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A Theoretical and Empirical Analysis of the Usage Levels of Futures Contracts

by

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(ABSTRACT)

The use of futures contracts has grown enormously in recent years. From 1979 to 1985 the number of futures contracts traded literally doubled. Most of the growth can be attributed to the development of recent contract innovations. Trading in financial futures, alone, increased sixteen fold over this period. This remarkable rise in futures usage and the importance of innovation highlights the constant struggle by exchanges to develop and initiate successful contracts. However, there is no known process for actually identifying potentially successful contracts. It is this general question of what leads to a successful contract that forms the initiative behind this work.

Formally, this study is a theoretical and empirical analysis of futures usage. The purpose of the theoretical section is to develop a model of contract usage that leads to a set of testable hypotheses about the determinants of contract use. Usage is defined in this study as being measured by the number of contracts in existence at a certain time. The theoretical work is general in the sense that it is not directed at behavior in one specific contract; but rather, it rests on the belief that certain underlying fundamental economic factors will affect, in general, usage in all futures contracts. The theoretical model is based upon firm behavior in an uncertain world with the firm having the ability to enter a portfolio of futures contracts.

The purpose of the empirical section is to provide support for the theoretical section by determining, through time series analysis, which fundamental variables affect futures usage and how these effects are transmitted. The exogenous variables center upon the variance-covariance matrix of actual price series, transactions costs, and production levels.

The empirical results yield strong support for the theoretical section developed in this work and the overall portfolio approach. Additionally, the results draw into question the importance of several variables which have classically been considered essential in determining usage. While the results strongly support the model and the portfolio perspective, they did not suggest a specific set of variables that uniquely determine contract usage across a wide set of different contracts.

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Chapter I

Introduction

1.1 Background

This research began with a very basic question: why do certain futures contracts succeed and others fail? Simply, a futures contract is an agreement made today to buy or sell a certain commodity at some specified future time. The critical point being that a price is agreed upon today for a transaction that will occur in the future. Futures contracting is, though, a fairly restrictive form of forward contracting in that the commodity traded is limited and standardized and the trading itself occurs within, and according to the rules of, an exchange (see Working, 1953). The limitations on the trading actually serve to facilitate the use of futures (see Telser and Higinbotham, 1977) and, indeed, the use of futures contracts has grown enormously in recent years. From 1979 to 1985 the number of contracts traded has literally doubled. It is interesting to note that, while the total number of contracts traded has doubled, activity in the oldest and traditional mainstay of futures usage, the grains group, actually declined. Instead, the incredible futures growth can be explained by the rise of a recent innovation, the financial futures.

The growth in the usage of financials highlights the importance of successful innovations. As the number of financial futures traded increased sixteen fold from 1979 to 1985, the impact of their growth extends well beyond the increased earnings to the exchange members. Indeed, there is an impact on the entire economy for entirely new financial markets have opened up which vastly increase the set of opportunities available to economic agents. As Silber (1981) states, "development of new products has long been recognized as a key ingredient to improvements in economic welfare." Yet, despite the importance of successful innovation, the development and initiation of a futures contract has always been, and remains today, a highly uncertain venture for the initiating exchange. There is no known process for discovering and then initiating successful contracts. Estimates of contract failure range from 30% to 70%.

If there is an opportunity costs to missed successful contracts, there are certainly direct costs to an exchange for failed ones. Estimating the costs of contract failures is difficult, yet, at a minimum there are considerable costs to the exchange for the work of its research staff, member's time spent in committees, the expense of acquiring regulatory permission to introduce the contract, marketing and educational expenses, etc. This is why the initial question is so important. It is in an exchange's, and the overall economy's, interest to neither miss an opportunity nor waste resources initiating doomed contracts.

1.2 Purpose of the Study

Formally, this study is a theoretical and empirical analysis of futures usage. Futures usage is generally measured either by the volume of contracts traded or by the number of contracts in existence at a certain time. As the first step of this research project is to develop a mathematical model that describes economic agent's behavior in futures markets and the agent's behavior in the model corresponds closely to the latter definition of usage, this research will use the latter definition of success. Gray (1960) considers the number of contracts outstanding to best measure the "level of use that a market receives."

