fat cattle at $69/cwt.</td>
<td>$9.00/cwt.</td>
</tr>
</tbody>
</table>

+ $1/cwt. + $1/cwt. Δ$2/cwt.

Net = $2/cwt.

The improvement in the basis (reduction in unhedgable risk) causes a net increase from hedging, $d\delta > d(1-\delta)\alpha + d\gamma$. The right hand expression $d(1-\delta)\alpha + d\gamma$ can change many ways, i.e., $d(1-\delta)\alpha \leq 0$ or $d\gamma \leq 0$. The reduction in risk could be completely on the cash side, futures side, both, cash reduction but futures increase, or futures reduction and cash increase. The additive right hand expression only requires a relative change in unhedgable risks compared to hedgable risks (left hand expression).

An improvement in basis typically occurs because of time, but other factors can outweigh this time effect. Aggregate cash risks can momentarily increase because of a natural disaster, transportation impasses,
or other factors and overshadow the time factor. Futures risks can also cause this through contract and exchange default, regulatory injunctions, or market "corners". Either or both of these factors could cause the time factor to be outweighted and thus a basis increase, i.e., $d_\beta < (1-\delta) \alpha + dy$. The continuing example would show this as illustrated in Table 17.

Table 17. Hedging table for a cattle feeder where the basis widens

<table>
<thead>
<tr>
<th>Cash</th>
<th>Futures</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>(cash spot at $60/cwt.)</td>
<td>(40,000 lbs.) June fat cattle at $69/cwt.</td>
<td></td>
</tr>
<tr>
<td>on cash market $60/cwt.</td>
<td>June fat cattle at $71/cwt.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$0/cwt.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-$2/cwt.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$2/cwt.</td>
</tr>
</tbody>
</table>

Net = -$2/cwt.

These examples are for short hedgers and the opposite situation prevails for long hedgers.

Hedging exchanges one risk for another. **Absolute** price movement in the cash and futures market (hedgable risk, $\beta$) is exchanged for **relative** price movements in the cash and futures market (unhedgable risk, $\alpha$ and $\gamma$).
Option Hedging Theory

Option hedging theory is analogous to futures hedging theory in that it involves shifting the risk of cash price movements and exchanging types of risk. The Venn diagram representation of option hedging theory is illustrated in Figure 10.

Options right but not the obligation to trade futures contracts implies a purchasable (avoidable) portion of the risk of futures contracts, Θ (the premium).

An effective option hedge (the gain in the reduction of hedggable risk is greater than unhedgable risks) would be:

\[ dβ > d(1-δ)α + d(1-Θ)γ \]  

(31)

Option Versus Futures Hedges

The principal difference between futures hedging and hedging with futures through options is simply the ability to purchase a portion of the unhedggable risk. Theoretically an option hedge should have a smaller unhedgable risk factor than a futures hedge (given the same time span, commodity, cash position, and individual), or:

\[ (dβ > d(1-δ)α + d(1-Θ)γ) < (dβ > d(1-δ)α + dγ) \]  

(32)

or in reduced form:

\[ d(1-Θ)γ < dγ \]  

(33)

This latter reduced form expression holds only if the option and futures markets move and change exactly the same. In the absence of perfectly correlated movements between these two markets, the original
where: $\alpha = \text{non-hedgable cash risks (grade change, natural disasters, shipping loss, etc.)}$

$\delta = \text{individual cash risks}$

$(1-\delta) = \text{aggregate cash risks}$

$\beta = \text{offsetting value risks}$

$\gamma = \text{non-hedgable futures risk (exchange problems, contract problems, regulation, etc.)}$

$\theta = \text{unavoidable futures risk}$

$(1-\theta) = \text{avoidable (purchasable) futures risk}$

Figure 10. Venn diagrams of cash and option risk
expression (32) more correctly shows the mathematical representation of the risks. With the two markets not in perfect synchronization the change in hedgable risks (dβ) has the potential to be different for options than for futures since dβ reflects the magnitude of price volatility. The expressions need to be changed to dβ^o for options and dβ^f for futures. Likewise, α and γ have the potential to be different between the two markets since both non-hedgable cash and futures risks are functions of price variance, as:

\[(α, γ) = f \left( \frac{\delta^2}{p}, X \right) \]  

(34)

where:

- \(α\) = non-hedgable cash risks
- \(γ\) = non-hedgable futures risks
- \(p\) = price of the commodity
- \(X\) = other unquantifiable factors

Cash risks \((α)\) such as grade changes and natural disasters increase in size as the price variance goes up and vice versa. Also, futures risks \((γ)\) such as contract rigidities and regulations increase in size as price variance increases and vice versa. The unquantifiable factors \((X)\) are all other factors that affect risk. These are not discussed in detail but are included only for conceptual and mathematical completeness.

With \(α\) and \(γ\) a function of price, a distinction between the two markets must be made since the values for \(α\) and \(γ\) may differ due to price variance \((α^o\) and \(γ^o\) for options and \(α^f\) and \(γ^f\) for futures).
Expression (32) then becomes:

\[(d\beta^o > d(1-\delta)\alpha^o + d(1-\theta)\gamma^o) \geq (d\beta^f > d(1-\delta)\alpha^f + d^f)\]  \hspace{1cm} (35)

Notice, however, that the total expression is now indeterminant with regard to sign. Allowing for imperfections within each market also nullifies the absolutes with regard to hedgable and unhedgable risks. Let \((d\beta^o \geq d(1-\delta)\alpha^o + d(1-\theta)\gamma^o) = \lambda^o\) and \((d\beta^f \geq d(1-\delta)\alpha^f + d\gamma^f = \lambda^f\) and re-express (35) as

\[\lambda^o \geq \lambda^f\]  \hspace{1cm} (36)

It cannot now be argued \textit{a priori} that \(\lambda^o < \lambda^f\) because even if \(d(1-\theta)\gamma^o < d\gamma^f\) still holds (it theoretically does not now have to) other expressions may offset the magnitude of \(d(1-\theta)\gamma^o < d\gamma^f\). For instance, \(d(1-\delta)\alpha^f < d(1-\delta)\gamma^o\) may be greater than \(d(1-\theta)\gamma^o < d\gamma^f\) and thus \(\lambda^o > \lambda^f\), or \(d\beta^o > d\beta^f\) or any combination of factors in expression (35).

**Objective and Hypotheses**

The final objective of this thesis is:

**Objective 3:** Develop, compare, and test various hedging and option strategies in live beef cattle futures for

\[\text{---}
\]

\[1\text{The expressions show } > \text{ for both markets within the parentheses. This assumes an effective hedge as described in the text. A } < \text{ sign could be inserted to allow for basis changes that reflect less effective hedges or offsetting hedges. This would not change the meaning or validity of expression (35). The } > \text{ sign is retained within the parentheses only to emphasize the principal reason for hedging -- to be effective.}\]
a typical midwestern cattle feeder in terms of variance of prices received and mean gross returns from hedging.

Variance of prices

The variance of prices both in the cash and futures markets represent the risk involved with hedging. Without price variance there is no risk (except individual unhedgable cash risk and purchasable (futures risk)), thus equations (1) and (2) contain the risk expressions for price variance in the option and futures markets.

The theoretical hypotheses are:

\[ \text{Ho: } [d\beta^o > d(1-\delta)\alpha^o + d(1-\theta)\gamma^o] < [d\beta^f > d(1-\delta)\alpha^f + d\gamma^f] \]
\[ \text{Ha: } [d\beta^o > d(1-\delta)\alpha^o + d(1-\theta)\gamma^o] > [d\beta^f > [d\beta^f > d(1-\delta)\alpha^f + d\gamma^f] \]

The statistical or testable hypotheses are:

\[ \text{Ho: } \sigma^2_p < \sigma^2_{pf} \]
\[ \text{Ha: } \sigma^2_p > \sigma^2_{pf} \]

Mean gross returns

Gross returns from hedging with futures for producers\(^2\) can be expressed as:

\[ \frac{IF_p - EF_p}{p} = \frac{+NFT}{p} \]
\[ +NFT + RC_p - NHC_p = GR_p \]

\(^2\)The expression changes somewhat for merchandisers who purchase initially in the cash market.
where

\[ \text{IF}_p = \text{initial futures price} \]
\[ \text{EF}_p = \text{ending futures price} \]
\[ \text{NFT} = \text{net futures transaction} \]
\[ \text{RC}_p = \text{releasing cash price} \]
\[ \text{NHC} = \text{net hedging costs (insurance, brokerage fees, etc.)} \]
\[ \text{GR}_f = \text{gross returns with futures} \]

For hedging with options the equation would be:

\[ \text{IS}_p - \text{ES}_p - \text{OP} = +\text{NOT} \]
\[ +\text{NOT} + \text{RC}_p - \text{NHC} = \text{GR}_o \]

where

\[ \text{IS}_p = \text{initial striking price} \]
\[ \text{ES}_p = \text{ending striking price} \]
\[ \text{OP} = \text{option premium} \]
\[ \text{NOT} = \text{net option transaction} \]
\[ \text{RC}_p = \text{releasing cash price} \]
\[ \text{NHC} = \text{net hedging costs} \]
\[ \text{GR}_o = \text{gross returns with options} \]

If the option is not exercised, then \( \text{IS}_p \) and \( \text{ES}_p \) collapse to zero and the \( \text{NOT} \) is equal to the option premium (\( \text{OP} \)), or \( \text{NOT} \) will always be positive (\( \text{OP} \)), or \( \text{NOT} \) will always be negative under non-exercised options. There is no a priori theoretical basis to establish whether \( \text{GR}_o < \text{GR}_f \),
GR_o > GR_f, or GR_o = GR_f. It can be argued OP will constitute a larger effect than IF_p - EP_p (106, p. 30) and thus GR_o < GR_f, but this cannot be argued from a purely theoretical basis. From an empirical basis it has some validity because of the tradeoff usually observed between variance and returns. As variance (risk) is reduced so (usually) is return (103, p. 29); only from this rather incomplete basis can the theoretical hypotheses be stated as:

\begin{align*}
&H_0: GR_o \leq GR_f \\
&H_a: GR_o > GR_f
\end{align*}

and the testable statistical hypotheses:

\begin{align*}
&H_0: \mu GR_o \leq \mu GR_f \\
&H_a: \mu GR_o > \mu GR_f
\end{align*}

Testable hypothesis for objective 3

The aggregate testable hypotheses involving both variance (risk) and mean gross returns are:

\begin{align*}
&H_0: \sigma^2_o \leq \sigma^2_f \\
&\mu GR_o \leq \mu GR_f \\
&H_a: \sigma^2_o > \sigma^2_f \\
&\mu GR_o > \mu GR_f
\end{align*}

Each segment, however, will be tested separately.