The definition, though, needs to be expanded a bit further. It is not clear what is meant by success or failure across time. Some contracts, upon introduction, never acquire much interest and are soon discontinued. This is clearly a case of a failed contract. Other contracts do quite well initially and then begin to die out. This, in a sense, is a failed contract; yet, at one point it was quite successful. To avoid this type of definitional problem, the question will not be considered from the perspective that the contract is either successful or failed, rather, as what is its level of usage at any point in time and what economic factors influence this usage at that time. Thus, this research extends the basic question beyond the innovation stage and asks the question about a contract at any point in time.

1.3 Overview of Literature Review

The earlier literature in this area centered upon the idea that there is a set of criteria that a commodity underlying a contract must meet in order for a contract to be successful. The criteria centered upon how well the commodity could be delivered in fulfillment of the forward contract. The emphasis changed as it was realized that futures contracts are not used foremost as delivery contracts; rather, the futures contract is generally entered into in order to capture the futures price change. As such, the set of criteria centered upon what features of a contract are needed to attract both hedgers and speculators to the contract. This work remained without theoretical or empirical support.

Along side this literature was growing a body of theoretical work that sought to describe firm behavior in an uncertain world. This literature did not particularly interest itself in trying to answer the questions that this research is interested in. The work did not explore the relationship between exogenous variables and the firm's decision to enter futures contracts. It does serve, though, as a basis for the theoretical work in this research.

In the past several years, a body of empirical work has developed in the area of contract success. This work is similar in terms of interest and general format as the empirical work in this research. However, the existing literature does not develop and then draw on a strong theoretical basis, and none of the works genuinely performs the empirical work in a portfolio framework.

1.4 Overview of the Theoretical Section

The theoretical work is general in the sense that it is not directed at behavior in one specific contract; but rather, it rests on the belief that certain economic theory pervades all futures contracts. So often, the existing literature considering this general question of contract success focuses on specific details of specific contracts as to why a contract does well or not. While the importance of this anecdotal approach is not questioned, this research shall remain as general as possible. In fact, the interest in generality is so strong, that becoming enmeshed in any contract-specific details is assiduously avoided throughout this research. Instead, theoretically, it is believed that there are certain underlying fundamental economic factors that will affect, in general, usage in futures contracts. The theoretical model allows for the development of testable hypotheses about the determinants of contract usage in futures markets. The empirical analysis will follow naturally from the theoretical portion and test the hypotheses developed there.

The theoretical section models the behavior of the two principal types of agents involved in futures contracting. The first type of agent is generally referred to as the producer or hedger. Although one needs to be careful in applying this term, the hedger is generally considered to be one who holds, or will hold, a position in a commodity that will be sold at a later time. This position in an actual commodity is often termed the 'spot' or 'cash' position. He is typically thought of as entering a futures market to reduce the price risk associated with holding his spot position prior to its sale on the spot market. The problem with this line of thinking is that hedgers do not always use futures markets to acquire risk reduction. They may enter the fu-

tures market and actually incur additional risk beyond the price risk associated with their spot position. For explanatory and descriptive purposes the key to distinguishing this participant will be the possession of an actual physical position in a commodity. The other agent is the speculator. Traditionally, he holds no actual spot position in a commodity; rather, he takes futures position in order to 'speculate' on changes in spot and futures prices. The speculator is traditionally considered to enter the futures markets willing to take additional risk if the compensation is sufficient.

The model considers these two types of agents acting within an economic framework with markets for two futures contracts that are closely related to each other and to a distinct commodity which is traded on a separate spot market. Two contracts are considered closely related if there is any degree of correlation between their price movements. Depending on the needs of the agent, he can enter either, neither, or both of the futures markets, and additionally may enter the spot market.

Each agent, as is typical in classical microeconomic models, faces perfectly competitive input and output markets. The agents choose their spot and futures positions so as to maximize their expected utility of profits. For each agent, his relevant profit function is described, and then the marginal changes in the agent's futures position as changes occur to the exogenous variables in the model are observed. From this are derived various testable hypotheses regarding futures contract usage.

1.5 Overview of the Empirical Section

The theoretical section provides a general framework for the empirical work in this dissertation. The empirical section follows the theoretical model in general form as closely as data and empirical constraints will permit. The purpose of this section is analogous to that of the theoretical model. The purpose is to determine, through time series analysis, which fundamental variables affect futures usage and how those effects are transmitted.

Futures usage, the dependent variable, is measured via 'open interest' statistics. Open interest statistics list the number of contracts entered into, and not yet liquidated or delivered upon, at the time the statistics are collected. The exogenous variables are those suggested by the theoretical model, and center upon the variance-covariance matrix, transactions costs, and production levels. The design of the empirical section is quite general and oriented toward determining the practical applicability of the theoretical section.

1.6 Overview of Empirical Results

The empirical results yield strong support for the theoretical section developed in this work and the overall portfolio approach. Additionally, the results draw into question the importance of several variables, such as spot variance and own- volume, which have classically been considered essential in determining contract usage. While there is strong indication that the fundamental question of what factors determine the

usage of a futures contract should be approached from the portfolio perspective, the results do not indicate a specific set of variables that uniquely determine contract usage. While these tests did not discern a specific, universal set of critical variables, the results are fairly strong and interesting.

Chapter II

Literature Review

2.1 *Introduction*

This chapter is a review of the body of literature surrounding the question of why futures contracts succeed or fail. This general question has been far from ignored in the literature and like so much of the existing work in finance and economics, the development of this literature evolves through stages of sophistication and rigor. The literature in this area can be divided into three main groups. The early work in the area consists primarily of describing the prevailing common thought among market participants and academics as to what leads to a successful contract. It lacked the theoretical and empirical backing that is traditionally associated with research in finance and economics today. Along side this literature, a body of theoretical literature was also developing that used mathematical economic models to describe futures usage. Finally, in the past several years some empirical testing has occurred.

It is important to understand that throughout most of the literature in this area, the underlying thrust has been in determining what traits, or characteristics, a contract,

or even the commodity underlying the contract, must have in order to succeed. Indeed, the existing empirical research has centered on the effect of these traits upon a contract's success. The suggested traits put forth have been fairly broad and have ranged from the storability of the commodity underlying the contract to the market position of the initiating exchange. As can be expected, through time, the characteristics considered have gotten broader and broader.

The existing literature has also used a general interpretation of what is meant by success. Subject to regulatory permission, it is an exchange's decision to initiate and maintain a contract. An exchange is formally a non-profit organization composed of its members. The members can vary from small floor traders trading for their own account to clearing members to large national brokerage houses trading for customers (see Silber, 1981). Thus, a successful contract may be defined in terms of maximizing an exchange members' group utility function. For the obvious reasons of tractability, the idea of a group utility function has rarely been considered. From observing the innovation process of various exchanges, it can be recognized that member income is a direct function of contract usage. Therefore, usage level is generally used as a simple proxy of a contract's success (see Sandor, 1973). Support for this measure comes from the observation that contracts with strong levels of use are never voluntarily discontinued by an exchange.

2.2 Early Work

The main body of literature that has been labeled the 'early work' begins in the 1950s and early 1960s. This stage of the literature can be divided into two parts. Black (1986) labels these two stages as the "commodity characteristics approach" and the "contract characteristics approach". Both stages, though, can be described as descriptive and anecdotal in the sense that the work is generally an expression of prevailing opinion without theoretical or empirical support.

2.2.1 First Stage

The first stage placed an emphasis on the idea that, for a contract to succeed, the commodity underlying it had to meet a set of criterion. (see Kohls, 1985). In other words, exchanges sought to develop contracts based on commodities with the appropriate characteristics. The emphasis on the commodity stemmed mainly from the idea that the futures contract serves not only for forward pricing purposes but also as a delivery mechanism. The following list of commodity characteristics generally considered essential for contract success reflects this emphasis.

1. Variability, or uncertainty, in the commodity price - Perhaps the most prominent characteristic cited as essential for a successful contract is price variability. Simply, a hedger has little incentive to hedge his spot position if there is minimal price risk, and speculators have no profit opportunities in stable prices.