Model, Hedging Strategies, and Data Base

A simulation model will be used to test the hypotheses. This model will be used to place and lift both option and futures hedges over
historical prices to recreate (simulate) what would happen to price variance and mean gross returns.

Assuming an efficient market, one simple strategy of a complete hedge could be used as a test for $\mu_{GR_0} \leq \mu_{GR_f}$ since an efficient market would automatically yield a "fail to reject Ho" for $\sigma^2_{po} \leq \sigma^2_{pf}$. Therefore, one hedging strategy placed over the historical time frame would yield an appropriate mean gross return test — if the market is efficient. Several studies, however, reject the efficient or random walk market idea. Cargill and Rausser (18), Houthakker (68, 69), Leuthold (81), Smidt (99), and Stevenson and Bear (101), present results that reject random walk markets or reveal the presence of increased gross returns when appropriate strategies are used.

This does not necessarily imply all futures markets are non-random. Indeed, a considerable body of empirical research shows random walk or more sophisticated martingale models do not disprove efficient markets for certain commodities (Cargill and Rausser (18), Gray (61), Powers (89), and Working (110), to name only a few). The conflicting nature of the research necessitates at least an elementary use of difference strategies (mechanical filters) to test for increased gross returns. The presence of increased gross returns will effect $\mu_{GR}$ and $\sigma^2_p$ since non-symmetric price variance causes unequal price moves.

**Simulation model**

The model is designed to simultaneously place both a futures and option hedge and lift the hedge at the designated time. During this
active hedge time the model calculates the interest costs on margins, margin calls, and option premiums and makes appropriate deductions for brokerage fees. Therefore, for each strategy tested the futures and option hedge will be retained the same length of time. Figure 11 shows the flow diagram of the simulation model.

**Assumptions**

The model is constrained by several assumptions regarding options, futures, interest rates, premiums, and other costs for the sake of simplicity. None of the assumptions critically impaire the model's functions or applicability to the basic objective.

**Futures**

The Live Cattle Futures contract as traded on the Chicago Mercantile Exchange will be used as the basic contract. It calls for 40,000 lbs. of USDA Choice cattle (approximately 38-40 head). Trading months include February, April, June, August, October, and December. The exchange allows for \( \frac{1}{4} \)¢/lb. as the minimum price fluctuation and 1.5¢/lb. as the maximum or limit move per trading day (9:05 A.M. to 12:45 P.M. Central Time).

**Options**

The type of option market assumed for the simulation model will be based on data presented in Chapter 4. The option market will have the following characteristics:

1. Options will be written against futures contracts, not the actual commodity. Thus the option will be written against one of the futures contracts outlined previously.
Figure 11. Flow diagram of simulation model for futures and option hedges
2. Major trading of the options will be by exchanges, not dealers. The issue of dealers versus exchanges would not substantually alter the model, but an exchange is assumed for uniformity of price reporting.

3. 'Weak' options are assumed for simplicity. Once an option is bought it must either be exercised or allowed to expire without the possibility of resale.

4. Variable striking prices will be used. Without any evidence to base fixed striking prices upon, the variable striking price reduces unnecessary statistical bias. Arbitrary fixed levels introduces another unexplainable variable and therefore another unaccountable statistical white noise in the error term.

**Interest, brokerage fees, premiums and other costs**

Interest will be charged daily against option premiums, margins, and margin calls for futures contracts at an annual rate of 8 percent (this is a weighted average of prime rates over the data frame).

Brokerage fees for transacting a futures contract will be $50 per roundturn and likewise for an option contract.

Option premiums will be a variable parameter, and will be calculated as a percentage of the value of the contract. The percentages will be varied over each strategy and will include 5 percent, 10 percent, and 15 percent (33, p. 46).
Producer

A midwestern cattle feeder is assumed as the decision unit. The producer buys fairly light feeders (600 lbs.) and feeds them 180 days with an average daily gain of 2.75 lbs. The animals weigh 1,095 lbs. at the end of each period and grade choice. Four percent pencil shrink is assumed and a 2 percent death loss. The producer places 40 head in the pen at the beginning of the feeding period and markets 39 head, or approximately 40,000 lbs. (size of one futures contract). Live cattle are sold on the cash market at Omaha, Nebraska.

Data base

Figure 12 shows the cattle cycle from 1892-1980. The last four complete cycles have oscillated in 10 year intervals. The last complete cycle was from 1965-1975. Live Cattle Futures began trading on the Chicago Mercantile Exchange on November 30, 1964 for the April 1965 contract. Thus for hedging purposes, data earlier than 1965 cannot be used.

To fully incorporate a complete cattle cycle the time frame for the simulation model will be January 1, 1965 until December 30, 1977 encompassing 13 complete years of cash and futures prices.

Using data from 1965 to 1977 incorporates a liquidation phase (1965-1969) and an expansion phase (1969-1975). An additional two years of liquidation in the current cycle are also included (1975-1977). Daily cash and futures closing prices will be the price information used. A new feeding period is assumed to start at the beginning of
Figure 12. Cattle cycle for all cattle from 1892 to 1980 in the U.S.
each month. The prices were assembled from the Wall Street Journal and the Market News Service, Iowa State University, Ames, Iowa.

Futures and Option Strategies

Selection of mechanical filters (strategies) necessitates having the futures strategy and the option strategy as comparable as possible to avoid additional white noise statistical bias. This constrains the use of strategies that involve selective place-lift hedges. While futures can be readily offset and initiated, options because of the particular time length and the assumption of 'weak' trading cannot be offset.

Five different futures strategies are used with two option strategies for each futures strategy plus a double option strategy for a total of 16 different strategies.

Futures strategies

Filter 1. A full hedge is initiated by selling a futures contract at the beginning of the feeding period and retained throughout. When the cattle are sold on the cash market the hedge is lifted by buying a futures contract. During the time the hedge is maintained, if margin calls are made, interest on the extra margin is calculated. The gross return is calculated as:

\[ \frac{C_p + (BF_p - EF_p) - HC_p}{p} = GR_p \]
where

\[ C_p = \text{cash price received when cattle are sold on the spot market} \]

\[ BF_p = \text{futures price at the beginning of the feeding period (what the contract was sold for)} \]

\[ EF_p = \text{futures price at the end of the feeding period (what the contract was bought for — i.e., offset)} \]

\[ HC = \text{hedging cost which includes interest on initial margin, interest on margin calls, and brokerage fees.} \]

\[ GR^1 = \text{gross returns from hedging.} \]

The mean gross returns from using Filter 1 over the data set are calculated as:

\[ \frac{\sum_{i=1}^{n} GR^1}{n} = \mu GR^1 \]

where

\[ n = \text{the number of different times Filter 1 was used over the 13 years of data.} \]

**Filter 2.** A full hedge as in Filter 1 is placed only during a feeding period when the cattle are finished during a delivery month. Gross and mean returns are calculated as in Filter 1.
Filter 3. A full hedge as in Filter 1 is placed during a feeding period when the cattle are finished during a non-delivery month. Gross and mean returns are calculated as in Filter 1.

Filter 4. A hedge is placed only if at the beginning of the feeding period the basis is at least $1.00/cwt. Gross and mean returns are calculated as in Filter 1.

Filter 5. A hedge is placed only if at the beginning of the feeding period the basis is at least $1.50/cwt. Gross and mean returns are calculated as in Filter 1.

Option strategies

Filter 1a. A full hedge is initiated by buying a put option at the time the cattle are placed on feed. The option is allowed to expire when the cattle are sold on the cash market. Gross returns are calculated as:

$$G_{R,1a} = C_p - O_p - HC_{1a}$$

where

- $C_p$ = cash price received when cattle are sold on the spot market.
- $O_p$ = option premium paid for put option
- $HC_{1a}$ = hedging cost which includes interest on the option premium and transaction costs.
- $G_{R,1a}$ = gross returns from hedging with filter 1a.
Filter 1b. A full hedge is initiated by buying a put option. The option is exercised at the time the cattle are sold. When the option is exercised a short futures is obtained and offset by buying a futures contract at the current futures price. Gross returns are calculated as:

\[ C_p + (B_S - E_F)_p - O_p - H_C_{1b} = G_{R_{1b}} \]

where

- \( C_p \) = cash price received when the cattle are sold on the spot market.
- \( B_S \) = striking price of put option (price of the short futures contract)
- \( E_F \) = price of the futures contract used to offset the exercised option.
- \( O_p \) = option premium paid for the put
- \( H_C_{1b} \) = hedging costs which include interest on the option premium, margin money, brokerage fees, and transaction costs
- \( G_{R_{1b}} \) = gross returns from hedging with Filter 1b

For Filter 1a and 1b the mean gross returns are calculated as:

\[ \frac{\sum_{i=1}^{n} G_{R_{1a}}}{n} = \mu G_{R_{1a}} \]

and

\[ \frac{\sum_{i=1}^{n} G_{R_{1b}}}{n} = \mu G_{R_{1b}} \]
Filter 2a. A full hedge is placed only when the cattle are marketed during a delivery month. A put option is purchased at the beginning of the feeding period and allowed to expire. Gross and mean returns are calculated as in Filter 1a.

Filter 2b. A full hedge is placed only when the cattle are marketed during a delivery month. A put option is purchased at the beginning of the feeding period and exercised when the cattle are sold. Gross and mean returns are calculated as in Filter 1b.

Filter 3a. A full hedge is placed as in Filter 2a except it is placed during non-delivery months instead of delivery months.

Filter 3b. A full hedge is placed as in Filter 2b except it is placed during non-delivery months instead of delivery months.

Filter 4a. At the beginning of each feeding period a put option is purchased only if the cash and futures differ by at least $1.00/cwt. Once placed the hedge is maintained and the option is allowed to expire. Gross and mean returns are calculated as in Filter 1a.

Filter 4b. If the basis is at least $1.00/cwt. at the beginning of the feeding period a put is purchased and exercised at the end. Gross and mean returns are calculated as in Filter 1b.
Filter 5a. A put option is purchased at the beginning of the feeding period only if the cash and futures differ by $1.50/cwt. If the hedge is placed it is maintained until the feeding period is ended and the option is allowed to expire. Gross and mean returns are calculated as in Filter 1a.

Filter 5b. If the basis is at least $1.50/cwt. at the beginning of the feeding period a put option is purchased and exercised when the feeding period is over.

Filter 6. This is the double option strategy. A double option is purchased at the beginning of each feeding period. It is exercised as a put option when the gain is more than the variable hedging costs and as a call option when the gain is greater than hedging costs.

Filters 1, la, and lb have as their rational the idea behind a "complete" hedge. That is, the hedge is placed when a cash position is entered (cattle placed on feed) and maintained until the cash position is liquidated (feeding period ended). This allows for the possibility of the futures or options on futures to offset the cash price movement. A cash strategy is provided as a basis for comparison on how well this idea works.
Filters 2, 2a, 2b, 3, 3a, and 3b are used to allow for the possibility of imperfections due to the absence of a complete set of trading months. Having to hedge with a contract that does not expire until after the marketing period adds an extra time variable that may influence price variance and gross returns.

Filters 4, 4a, 4b, 5, 5a and 5b are used to test for the effect of difference levels of basis. With a short hedge or put option the basis needs to narrow for expected gross returns to increase over Filters 1, 1a and 1b. By placing a hedge only when the basis is at a certain width, the addition to gross returns has a higher probability of occurring. This probability increases because of the market forces that brings cash and futures together as time expires.

Filters 1-5 were also selected because similar filters were tested by Leuthold (81), and Erickson (40), on Live Cattle. This allows for comparisons and checks although the data periods differ.

In addition to the put options used for Filters 1a,b-5a,b a Double option will be purchased as an additional strategy. While this double option strategy is not necessary to test the formal hypothesis, it does provide additional information about the possible uses for options as hedging mechanisms.
Complete and Partial Feeding Activities

The simulation model used to generate gross mean returns and variance of selected hedging strategies for futures and options was also used to evaluate two completely different feeding activities. The Complete Feeding Activity is the analysis of major importance, but a Partial Feeding Activity was also analyzed. The CFA simulation assumes that the feeder places a pen of cattle on feed at the beginning of each month for the entire data period. The cattle are either hedged with futures contract, an option, or unhedged depending on each strategy. Under the PFA, however, the feeder may or may not place a pen of cattle on feed at the beginning of each month. This provides in addition to the strategies of hedging or remaining unhedged a choice of either feeding or not feeding.

Details of the Model

For futures hedges, an initial margin deposit of $1,000 per contract was assumed (this is a realistic value that generally prevailed over the time frame). The maintenance margin was set at $700 per contract. A price move of .75 /cwt. or more triggered the maintenance margin and the margin account was brought back to $1,000. Interest was calculated for the entire feeding period on the initial $1,000 margin plus any margin calls. Interest was assumed to be 8 percent per year or
.000222 percent per day. Brokerage fees were assumed to be $60 per contract or .15 per cwt. for both a futures contract roundturn and an option contract. If an option was exercised then a charge of $120 or .30 per cwt. was charged due to two brokerage transactions.

Premiums for the option contracts were set at 5 percent, 10 percent, and 15 percent of the striking price at the beginning of each feeding period. For each of the three premium values the simulator was used throughout the entire data period (1965-1977). The early U.S. commodity options market had premiums which typically varied between the 5 percent and 10 percent range. The London commodity option market also shows premiums which vary between the 5 percent and 10 percent range. The sketchy evidence of the early U.S. option market and the London option market shows a 10 percent premium to be the most prevailing premium charge.

The simulator placed the cattle on feed the first Friday of each month and carried them on feed for 27 weeks. According to each strategy, if the cattle were to be hedged, the futures contract for the month following the month when the cattle would be sold was used. For example, the first feeding period started on January 8, 1965 and ran 27 weeks until July 9, 1965. Since the cattle came off feed in July, the next futures contract was August. So August live cattle was the contract used for hedging both by futures and options. This is a standard hedging procedure to avoid erratic delivery month price relationships (81, p. 881).
For the normal futures hedges the sequence of the simulation model (as outlined in Chapter 5) was: 1) the cattle were placed on feed on the first Friday of each month, 2) if hedged, a futures contract was sold for a delivery month beyond the last month on feed, 3) an initial margin of $1,000 was deposited and margin calls made if a $.75 pr cwt. or greater price move occurred during the 27 weeks on feed, 4) an 8 percent opportunity cost was charged for the initial margin and all margin calls, 5) the feeding period ended on the Friday of the 27th week, 6) the futures contract was bought back and the cattle sold on the cash market in Omaha the same day, 7) the gross return was calculated by subtracting costs of the margins and the brokerage fees and the profit or loss from the futures transaction, 8) steps 1-7 were repeated each month during the 1965-1977 period for 150 different feeding periods, 9) variance of these gross returns was calculated as well as the overall gross mean.

The option hedge sequence for the simulation model was: 1) the cattle were placed on feed on the first Friday of each month, 2) if hedged, a put option was purchased the day the cattle were placed on feed for a delivery month beyond the last month on feed, 3) the option premium was calculated as 5, 10, or 15 percent of the striking price (futures price) at the beginning of the feeding period, 4) the feeding period ended on the Friday of the 27th week, 5) the option was either exercised or allowed to expire depending on the strategy, 6) if allowed to expire, the cattle were sold on the cash market in Omaha and gross returns were calculated by subtracting the premium cost and $.15 per cwt.
brokerage fees from the cash price, 7) if exercised, the cattle were sold on the cash market in Omaha and gross returns were calculated by subtracting the premium cost and $.30 per cwt. brokerage fees from the cash price. By exercising the put option, a short futures was obtained and therefore offset the same day with a long contract. The profit from exercising the put was added to the gross return (the option was not exercised if the profit was less than brokerage fees ($0.15/cwt.)), 8) steps 1-8 were repeated each month during 1965-1977 for 150 different feeding periods, 9) variance of these gross returns was then calculated as well as the overall gross mean.

For double options the simulation sequence was: 1) the cattle were placed on feed on the first Friday of each month, 2) a double option was purchased for a delivery month beyond the last month on feed, 3) the option premium was calculated as 10, 20, or 30 percent of the striking price at the beginning of the feeding period, 4) the feeding period ended on the Friday of the 27th week, 5) the option was exercised if the profit was greater than brokerage fees of $.15 per cwt., 6) if the futures price at the close of the feeding period was less than the striking price by more than $.15/cwt. the double was converted to a put and exercised, 7) if the ending price was greater than the striking price by more than $.15/cwt. the double was converted to a call and exercised, 8) the profit from exercising the option was added to the Omaha cash and premium and brokerage fees of $.30/cwt. were subtracted to get gross returns, 9) steps 1-8 were repeated for each month
during 1965-1977 for 150 different feeding periods, 10) variance of these gross returns was calculated as well as the overall gross mean.

The Partial Feeding Activity utilized the same simulation sequence except for the first step for futures, options and doubles. The first step was changed to: 1) Cattle are placed on feed on the first Friday of each month if the criteria for each strategy was met (i.e., non-delivery month, delivery month, $1.00 beginning basis, or $1.50 beginning basis). If the strategy criteria was not met, then no cattle were placed on feed. That is, for the non-delivery month strategy if the cattle could be finished during a non-delivery month they were hedged, if not, no cattle were placed on feed. The remaining steps of each sequence were the same.

Tests of significance

One of the purposes of using a large data set (1965-1977) and incorporating a time span long enough to cover any cyclic movement was to invoke the Law of Large Numbers or the Central Limit Theorem. By having a large enough data set, tests involving normal populations can be used. As Lentner states, "The assumption of normality is not critical and may be relaxed when making inference about the mean of any population so long as the sample size is sufficiently large" (80, p. 143). Lentner further states, "For continuous random variables having symmetric distributions, samples of size 20 or more are generally
sufficient" (80, p. 143). The sample size for the Complete Feeding Activity was 150 and for the Partial Feeding Activity never less than 51.

Tests of variance equality

The sum of squares of independent standard normal variables has a special distribution called a chi-square distribution, thus,

\[ \chi^2 = \sum_{i=1}^{n} z_i^2 \]

is a chi-square variable with n degrees of freedom if \( z_1, z_2, \ldots, z_n \) are independent N(0,1) variables (80, p. 140),

\[ \chi^2_{n-1} = (n-1)S^2/\sigma^2 = SS/\sigma^2 \]

In testing two populations it follows from the above equation that,

\[ \chi^2_{n_1-1} = SS_1/\sigma_1^2 \quad \text{and} \quad \chi^2_{n_2-1} = SS_2/\sigma_2^2 \]

The variance-ratio is obtained by,

\[ F_{n_1-1, n_2-1} = \frac{S^2_1/\sigma_1^2}{S^2_2/\sigma_2^2} \]

Under the hypothesis of equal variance the right hand side of the above equation reduces to a ratio of sample variances and becomes a test statistic.

For testing the hypothesis of objective 3 of

\[ H_0: \sigma^2_o > \sigma^2_f \]

\[ H_a: \sigma^2_o < \sigma^2_f \]

under \( H_0, \) \( F_{n_1-1, n_2-1} = S^2_1/S^2_2 \)
so Ho is rejected if

$$\frac{F_{n_1-1, n_2-1}}{F_{n_1-1, n_2-1}} \geq \frac{1}{1-\alpha}$$

Tests for gross mean equality

Two population testing of random samples to compare $\mu_1$ and $\mu_2$ reveals the following:

$$\bar{X}_1 \sim N(\mu_1, \frac{\sigma_1^2}{n_1})$$

$$\bar{X}_2 \sim N(\mu_2, \frac{\sigma_2^2}{n_2})$$

$$\bar{X}_1 - \bar{X}_2 \sim N(\mu_1 - \mu_2, \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2})$$

where $n_1$ and $n_2$ are the respective sample sizes (80, p. 199).

Testing for equality of gross mean returns requires two tests. First, a test for the equality of means when the variances are unknown but estimated and equal. Secondly, a test for equality of means when the variances are unknown but estimated and unequal.