2. **Fungible product and capable of being easily graded and measured** - One of the critical features that reduces the transaction costs of a futures contract is that the participants enter a contract without knowing who is on the other side of the agreement. Thus, as there is no specific bargaining, other than price, the standard futures contract must make it quite clear as to what is being delivered. An agreed upon standard must exist. For this to work in practical operation, one unit that satisfies a contract must be the same as another acceptable unit. To have a broad appeal, the limits placed on what may be delivered cannot be too restrictive and the cost of the actual grading cannot be prohibitively high. Diamonds are a classic example of a commodity lacking these characteristics. First, with their many and varying traits they are quite non-homogenous, and attempting to grade and value a diamond is subjective and expensive.
3. **Viable cash market** - A large and efficient cash market, where trades can be quickly and cheaply made, is considered necessary to keep the delivery mechanism of the contract working smoothly.
4. **Competitively determined prices** - The fear of anything less than a competitive market is that prices can be too easily manipulated. Manipulation can be by individuals and cartels, such as the Hunt's silver run in the late 1970s, or by governments through price supports or holding huge inventories of commodities. Futures use either diminishes through fear of prices being controlled to the detriment of traders or through lack of need because, say, price supports remove price fluctuations.
5. **Commodity must be non-perishable** - The origins of futures markets can be found in the economic role of smoothing out the disparities between production and

consumption. Holders of inventories use futures markets to guide their decisions and hedge their product. Logically, if the product cannot be stored over time, then a futures market is not needed.

6. Low Delivery Costs - Low delivery costs were considered essential in delivery on contract and for convergence of cash and futures price.

2.2.2 Second Stage

The success of contracts on commodities which lacked these essential traits, such as cattle, frozen pork bellies, plywood, and live hogs, contradicted the early focus of the literature. Indeed, the success of contracts with no delivery at all, such as the stock market index futures, suggests that the desire to use the contract as a delivery mechanism is not paramount. The attitude towards futures as a delivery mechanism changed as a recognition of patterns in trading data reveal that very, very few of the contracts entered into are actually delivered upon. Instead, it was assumed that the contract's settlement would occur almost entirely via a reversing trade or by paying the difference in cash, and not by delivery. As opposed to trading in the actual good, the futures contract was more thought of as trading in the right, or title, to the good. In a sense, the trader is capturing for better or worse, the price change of the underlying commodity, although his interest need not be in actually acquiring or delivering the traded commodity itself and not the commodity.

Given that there did not exist a set of commodity characteristics that would indicate a contract's success, the emphasis shifted toward the "underlying economics that predisposes a contract toward success or failure" (see Silber, 1981). The interest

turned toward the question of whether attracting a certain type of participant was essential for a contract's success. If so, the next question was how to develop contracts that indeed attracted these traders.

In regard to the first question, Working (1953) considers the attraction of hedgers to be the dominant force behind a contract's success. In consideration of the accumulated "statistics", he views hedging as the "driver, and speculating like a companion going where hedging gives it an opportunity to go." Gray (1960), on the other hand, likens a contract's use to the use of a trail in the forest. Perhaps the new trail may offer a may more direct route; yet, its lack of use makes it more difficult to travel. Gray's concern, though, is that it is easier to travel in one direction than the other. That is, the new contract is easier for one type of trader to use than another. Gray observed a price bias in thin markets that does not exist in heavily used markets. The bias Gray observed was a tendency for futures prices to rise over time while the spot price remained basically the same. This raises the cost for agents on one end of the contract and is a hindrance to contract development. Gray blames this on the dominance of one type of trader, generally the hedger, on one side of the market. Gray, thus, attributes contract failure to a failure to attract speculators. The lopsidedness of the market leads to the contract's failure.

Working, however, also considers the speculators' attraction critical to a contract's success in order to avoid the "bivalence" of market price. That is, speculator's capital is required to lower the cost of hedging by minimizing the bid-ask spread. Yet, Gray also considers hedging as the fundamental reason for a contract's success. He argues that futures contracts grow only out of hedging needs.

Logically, then, a contract will do well if it serves a hedging purpose and attracts sufficient speculative capital. With the need to attract both types of traders to the market the traditional list was somewhat redefined. The 'list' became much less restrictive as no commodity lay out of bounds due to its physical properties. For a contract to attract the hedger, price variability remained essential. In addition, contracts needed to be developed such that there was a fair amount of homogeneity of the price movements (see Carlton, 1984). That is, prices between spot and futures had to be well correlated in order to provide effective hedging. Price homogeneity also implied that the futures and spot price were well correlated with different grades of the commodity and different locations of the commodity in order to attract even more hedging activity. In developing a contract, consideration also had to be given to the economic organization of the potential hedgers. Questions arose regarding the total potential hedging volume and how large is the average size of the hedger, whether or not they were specialists in the commodity and thus had a big stake in price movements, and the degree of vertical integration in the sense that a producer and supplier in one unit eliminates the need for hedging (see Gray, 1972).