Testing when the variances are equal and estimated involves using a Student T test (because of the estimates) and using a pooled estimator. The pooled estimator, denoted as $S_p^2$ is:

$$S_p^2 = \frac{\text{Pooled } SS}{\text{Pooled df}} = \frac{SS_1 + SS_2}{(n_1-1) + (n_2-1)}$$

or in standard error form as,

$$S_{\bar{X}_1} = S_p / \sqrt{n_1}$$
\[
S_{x_2} = \frac{S_p}{\sqrt{n_2}}
\]
\[
S_{x_1, x_2} = \frac{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}{n_1 n_2}
\]

thus to test for
\[
H_0: \mu_{GR_0} \geq \mu_{GR_f}
\]
\[
H_a: \mu_{GR_0} < \mu_{GR_f}
\]

where \( H_0 \) is
\[
T_{n_1 + n_2 - 2} = \frac{\bar{x}_{x_1} - \bar{x}_{x_2}}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}
\]

When the variances are unequal, the Behrens–Fisher technique must be used. This formula is
\[
T^1 = \frac{\bar{x}_{x_1} - \bar{x}_{x_2} - (\mu_1 - \mu_2)}{\sqrt{S_1^2 + S_2^2}}
\]
\[
\frac{1}{n_1} + \frac{1}{n_2}
\]

To test for
\[
H_0: \mu_{GR_0} \geq \mu_{GR_f}
\]
\[
H_a: \mu_{GR_0} < \mu_{GR_f}
\]

where \( H_0 \)
\[
T^1 = \frac{\bar{x}_{x_1} - \bar{x}_{x_2}}{\sqrt{S_1^2 + S_2^2}}
\]
\[
\frac{1}{n_1} + \frac{1}{n_2}
\]
Ho is rejected if

$$|T^1| > t^1_{1-\alpha}$$

this requires, however, that $t^1$ be weighted means of the regular Student T points as defined by

$$t^1 = \left( \frac{W_1 t_{n_1-1} + W_2 t_{n_2-1}}{W_1 + W_2} \right) \left( \frac{W_1 + W_2}{n_1} \right)$$

$$W_i = \frac{s_i^2}{n_i} \text{ for } i = 1, 2$$

In making the tests of significance to test for equality of variances and mean gross returns, first the test for equality of variances was made. If Ho was rejected then the Behrens-Fisher test was used for gross mean return testing, otherwise the normal Student T test was used.

Testing for equality of variances and means with these tests implies independent populations. This assumption is not invalidated in testing between futures hedges and option hedges. These two populations are independent and the previously outlined tests are appropriate. Since these are the populations of major importance, the results and interpretations will rely heavily upon these test results. However, the other tests involving hedging strategy differences and option strategy differences may be biased statistically since these populations are not completely independent. For example, a test for equality of means and variance between a full hedge and a different hedging strategy (such as non-delivery months) carry at least some of the same price information
(data points) -- thus non-independence. The number of observations that are different between the full hedge and partial hedging strategies is large so the non-independence factor is relatively small. This does, however, place these tests on a lower reliability level compared to the major futures verses options tests. The tests are calculated and reported only as a guide and further interpretations should bear this in mind.
CHAPTER 6. RESULTS AND INTERPRETATIONS

Table 18 shows the mean gross returns and variances for futures hedges and the three option hedges (5 percent, 10 percent, and 15 percent). It also shows the tests of significance for variances (F values) and gross mean returns (t values). Figures 13, 14, 15, 16 and 17, show the graphical representation of variance and gross mean returns. For each futures strategy there are two option sub-strategies: 1) a naive option strategy where a put option is purchased but is always allowed to expire, 2) the option is exercised if a profit greater than exercise costs ($ .15/cwt.) can be realized. They will be referred to as the naive and rational strategies respectively.

Full Hedge Strategy

The variance of gross mean returns for a full futures hedge over 150 feeding periods is $59.26 per cwt. and the gross mean return is $34.19 per cwt. (Table 18). For the typical 10 percent option premium and the rational sub-strategy (2) the variance is $55.74 per cwt. and a gross mean return of $32.76 per cwt.

Although numerically the variance is lower for an option hedge, statistically the difference is not significant at the $\alpha = 10$ percent level. Therefore, a fail to reject Ho results. There is no evidence at the 10 percent level of significance that the variance of futures hedges is greater than a 10 percent option hedge.
Table 18. Tests of significance for futures hedges and option hedges for the complete feeding activity

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>Options</th>
<th>( \mu_{.05} )</th>
<th>( t^a )</th>
<th>( \mu_{.10} )</th>
<th>( t )</th>
<th>( \mu_{.15} )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Hedge ( \sigma_H^2 = 59.26 )</td>
<td>(1)</td>
<td>33.17</td>
<td>1.19</td>
<td>31.45</td>
<td>3.26</td>
<td>29.71</td>
<td>5.43</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>34.48</td>
<td>0.32</td>
<td>32.76</td>
<td>1.63</td>
<td>31.03</td>
<td>3.69</td>
</tr>
<tr>
<td>Non-Delivery ( \sigma_H^2 = 66.65 )</td>
<td>(1)</td>
<td>34.09</td>
<td>1.11</td>
<td>33.21</td>
<td>1.67</td>
<td>32.32</td>
<td>2.63</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>34.86</td>
<td>0.16</td>
<td>33.97</td>
<td>0.81</td>
<td>33.10</td>
<td>1.76</td>
</tr>
<tr>
<td>Delivery ( \sigma_H^2 = 54.74 )</td>
<td>(1)</td>
<td>34.11</td>
<td>0.45</td>
<td>33.27</td>
<td>1.43</td>
<td>32.42</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>34.65</td>
<td>0.22</td>
<td>33.80</td>
<td>0.80</td>
<td>32.96</td>
<td>1.78</td>
</tr>
<tr>
<td>$1.00 Basis ( \sigma_H^2 = 62.09 )</td>
<td></td>
<td>34.20</td>
<td>1.59</td>
<td>33.47</td>
<td>1.45</td>
<td>32.63</td>
<td>3.43</td>
</tr>
<tr>
<td></td>
<td>( \mu_H = 35.59 )</td>
<td></td>
<td>34.48</td>
<td>1.27</td>
<td>34.30</td>
<td>1.46</td>
<td>32.72</td>
</tr>
<tr>
<td>$1.50 Basis ( \sigma_H^2 = 62.15 )</td>
<td></td>
<td>34.32</td>
<td>1.40</td>
<td>33.69</td>
<td>2.15</td>
<td>32.95</td>
<td>3.01</td>
</tr>
<tr>
<td></td>
<td>( \mu_H = 35.54 )</td>
<td></td>
<td>35.23</td>
<td>0.35</td>
<td>34.60</td>
<td>1.07</td>
<td>33.87</td>
</tr>
<tr>
<td>Double ( \sigma_H^2 = 59.26 )</td>
<td></td>
<td>32.97</td>
<td>1.47</td>
<td>31.25</td>
<td>3.21</td>
<td>29.39</td>
<td>5.36</td>
</tr>
<tr>
<td>( \mu_{FH} = 34.19 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) to reject \( H_0 \) is \( |t_{n_1+n_2-2}| > t_{n_1+n_2-2}; 1-\alpha \) where \( t_{n_1+n_2-2} \) is \( t_{298} \) and the value in the table and \( t_{n_1+n_2-2}; 1-\alpha \) is \( t_{298.090} = 1.285 \) or \( t_{298.095} = 1.648 \).

\(^b\) to reject \( H_0 \) is \( F_{n_1-1,n_2-1} > F_{n_1-1,n_2-1}; 1-\alpha \) where \( F_{n_1-1,n_2-1} \) is \( F_{149,149} \) and the value in the table and \( F_{n_1-1,n_2-1}; 1-\alpha \) is \( F_{149,149.090} = 1.17 \) or \( F_{149,149.095} - 123 \).
<table>
<thead>
<tr>
<th>$\sigma^2_{0.05}$</th>
<th>$f^b$</th>
<th>$\sigma^2_{0.10}$</th>
<th>$F$</th>
<th>$\sigma^2_{0.15}$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.32</td>
<td>1.16</td>
<td>46.92</td>
<td>1.26</td>
<td>42.78</td>
<td>1.39</td>
</tr>
<tr>
<td>61.33</td>
<td>1.04</td>
<td>55.74</td>
<td>1.06</td>
<td>50.53</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54.63</td>
<td>1.22</td>
<td>54.98</td>
<td>1.21</td>
<td>57.06</td>
<td>1.17</td>
</tr>
<tr>
<td>59.91</td>
<td>1.11</td>
<td>58.24</td>
<td>1.14</td>
<td>58.26</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54.21</td>
<td>1.01</td>
<td>54.14</td>
<td>1.01</td>
<td>55.72</td>
<td>1.02</td>
</tr>
<tr>
<td>57.33</td>
<td>1.05</td>
<td>55.87</td>
<td>1.02</td>
<td>56.06</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51.89</td>
<td>1.20</td>
<td>49.99</td>
<td>1.24</td>
<td>49.89</td>
<td>1.24</td>
</tr>
<tr>
<td>52.00</td>
<td>1.19</td>
<td>54.58</td>
<td>1.14</td>
<td>49.70</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51.48</td>
<td>1.21</td>
<td>49.16</td>
<td>1.26</td>
<td>48.81</td>
<td>1.27</td>
</tr>
<tr>
<td>48.90</td>
<td>1.06</td>
<td>53.65</td>
<td>1.16</td>
<td>50.36</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44.63</td>
<td>1.33</td>
<td>66.28</td>
<td>1.12</td>
<td>60.87</td>
<td>1.03</td>
</tr>
</tbody>
</table>
Figure 13. Gross mean returns and variance for futures hedges under five strategies.
Figure 14. Gross mean returns and variance for option hedges under five strategies with a 5 percent premium
Figure 15. Gross mean returns and variance for option hedges under five strategies with a 10 percent premium.
Figure 16. Gross mean returns and variance for option hedges under five strategies with a 15 percent premium.
Figure 17. Gross mean returns and variance for futures and option hedges with 5, 10, and 15 percent premiums

- **F** = Futures Hedges
- **L** = 5% Option Hedges
- **M** = 10% Option Hedges
- **H** = 15% Option Hedges
- **D** = Double Option Hedges
- **1-5** = Various Hedging Strategies
There is no statistical difference between the two variances under an option hedge with a 10 percent premium compared to a full futures hedge but the option hedge does reduce gross mean returns. If the hedger followed the naive sub-strategy (1) then statistically both variance and mean gross return are less for the option hedge. The option hedge could reduce the variance of gross returns but the gross mean return is significantly less — $2.74 per cwt.

Under the 5 percent option premium a fail to reject Ho results for both variance and gross mean returns. There is no statistical evidence that a 5 percent option hedge produces a variance or gross mean return that is different from a futures hedge.

For the 15 percent option premium the result is just the opposite. Both the naive and rational option hedges show F and t values to reject Ho. There is evidence at the 10 percent level that the variance and gross mean returns are less for the option hedge than for the futures hedge.

Non-Delivery Month Strategy

When hedging was done only when the cattle were sold during a non-delivery month (January, March, May, July, September, and November), the futures hedge yielded a gross mean return of $34.71 per cwt. with a variance of $66.65 per cwt. The 10 percent rational option hedge had a gross mean return of $33.97 and a variance of $58.24. A fail to reject Ho for both gross mean return and variance results. There is no statistical evidence at the 10 percent significance level
that the option hedge produces a lower gross mean return or variance compared to the futures hedge — although numerically the option variance is $8.41 per cwt. less and the gross mean return is $.74 per cwt. less than the futures hedge.

The 5 percent rational option hedge leads to a fail to reject Ho for both variance and gross mean returns. Statistically, 5 percent hedges are not different from futures hedges. The naive option strategy, however, leads to a reject Ho for differences in variance but not for gross mean returns providing evidence that the variance is significantly less under a 5 percent option hedge than a futures hedge.

The 15 percent rational option shows the variance not to be statistically different from the futures hedge, but the gross mean return is lower at the 10 percent significance level. The naive option hedge leads to a reject Ho for both tests.

Delivery Months Strategy

This strategy which hedges cattle on feed only if the feeding period ends in a delivery month (February, April, June, August, October, and December), leads to a fail to reject Ho for all three option hedges (for both the native and rational sub-strategies) for tests on equality of variance. Thus, there is no evidence at the 10 percent level that the variance of the futures hedge is larger than the three option hedges. Numerically the differences are small. The futures hedge variance is $54.74 while the three rational options variances are $54.21, $54.14 and $55.72 respectively.
Tests for gross mean return differences leads to a fail to reject $H_0$ for both the 5 percent option and the 10 percent option. For the 15 percent option, however, $H_0$ is rejected. The futures hedge has a mean gross return of $34.49$ while the 5 percent option is $34.65$ and the 10 percent is $33.80$. The 15 percent rational option has a mean gross return of $32.96$. Evidence suggests that the gross mean return of the 15 percent option is less than the futures hedge. For the naive option $H_0$ is rejected for both the 10 percent and 15 percent option.

$1.00$ Basis Strategy

The variance of gross mean return for the futures hedge is $62.09$ per cwt. and for the rational 10 percent option $54.58$ per cwt. However, the test for significant difference yield a fail to reject -- no evidence at the 10 percent level of significance that the futures variance is greater than the option variance. All other variance tests including both naive and rational sub-strategies leads to a rejection of $H_0$.

The gross mean return for all option strategies and sub-strategies are statistically less than the futures hedge. $H_0$ is rejected on all tests for equality of gross mean returns. The mean gross return value for the futures hedge is $35.59$ and for the rational 10 percent option $34.30$.

$1.50$ Basis Strategy

Both the 5 percent option and 10 percent option hedge do not statistically have lower variances than the futures hedge. The 15
percent option does, however, produce a rejection of Ho. There is evidence at the 10 percent level that the 15 percent option variance is less than the futures variance. The naive sub-strategy rejects Ho for all three option strategies.

Gross mean returns for the 5 percent and 10 percent option are not statistically different from the futures hedge. The futures gross mean return is significantly larger than the 15 percent option at the 10 percent level of significance. The naive sub-strategy rejects Ho for all three option strategies.

In regard to Figures 13, 14, 15, 16, and 17, only the gross mean returns show any discernible pattern. Beginning with Figure 13 with the futures hedges and through figures 14, 15, and 16, with the 5 percent 10 percent and 15 percent options the pattern of gross mean returns is down or lower. This is more clearly seen in Figure 17 where all of the strategies are displayed together. The futures hedges have the highest gross mean returns and the 15 percent option the lowest with the 5 and 10 percent options in between. The variance pattern is not as obvious. The futures hedges and 5 percent option show higher variances than the 10 and 15 percent in Figure 17 but not for all strategies. A pattern for 10 and 15 percent option variances does not appear to exist.

Double Options

A comparison of a double option with a full futures hedge produces a fail to reject Ho for the 10 percent (really 20 percent since it is a double) and the 15 percent (30 percent) option hedges for test on
equality of variances. There is no statistical evidence at the 10 percent level of significance that the futures variance is smaller than the option variance. There is evidence at the 10 percent level that the variance for the 5 percent (10 percent) option is less than the futures variance since $H_0$ is rejected.

All three double option strategies have statistically lower gross mean returns than the futures hedge. Numerically the variance for a 10 percent (20 percent) double option is greater than the futures hedge ($66.28$ verses $59.26$) and the gross mean return is significantly lower ($31.25$ verses $34.19$). For a 15 percent option the numeric difference in variances is smaller ($60.87$ verses $59.26$) but the gross mean return is much lower ($29.39$ verses $34.19$).

Options Comparisons

Table 19 shows the $F$ and $t$ values for tests of significance in comparing the three option premiums and doubles with each other. Comparisons are made between the 5 percent and 10 percent, the 5 percent and 15 percent, and the 10 percent and 15 percent options. These tests are used to show if differences exist in variance and mean gross returns as the option premium increased and between doubles and regular options. With the exception of the double, the variance of the 5 percent and 15 percent option hedge was significantly different and this was only on the full hedge strategy and the $1.50$ basis strategy. In other words, only the increase from a 5 percent premium to a 15 percent premium caused a significant change in variance
<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>$\sigma^2_{.05} \text{ vs. } \sigma^2_{.10}$</th>
<th>$\sigma^2_{.05} \text{ vs. } \sigma^2_{.15}$</th>
<th>$\sigma^2_{.10} \text{ vs. } \sigma^2_{.15}$</th>
<th>$\mu_{.05} \text{ vs. } \mu_{.10}$</th>
<th>$\mu_{.05} \text{ vs. } \mu_{.15}$</th>
<th>$\mu_{.10} \text{ vs. } \mu_{.15}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Hedge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.09</td>
<td>1.20*</td>
<td>1.10</td>
<td>2.31*</td>
<td>4.37*</td>
<td>2.25*</td>
</tr>
<tr>
<td>(2)</td>
<td>1.10</td>
<td>1.21*</td>
<td>1.10</td>
<td>1.95*</td>
<td>4.00*</td>
<td>2.06*</td>
</tr>
<tr>
<td>Non-Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.01</td>
<td>1.04</td>
<td>1.04</td>
<td>1.03</td>
<td>2.05*</td>
<td>1.03</td>
</tr>
<tr>
<td>(2)</td>
<td>1.03</td>
<td>1.03</td>
<td>1.00</td>
<td>1.00</td>
<td>1.98*</td>
<td>.99</td>
</tr>
<tr>
<td>Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.00</td>
<td>1.03</td>
<td>1.03</td>
<td>.99</td>
<td>1.97*</td>
<td>.99</td>
</tr>
<tr>
<td>(2)</td>
<td>1.03</td>
<td>1.02</td>
<td>1.01</td>
<td>.98</td>
<td>1.94*</td>
<td>.97</td>
</tr>
<tr>
<td>$$1.00$ Basis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.04</td>
<td>1.04</td>
<td>1.00</td>
<td>.89</td>
<td>1.91*</td>
<td>1.03</td>
</tr>
<tr>
<td>(2)</td>
<td>1.05</td>
<td>1.05</td>
<td>1.10</td>
<td>.21</td>
<td>2.14*</td>
<td>1.89*</td>
</tr>
<tr>
<td>$$1.50$ Basis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.05</td>
<td>1.05</td>
<td>1.01</td>
<td>.77</td>
<td>1.68*</td>
<td>.92</td>
</tr>
<tr>
<td>(2)</td>
<td>1.10</td>
<td>1.17*</td>
<td>1.07</td>
<td>.73</td>
<td>1.59*</td>
<td>.88</td>
</tr>
<tr>
<td>Double</td>
<td>1.49*</td>
<td>1.36*</td>
<td>1.09</td>
<td>2.00*</td>
<td>4.27*</td>
<td>2.02*</td>
</tr>
</tbody>
</table>

*Significance at the 10 percent level or higher is represented by an * and therefore a rejection of Ho.
and this occurred only on the full hedge strategy and the $1.50 basis strategy. The double comparison leads to a reject Ho on both the 5 percent versus the 10 percent and the 5 percent versus the 15 percent, but not on the 10 percent versus the 15 percent option strategies.

Figure 18 points out the relationship of the numeric variance and the three option premiums. No clear relationship exists. Strategies I, II, III, and V show a reduction of variance as the option premium increases from 5 percent to 10 percent. Strategies I, II, and V show that declining relationship continues from the 10 percent to the 15 percent range. Strategy III, however, exhibits an increase in variance in the 10 percent to 15 percent range. Strategy IV and the double strategy reveal an increase in variance from the 5 to 10 percent range and a decrease from the 10 percent to 15 percent range.

Gross mean returns exhibit the greatest statistical differences between the 5 percent and 15 percent options. In fact, all strategies reveal a lower gross mean return for the 15 percent compared to the 5 percent. Only the double, full hedge and $1.00 basis strategy show any significant difference in the 5 percent versus the 10 percent or the 10 percent versus the 15 percent range.

Figure 19 indicates the relationship between gross mean returns and the various option premiums. All strategies produce a lower gross mean return as the option premium is increased. Strategy IV shows a smaller change in the gross mean return from the 5 percent to the 10 percent range than the other strategies.
Figure 18. Relationship between option strategies, variance of gross mean returns, and various hedging strategies.
Figure 19. Relationship between option strategies, gross mean returns, and various hedging strategies
The double option and full hedge strategy (I) lie considerably below the other strategies implying an overall lower gross mean return. The use of some strategy, therefore, can increase the numeric gross mean returns over a conventional full hedge or double.

Naive Versus Rational Option Sub-Strategies

The two option sub-strategies within each hedging strategy were tested to provide a basis for the idea of an option being "insurance," that is, purchasing a put option as insurance against a price decline. The naive strategy says that a put is purchased at the beginning of each period but never exercised. The cattle are sold on the cash market and the option was merely treated as price "insurance" and allowed to expire as most insurance policies are used.

The second sub-strategy, or rational strategy, treats the idea of an option as insurance, but allows for the put to be exercised when the transaction costs are less than the exercise profit. A test between the rational and naive strategy over the various hedging strategies can show whether the need existed to exercise the option when appropriate or to always just let it expire.

Table 20 points out the tests of significance for the two sub-strategies. Only the full hedge strategy reveals a reject Ho for both the variance and gross mean returns. There is evidence at the 10 percent level that the variance and gross mean returns are lower for the naive strategy than the rational strategy. The idea of purchasing the put option but never exercising it, therefore can be rejected as a
<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>$\sigma^2$</th>
<th>F</th>
<th>$\sigma^2$</th>
<th>F</th>
<th>$\sigma^2$</th>
<th>F</th>
<th>$\mu$</th>
<th>t</th>
<th>$\mu$</th>
<th>t</th>
<th>$\mu$</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.05</td>
<td></td>
<td>.10</td>
<td></td>
<td>.15</td>
<td></td>
<td>.05</td>
<td></td>
<td>.10</td>
<td></td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>Full Hedge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>51.32</td>
<td>1.20*</td>
<td>46.92</td>
<td>1.19*</td>
<td>42.78</td>
<td>1.19*</td>
<td>33.17</td>
<td>1.51*</td>
<td>31.45</td>
<td>1.58*</td>
<td>29.71</td>
<td>1.67*</td>
</tr>
<tr>
<td>(2)</td>
<td>61.33</td>
<td></td>
<td>55.74</td>
<td></td>
<td>50.53</td>
<td></td>
<td>34.48</td>
<td></td>
<td>32.76</td>
<td></td>
<td>31.03</td>
<td></td>
</tr>
<tr>
<td>Non-Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>54.63</td>
<td>1.10</td>
<td>54.98</td>
<td>1.06</td>
<td>57.04</td>
<td>1.02</td>
<td>34.09</td>
<td>.86</td>
<td>33.21</td>
<td>.88</td>
<td>32.32</td>
<td>.89</td>
</tr>
<tr>
<td>(2)</td>
<td>59.91</td>
<td></td>
<td>58.24</td>
<td></td>
<td>58.26</td>
<td></td>
<td>34.86</td>
<td></td>
<td>33.47</td>
<td></td>
<td>33.10</td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>54.21</td>
<td>1.06</td>
<td>54.14</td>
<td>1.03</td>
<td>55.72</td>
<td>1.01</td>
<td>34.11</td>
<td>.63</td>
<td>33.27</td>
<td>.62</td>
<td>32.42</td>
<td>.65</td>
</tr>
<tr>
<td>(2)</td>
<td>57.33</td>
<td></td>
<td>55.87</td>
<td></td>
<td>56.06</td>
<td></td>
<td>34.65</td>
<td></td>
<td>33.80</td>
<td></td>
<td>32.96</td>
<td></td>
</tr>
<tr>
<td>$1.00$ Basis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>51.89</td>
<td>1.01</td>
<td>49.99</td>
<td>1.09</td>
<td>49.89</td>
<td>1.00</td>
<td>34.20</td>
<td>.12</td>
<td>33.47</td>
<td>1.21</td>
<td>32.63</td>
<td>.11</td>
</tr>
<tr>
<td>(2)</td>
<td>52.00</td>
<td></td>
<td>54.58</td>
<td></td>
<td>49.70</td>
<td></td>
<td>34.30</td>
<td></td>
<td>34.48</td>
<td></td>
<td>32.72</td>
<td></td>
</tr>
<tr>
<td>$1.50$ Basis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>51.48</td>
<td>1.14</td>
<td>49.16</td>
<td>1.09</td>
<td>48.81</td>
<td>1.03</td>
<td>34.32</td>
<td>1.06</td>
<td>33.69</td>
<td>1.10</td>
<td>32.95</td>
<td>1.13</td>
</tr>
<tr>
<td>(2)</td>
<td>58.90</td>
<td></td>
<td>53.65</td>
<td></td>
<td>50.36</td>
<td></td>
<td>35.23</td>
<td></td>
<td>34.60</td>
<td></td>
<td>33.87</td>
<td></td>
</tr>
</tbody>
</table>

*Significance at the 10 percent level or lower is represented by an * and therefore a rejection of Ho.
rational strategy. All the other strategies yield a fail to reject Ho for both variance and gross mean returns; there is no statistical evidence that the variances or gross mean returns are different under either strategy.

In all cases, however, the numerical variances and gross mean returns are lower under the naive strategy.

Futures Hedges

Table 21 shows the tests of significance for the cash versus the various hedging strategies and some selected hedging strategies compared to others. Surprisingly, the futures hedges do not reveal any major differences in variance or gross mean return compared to the cash position.

The cash position gives a higher numeric gross mean return than the full hedge strategy, non-delivery month strategy, and the delivery month strategy. The $1.00 basis and $1.50 basis strategies have higher numeric values than the cash, but none of the tests yield a reject Ho.

Only the delivery month strategy has a lower numeric variance than the cash position, the rest are higher. The non-delivery month strategy is the only strategy that yields a reject Ho for variance. The idea that any hedging strategy will reduce variability is disproved by this analysis. Only certain strategies will result in lower variances.

In comparing various hedging strategies with each other, only the $1.00 and $1.50 basis strategies compared to the full hedge produces a
Table 21. Tests of significance between futures hedges and the cash position (complete feeding activity)

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>( \frac{F}{\sigma^2 = \sigma^2} )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash versus Full Hedge</td>
<td>1.06</td>
<td>.96</td>
</tr>
<tr>
<td>Cash versus Non-Delivery</td>
<td>1.19</td>
<td>.35</td>
</tr>
<tr>
<td>Cash versus Delivery</td>
<td>1.02</td>
<td>.63</td>
</tr>
<tr>
<td>Cash versus $1.00 Basis</td>
<td>1.11</td>
<td>.63</td>
</tr>
<tr>
<td>Cash versus $1.50 Basis</td>
<td>1.11</td>
<td>.60</td>
</tr>
<tr>
<td>Full Hedge versus Non-Delivery</td>
<td>1.12</td>
<td>.57</td>
</tr>
<tr>
<td>Full Hedge versus Delivery</td>
<td>1.08</td>
<td>.34</td>
</tr>
<tr>
<td>Full Hedge versus $1.00 Basis</td>
<td>1.05</td>
<td>1.56*</td>
</tr>
<tr>
<td>Full Hedge versus $1.50 Basis</td>
<td>1.05</td>
<td>1.50*</td>
</tr>
<tr>
<td>Non-Delivery versus Delivery</td>
<td>1.22*</td>
<td>.24</td>
</tr>
<tr>
<td>$1.00 Basis versus $1.50 Basis</td>
<td>1.01</td>
<td>.05</td>
</tr>
</tbody>
</table>

*Significance at the 10 percent level or lower is represented by an * and therefore a rejection of Ho.
reject Ho for equality of gross mean returns. These are also numerically higher than the full hedge. The use of these strategies can increase mean gross returns over the full hedge.

Variance differences were not statistically significant at the 10 percent level except for the non-delivery month strategy versus the delivery month strategy. These two variances differed numerically by almost $12 per cwt. ($66.65 per cwt. - $54.74 per cwt.).

Partial Feeding Activity

Table 22 exhibits the simulation results from using the strategy that enables the cattle feeder to decide not to feed cattle using each hedging strategy. The full hedge strategy, cash, and double option strategy are the same as the Complete Feeding Activity since they are used as benchmarks.

Table 23 shows the tests of significance for equality of variances and gross mean returns.

Non-delivery month strategy

All of the naive option strategies yield a reject Ho but only the 15 percent rational option rejects Ho for equality of variances ($48.68 versus $62.65). There is no evidence at the 10 percent level of significance that the 5 percent or 10 percent rational option hedges produces a variance that is smaller than the futures hedge.
Table 22. Simulation results for the partial feeding activity including futures hedges and option hedges with 5, 10, and 15 percent premiums

<table>
<thead>
<tr>
<th>n</th>
<th>Scenario</th>
<th>$\mu$</th>
<th>$\sigma^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\hat{\mu}_H$</td>
<td>$\hat{\mu}_{.05}$</td>
</tr>
<tr>
<td>150</td>
<td>Full Hedge</td>
<td>34.19</td>
<td>59.26</td>
</tr>
<tr>
<td>150</td>
<td>(1)</td>
<td>33.17</td>
<td>31.45</td>
</tr>
<tr>
<td>150</td>
<td>(2)</td>
<td>34.48</td>
<td>32.76</td>
</tr>
<tr>
<td>76</td>
<td>Non-Del. Months</td>
<td>34.55</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>(1)</td>
<td>33.07</td>
<td>31.33</td>
</tr>
<tr>
<td>76</td>
<td>(2)</td>
<td>34.59</td>
<td>32.85</td>
</tr>
<tr>
<td>74</td>
<td>Del. Months</td>
<td>34.13</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>(1)</td>
<td>33.28</td>
<td>31.57</td>
</tr>
<tr>
<td>74</td>
<td>(2)</td>
<td>34.37</td>
<td>32.65</td>
</tr>
<tr>
<td>61</td>
<td>$1.00 Basis</td>
<td>38.12</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>(1)</td>
<td>34.60</td>
<td>32.67</td>
</tr>
<tr>
<td>61</td>
<td>(2)</td>
<td>37.14</td>
<td>35.15</td>
</tr>
<tr>
<td>51</td>
<td>$1.50 Basis</td>
<td>38.64</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>(1)</td>
<td>35.41</td>
<td>33.41</td>
</tr>
<tr>
<td>51</td>
<td>(2)</td>
<td>38.09</td>
<td>36.09</td>
</tr>
<tr>
<td>150</td>
<td>Double</td>
<td>32.97</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>Cash</td>
<td>35.03</td>
<td></td>
</tr>
</tbody>
</table>
The naive option strategies reject Ho for gross mean returns and so do the 10 percent and 15 percent rational strategies. The 5 percent strategy produces a fail to reject Ho.

Numerically all but the 5 percent rational option have lower gross mean returns than the futures hedge. All of the option strategies have lower numeric variances than the futures hedge. The mean gross return for the futures hedge is $34.55 compared to $32.85 for the rational 10 percent option hedge.

**Delivery month strategy**

The numeric values of the variances of all the option strategies except the 5 percent rational option are less than the futures hedge. Only the 5 percent and 10 percent rational options have higher numeric variances than the futures hedges. The numeric variance for the futures hedge is $55.70 and the rational 10 percent option has a variance of $57.56. However, only the naive 10 percent option hedge has a statistically different variance from the futures hedge. The 10 percent and 15 percent option hedges lead to a reject Ho for equality of gross mean returns. There is statistical evidence at the 10 percent level of significance that the futures hedge has a higher gross mean return ($34.13) than the 10 percent option ($32.65).

**$1.00 basis strategy**

All numeric values for gross mean returns and variances for the option hedges are less than the futures hedge. The futures hedge has a gross mean return of $38.12 and a variance of $76.97 while the rational 10 percent option has a gross mean return of $35.15 and a variance of
Table 23. Tests of significance for futures hedges and option hedges for the partial feeding activity

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>$1.50 Basis</th>
<th>$1.00 Basis</th>
<th>$1.50 Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sigma^2$</td>
<td>$\sigma^2$</td>
<td>$\sigma^2$</td>
</tr>
<tr>
<td>Full Hedge</td>
<td>59.26</td>
<td>62.65</td>
<td>55.70</td>
</tr>
<tr>
<td>$\mu_H$</td>
<td>34.19</td>
<td>34.55</td>
<td>34.13</td>
</tr>
<tr>
<td>Non-Delivery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>76.97</td>
<td>98.26</td>
<td>59.26</td>
</tr>
<tr>
<td>$\mu_H$</td>
<td>38.12</td>
<td>38.64</td>
<td>34.19</td>
</tr>
<tr>
<td>$\mu_{.05}$</td>
<td>33.17</td>
<td>34.60</td>
<td>35.41</td>
</tr>
<tr>
<td>$\mu_{.10}$</td>
<td>31.45</td>
<td>32.67</td>
<td>33.41</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>3.26</td>
<td>5.73</td>
<td>5.13</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>29.71</td>
<td>30.74</td>
<td>31.42</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>5.43</td>
<td>7.91</td>
<td>7.20</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>32.97</td>
<td>31.25</td>
<td>29.39</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>1.19</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>1.29</td>
<td>1.29</td>
<td>1.29</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>3.69</td>
<td>3.69</td>
<td>3.69</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>4.21</td>
<td>5.06</td>
<td>4.21</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>2.78</td>
<td>4.42</td>
<td>2.78</td>
</tr>
<tr>
<td>$\mu_{.15}$</td>
<td>5.36</td>
<td>5.36</td>
<td>5.36</td>
</tr>
</tbody>
</table>

a to reject Ho is $|T_{n1+n2-2}| \geq t_{n1+n2-2}; 1-\alpha$ where $|T_{n1+n2-2}|$ is $T_{298}$ and the value in the above table and $t_{n1+n2-2}; 1-\alpha = t_{298;0.90} = 1.285$ or $t_{298;0.95} = 1.648$.

b to reject Ho is $F_{n1-1,n2-1} \geq F_{n1-1,n2-1}; 1-\alpha$ where $F_{n1-1,n2-1}$ is $F_{149,149}$ and the value in the above table and $F_{n1-1,n2-1}; 1-\alpha = F_{149,149;0.90} = 1.17$ or $F_{149,149;0.95} = 1.23$. 
<table>
<thead>
<tr>
<th>Options</th>
<th>$\sigma^2_{.05}$</th>
<th>$F^b$</th>
<th>$\sigma^2_{.10}$</th>
<th>$F$</th>
<th>$\sigma^2_{.15}$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>51.32</td>
<td>1.16</td>
<td>46.92</td>
<td>1.26</td>
<td>42.78</td>
<td>1.39</td>
</tr>
<tr>
<td></td>
<td>61.33</td>
<td>1.04</td>
<td>55.74</td>
<td>1.06</td>
<td>50.53</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>47.38</td>
<td>1.32</td>
<td>43.03</td>
<td>1.46</td>
<td>39.08</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>59.96</td>
<td>1.04</td>
<td>54.04</td>
<td>1.16</td>
<td>48.68</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>55.35</td>
<td>1.00</td>
<td>50.87</td>
<td>1.10</td>
<td>46.75</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>62.89</td>
<td>1.13</td>
<td>57.46</td>
<td>1.03</td>
<td>52.40</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>64.44</td>
<td>1.19</td>
<td>58.87</td>
<td>1.31</td>
<td>53.75</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>77.47</td>
<td>1.01</td>
<td>70.42</td>
<td>1.09</td>
<td>63.88</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td>62.77</td>
<td>1.57</td>
<td>57.48</td>
<td>1.71</td>
<td>52.63</td>
<td>1.87</td>
</tr>
<tr>
<td></td>
<td>74.03</td>
<td>1.33</td>
<td>67.39</td>
<td>1.46</td>
<td>61.20</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td>44.63</td>
<td>1.33</td>
<td>66.28</td>
<td>1.12</td>
<td>60.87</td>
<td>1.03</td>
</tr>
</tbody>
</table>
$70.42. Only the gross mean return for the 5 percent rational option, however, produces a fail to reject Ho. The other tests all reject Ho for both variance and gross mean returns.

There is statistical evidence at the 10 percent level of significance that most of the option hedges have lower variances and gross mean returns than the futures hedges.

$1.50 basis strategy

This strategy has a very high variance for the futures hedge ($98.26 per cwt.) and the highest gross mean return ($38.64 per cwt.). Consequently, all of the numeric values for the option hedges are lower. All but the rational 5 percent option for gross mean returns leads to a rejection of Ho.

There is considerable evidence at the 10 percent significance level that most option hedges produce lower gross mean returns and variances.

Complete Versus Partial Feeding Activities

The pattern of change between the numeric differences of the gross mean returns and variances of the complete and partial feeding activities is shown in Table 24 with the tests of significance shown in Table 25. All gross mean return differences increase as the option premium increases. The non-delivery and delivery strategies increase positively while the $1.00 basis and $1.50 basis strategy increase from a negative value to a positive or less negative value. Since the differences were calculated by subtracting the partial feeding activity from the complete feeding activity, the increase in the difference over the option premiums implies that the PFA gross mean return diminishes relative to the CFA.
Table 24. Numeric differences between the complete feeding activity and the partial feeding activity for gross mean returns and variances (CFA-PFA)

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>$\mu_H$</th>
<th>$\mu_{.05}$</th>
<th>$\mu_{.10}$</th>
<th>$\mu_{.15}$</th>
<th>$\sigma^2_H$</th>
<th>$\sigma^2_{.05}$</th>
<th>$\sigma^2_{.10}$</th>
<th>$\sigma^2_{.15}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Delivery</td>
<td>.16</td>
<td>1.02</td>
<td>1.88</td>
<td>2.73</td>
<td>7.25</td>
<td>11.85</td>
<td>17.98</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.27) 1.12</td>
<td>1.98</td>
<td>(.05) 4.20</td>
<td>9.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td>.36</td>
<td>(.83) 1.70</td>
<td>2.56</td>
<td>(-1.14) 3.27</td>
<td>8.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.28) 1.15</td>
<td>2.04</td>
<td>(-5.56) 1.59</td>
<td>3.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$1.00$ Basis</td>
<td>-2.53</td>
<td>-.40</td>
<td>.80</td>
<td>1.89</td>
<td>(-12.55) -8.88</td>
<td>-3.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-2.66) -.85</td>
<td>-.50</td>
<td>(-25.47) -15.84</td>
<td>-14.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$1.50$ Basis</td>
<td>-3.10</td>
<td>-1.09</td>
<td>.28</td>
<td>1.53</td>
<td>(-11.29) -8.32</td>
<td>-3.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-2.86) -1.49</td>
<td>-.22</td>
<td>(-15.13) -13.74</td>
<td>-10.84</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 25. Tests of significance between futures hedges for the complete feeding activity and the partial feeding activity

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>F</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Delivery versus non-delivery</td>
<td>1.06</td>
<td>.12</td>
</tr>
<tr>
<td>Delivery versus Delivery</td>
<td>1.02</td>
<td>.29</td>
</tr>
<tr>
<td>$1.00 Basis versus $1.00 Basis</td>
<td>1.24*</td>
<td>1.68*</td>
</tr>
<tr>
<td>$1.50 Basis versus $1.50 Basis</td>
<td>1.58*</td>
<td>1.75*</td>
</tr>
</tbody>
</table>

*Significance at the 10 percent level or lower is represented by an * and therefore a rejection of Ho.
The non-delivery and delivery strategies yield a higher mean gross return for the complete feeders activity versus the partial feeding activity. However, for the $1.00 and $1.50 basis strategies the mean gross return was higher for the partial feeding activity.

Variance difference patterns are similar to the gross mean return difference for the four strategies. As the option premium increases, the relative position of the partial feeding activity diminishes. The numeric variance is higher for the partial feeding activity for all strategies except the non-delivery strategy.

Table 25 shows the tests of significance between the complete and partial feeding activities. The test between the non-delivery futures strategies and delivery strategies produces a fail to reject Ho. There is no evidence that the complete feeding activity has a higher variance or gross mean return than the partial feeding activity for the non-delivery and delivery strategies. The numeric differences are small ($0.16 per cwt. and $0.36 per cwt. for gross mean returns and $4.00 per cwt. and $0.96 per cwt. for the variances) and support this test. The $1.00 basis and $1.50 basis strategies, however, lead to a rejection of Ho. There is evidence at the 10 percent level of significance that the gross mean returns and variances are different for these strategies. The gross mean returns are higher for the partial feeding activity ($2.53 per cwt. and $3.10 per cwt.) but so are the variances ($14.88 per cwt. and $36.11).
Table 26 exhibits the tests for the various option strategies. The option strategy results closely follow the futures results. For the non-delivery strategy, only the 15 percent rational option rejects Ho for both the gross mean return and variance test. Both the 10 percent and 15 percent naive options reject Ho. Tests for the delivery strategy indicate no rejection of Ho for equality of variances among the rational sub-strategies, and only the 15 percent option rejects Ho for gross mean returns.

The $1.00 basis and $1.50 basis tests reject Ho for variance equality over all these options. There is evidence that the partial feeding activity produces higher variances than the complete feeding activity. For gross mean returns, however, only the 5 percent option test produces a reject Ho. There is no statistical evidence that the 10 percent and 15 percent options are different among the feeding activities. A glance at the numeric values in Table 23 lends support to these statistical tests.

The tests for futures hedges and the cash position are shown in Table 27. The $1.00 and $1.50 basis strategies reject Ho for tests on the equality of both gross mean returns and variances. This was not the case on the complete feeding activity. Also, the full hedge versus the $1.00 and $1.50 basis strategy test rejects Ho. There is evidence at the 10 percent level of significance that the cash and full hedge positions have lower gross mean returns and lower variances than the
Table 26. Tests of significance between option strategies for the complete feeding activity and the partial feeding activity

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>$\sigma^2_{.05}$</th>
<th>$\sigma^2_{.10}$</th>
<th>$\sigma^2_{.15}$</th>
<th>$\mu_{.05}$</th>
<th>$\mu_{.10}$</th>
<th>$\mu_{.15}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Delivery versus Non-Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.15</td>
<td>1.28*</td>
<td>1.46*</td>
<td>.88</td>
<td>1.66*</td>
<td>2.43*</td>
</tr>
<tr>
<td>(2)</td>
<td>1.00</td>
<td>1.08</td>
<td>1.20*</td>
<td>.21</td>
<td>.92</td>
<td>1.66*</td>
</tr>
<tr>
<td>Delivery versus Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.02</td>
<td>1.06</td>
<td>1.19*</td>
<td>.68</td>
<td>1.43*</td>
<td>2.18*</td>
</tr>
<tr>
<td>(2)</td>
<td>1.10</td>
<td>1.03</td>
<td>1.07</td>
<td>.22</td>
<td>.93</td>
<td>1.69*</td>
</tr>
<tr>
<td>$1.00$ versus $1.00$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.24*</td>
<td>1.18*</td>
<td>1.08</td>
<td>.29</td>
<td>.60</td>
<td>1.45*</td>
</tr>
<tr>
<td>(2)</td>
<td>1.49*</td>
<td>1.29*</td>
<td>1.29*</td>
<td>1.83*</td>
<td>.59</td>
<td>.37</td>
</tr>
<tr>
<td>$1.50$ versus $1.50$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>1.22*</td>
<td>1.17*</td>
<td>1.08</td>
<td>.73</td>
<td>.19</td>
<td>1.08</td>
</tr>
<tr>
<td>(2)</td>
<td>1.26*</td>
<td>1.26*</td>
<td>1.22*</td>
<td>1.77*</td>
<td>.97</td>
<td>.15</td>
</tr>
</tbody>
</table>

*Significance at the 10 percent level or lower is represented by an * and therefore a rejection of Ho.
Table 27. Tests of significance between futures hedges and the cash position (partial feeding activity)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Hedging Strategy</th>
<th>F</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash versus Full Hedge</td>
<td>1.06</td>
<td>.96</td>
</tr>
<tr>
<td>Cash versus Non-Delivery</td>
<td>1.12</td>
<td>.94</td>
</tr>
<tr>
<td>Cash versus Delivery</td>
<td>1.00</td>
<td>.85</td>
</tr>
<tr>
<td>Cash versus $1.00 Basis</td>
<td>1.38*</td>
<td>2.42*</td>
</tr>
<tr>
<td>Cash versus $1.50 Basis</td>
<td>1.76*</td>
<td>2.87*</td>
</tr>
<tr>
<td>Full Hedge versus Non-Delivery</td>
<td>1.06</td>
<td>.33</td>
</tr>
<tr>
<td>Full Hedge versus Delivery</td>
<td>1.06</td>
<td>.06</td>
</tr>
<tr>
<td>Full Hedge versus $1.00 Basis</td>
<td>1.30*</td>
<td>3.05*</td>
</tr>
<tr>
<td>Full Hedge versus $1.50 Basis</td>
<td>1.66*</td>
<td>2.92*</td>
</tr>
<tr>
<td>Non-Delivery versus Delivery</td>
<td>1.12</td>
<td>.33</td>
</tr>
<tr>
<td>$1.00 Basis versus $1.50 Basis</td>
<td>1.28</td>
<td>.29</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Significance at the 10 percent level or lower is represented by an * and therefore a rejection of Ho.
$1.00 and $1.50 basis strategies. The complete feeding activity (Table 21) rejected Ho for only the gross mean returns but not for the test on equality of variances.
CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

Although several different variations were tested, the most important analysis centers around the futures hedges versus the option hedges and how the premium levels affect the option's viability. The other analyses concerning option sub-strategies, futures versus cash, and the complete feeding activity versus the Partial Feeding Activity were presented only for completeness. The principal test was simply, as stated in Objective 3, whether options can provide an alternative to traditional futures hedging.

Options as Hedges

Solid evidence exists both by raw numeric numbers and statistical tests at the 10 percent significance level that an option hedge will reduce gross mean returns compared to a futures hedge. This is true over all strategies and various option premiums. Over 50 percent of all the calculated gross mean returns for option hedges are statistically lower than the full futures hedge and all but three are numerically lower. The exceptions are the 5 percent option under a full hedge strategy, the non-delivery strategy, and the delivery strategy. The 5 percent option full hedge strategy yields a gross mean return of $34.48 per cwt. while the futures full hedge shows $34.19, or a $.29 per cwt. difference. This difference was not, however, statistically significant -- nor was the $.15 per cwt. difference for the non-delivery strategy statistically significant. A 5 percent option premium is an
unusually low premium and produces a higher gross mean return because futures hedging costs (margin costs and brokerage fees) account for more than the 5 percent premium. This option advantage quickly disappears as the option premium increases over 5 percent.

As the option premium increases, the gross mean return decreases. Certain strategies tend to slow the decrease in gross mean returns -- but not stop it. Therefore, while the use of options as hedges tends to reduce the gross mean returns when compared to futures, an option hedging strategy will somewhat offset this loss by slowing the rate of decrease. In other words, the use of hedging strategies can partially mitigate the lower gross mean returns for options versus futures.

The variance question is not as easily answered. Each strategy other than the full hedge produces conflicting results. Some variances increase and others decrease compared to a full futures hedge strategy without any apparent or explainable pattern. The full futures hedge strategy does, however, give some indication of the variance direction. This strategy is perhaps the best strategy to address the variance question since it serves as a hedging benchmark. Variance does decrease as gross mean returns decrease when the option premium increases. This is consistent with the theoretical development presented in Chapter 5. The reason the other strategies do not completely conform to the theoretical model is that they tend to accentuate the position of the cattle cycle. This is not so true for the non-delivery and delivery month strategies but it is very true for the $1.00 and $1.50 basis strategies. Each of these strategies were
activated only during periods of herd buildups and liquidations — when price variance was at a maximum. The delivery month strategy picked up the delivery month's erratic price behavior typically associated with non-storable commodities and the non-delivery month strategy the poor price representativeness of non-delivery activity. It is conceivable that storable commodities and non-cyclic commodities would more closely follow the theoretical aspects of price variance.

The natural question then becomes: Are option hedges 'superior' or 'worse' than futures hedges when both variance and gross mean returns are considered? This can partially be answered by Figure 20. If the cattle feeder is assumed to be risk averse, then he prefers higher returns only when the variance is less than or equal to some position. This position is typically the position he is used to; i.e. the last pen of cattle he sold. He will not accept lower returns with higher variances. Figure 20 divides the preferred and not preferred regions over all of the strategies using the full futures hedge as the comparison point. The ambiguous regions are points that cannot be called preferred or not preferred in the absence of a utility function for the feeder. Since no utility function exists these points remain ambiguous, nor can an efficiency frontier be generated since alternative levels of production were not considered. If the full futures hedge is accepted as the dividing plane, then the preferred and not preferred points become clear.

Only the 10 percent (20 percent) and 15 percent (30 percent) double options are in the not preferred region. Under no circumstances will
Figure 20. Gross mean returns and variance for futures and option hedges with 5, 10, and 15 percent premiums and preferred regions with the full futures hedge as the comparison point.
the feeder consider these options. They are clearly "worse" than any full futures hedge. In the preferred region are six possible points - F3, L3, L4, L5, M4 and M5. These are respectfully, delivery strategy for futures hedges, delivery strategy of the 5 percent option hedge, $1.00 basis strategy of the 5 percent option hedge, $1.50 basis strategy of the 5 percent option hedge, $1.00 basis strategy of the 10 percent option hedge, and the $1.50 basis strategy of the 10 percent option hedge. These points can be considered "superior" to the full futures hedge. Over eighty percent of the "superior" points are options; but sixty percent of these options are 5 percent options which are lower than normal premiums. The other two points are 10 percent options and therefore represent options that are more likely to occur. One of these two points is preferred even to the best futures strategy (F3-Delivery month) as illustrated in Figure 21. Using the best futures hedge as a comparison point moves the preferred, not preferred, and ambiguous regions such that more option hedges fall into the not preferred region than with a full hedge comparison point. However, the 10 percent $1.50 basis strategy for options remained in the preferred region. The answer to the questions of whether option hedges are "superior" or "worse" than futures hedges can be partially answered. Yes, they are "superior" but only when certain strategies are used. Yes, they can be "worse" when premiums for doubles are higher than 10 percent (20 percent). The remaining points are ambiguous until coupled with the feeder's utility function. With a utility function identified
Figure 21. Gross mean returns and variance for futures and option hedges with 5, 10, and 15 percent premiums and preferred regions with the best futures hedge strategy as the comparison point.
the preferred and not preferred areas will change as well as what constitutes "superior" strategies.

One observation and conclusion, however, can be clearly stated from this analysis: options as hedges for live beef cattle futures are not the high return - low risk instrument that much of the popular literature says they are. Nor are they, except for doubles, high risk - low return contracts that many opponents expose as reasons to keep options from being traded if they are used as part of a hedging program (33, 72, 73, 74, 88, 111).

Policy Recommendations

The next logical question is: Given the current ban on options, should options be allowed to be traded? This question has more ramifications than these analyses can completely address. The analyses presented here can, though, provide some realistic guides. Concerning options as a hedging mechanism, from an economic standpoint, given the assumptions of the simulation model, options can provide an alternative to traditional futures hedging. This argument suggests that options should be allowed to be traded -- at least on live beef cattle futures. The other issues that must be decided to develop an option market are those addressed in Chapter 4. These include: 1) 'strong' versus 'weak' options, 2) fixed versus variable striking prices, 3) options on futures versus options on actuals, and 4) exchange traded options versus dealer traded options.
The analyses of this thesis did not directly address any of these issues, but it indirectly addressed all four of them. First, the analysis shows that for options to be "superior" to full futures hedging they must be used in a hedging strategy. 'Weak' or non-retradable options severely limit the potential hedging strategies. By having 'strong' or retradable options (as the securities market does) an almost limitless set of hedging strategies can be incorporated. The potential for options to serve an even greater economic function can be increased by allowing 'strong' options.

Secondly, the analysis points out the sensitivity of gross mean returns and variance differences to the level of the option premiums. The level of the premium produces noticeable effects. Having fixed striking prices (like the securities market) increases the range of available option premiums. Out-of-the-money premiums will be lower than at-the-money or in-the-money premiums and could theoretically be lower than the 5 percent level. Conversely, in-the-money options' premium cost could exceed the 15 percent level. Having fixed instead of variable striking prices increases the economic viability of the options market by increasing the flexibility and potential kinds of strategies. Points (3) (options on futures) and (4) (exchange trading) do not get economic support from the analysis as do (1) and (2), however, they do have implications. The simulation model assumed options on futures and consequently the results tend to support the viability of these options. It does not support, nor refute, options on actuals. The issue
of exchange traded options or dealer traded options for this analysis was simply the need for uniform price reporting. The simulation model could have assumed dealer traded options by assuming that they reported uniform prices for the same kind of option.

This analysis suggests that the option market's economic function is not suspect as a hedging mechanism and therefore should be allowed to exist for a trial period once the structural problems have been adequately answered. Extensions from this analysis suggest the structural form should be: 'Strong' options should be used with 'fixed' striking prices. Options on futures will work as long as uniform prices are recorded either by exchanges or dealers.

Future Research

Additional option hedging research needs to be performed on storable commodities, fixed striking prices, 'strong' option strategies, the effects of option usage on futures market volume, the effects of decentralized trading by dealers on price and premium values, options on actuals, and the regulatory cost of implementing an options market. Proper answers to these questions could provide the CFTC with the necessary information to allow the systematic and orderly development of a pilot option market.
BIBLIOGRAPHY