Another element is the presence of failed forward contracting. Telser and Higinbotham develop a theory that futures contracting may evolve over forward contracting due to its cost-minimizing structure. What they do not develop is a theory of why hedgers forward contract in the first place. However, if it is observed that there is interest in forward contracting and that it had broken down, then a futures contract provides a potential alternative. Finally, it was recognized that in developing a contract with an existing competitor, the liquidity advantage of the existing contract creates a barrier to entry for the new contract (see Silber, 1981). An existing competitor for an innovation is either a contract based on the same commodity as the

innovation and traded on a different exchange, or a contract based on a very similar commodity that is traded on either the same or a different market. Interestingly, the liquidity factor is the argument often given for why there are not more varieties of contracts. Ideally, hedging needs would be better met if more contracts existed on different varieties and grades of commodities; however, the greater number of markets would mean thinner markets and higher transaction costs through less liquidity. This liquidity versus improved hedging theme was important throughout the literature.

Attracting speculator participation still centered on the need for price variability and a competitively determined price. Silber (1981) adds the need to write the contract such that it is not biased against the speculator and thus has a broad appeal. Additionally, he places emphasis on the need for the exchange to properly market its futures contracts in order to draw the needed participants.

In sum, the literature in this section shifted from a delivery-oriented approach to the recognition that delivery was not important; rather, a successful contract relied upon attracting both types of participants to the contract. With this transition, the list of traits needed for a successful contract also changed. In the end, there was a much stronger emphasis on developing contracts that would draw participants.

2.3 *Mathematical Modeling of Futures Positions*

As the literature on contracting success was developing, so was the development of mathematical models of futures use. This literature was a general response to the natural question of why agents take particular positions in futures contracts. The earlier work (see Hieronymus, 1977) simply assumed that hedgers took equal and opposite futures positions to their spot positions. Thus, they eliminated the greatest amount of risk. If one considers a futures contract to be a financial asset, then this view was clearly at odds with the growing study of asset selection in a risky world. Indeed, a body of literature grew out of considering the futures position question within the asset selection in a risky world framework. The work in this area forms the basis for the model in this research.

2.3.1 Stein

One of the earliest pieces, by Stein (1961), presents a graphical representation of the hedger's allocation between hedged and unhedged holdings of stock. His work, although early and confined principally to graphical analysis, presents what became the standard single-time period framework for observing this problem. Stein recognizes that producers or holders of a commodity can hold their stocks either hedged, unhedged, or anywhere in between. Different amounts of risk and expected return correspond to their chosen position. Thus, individuals will allocate their hedged and unhedged holding to maximize their expected utility.

In analyzing the hedger's decision, he first defines the hedger's profit function. The general form is the unhedged position multiplied by the spot price, which is a random variable at the beginning of the period when the decision to hedge is made, plus the hedged position multiplied by the gain or loss in the futures price. Transaction costs and/or carrying costs are then subtracted off. As mentioned, the profit function is uncertain as two of the variables in his model are random. The first is the eventual spot price at which the spot commodity will be sold. The other is the eventual futures price at which the agent will reverse his transaction. Many similar pieces in this area assume that spot and futures price converge. If so, then there is no risk to the hedged portion of the spot commodity as the gain or loss on the spot position is exactly compensated for in the futures position. Stein's treating both variables as random does not really affect the analysis as long as one assumes that different levels of risk and return accrue to hedged and unhedged stocks.

Stein recognizes that while risk can be reduced if more hedging occurs, it may not be optimal for the agent to want to reduce as much risk as possible. Stein considers the optimal amount of futures contracting using Tobin's theory of liquidity preference. The analysis then becomes one of straight forward utility maximization in a mean-variance world. Following Tobin, Stein uses the standard deviation of profits as a measure of risk and constructs a risk-return opportunity locus. He notes that there is no reason that the risk-return trade-off is, as traditionally assumed, positive. If it is not, then certainly all stocks would be hedged. In any event, the constructed opportunity set combined with the agent's expected utility function produces the optimal futures position.

2.3.2 Anderson and Danthine

Anderson and Danthine (1981) extend Stein's work in developing a theoretical model that is broader in mathematical rigor, class of agents, and types of contracts considered. Like Stein, their intent is to develop a "systematic account" of optimal futures use. In a sense, the form of their analysis is similar to Stein's; however, through their extensions they capture much more of the analysis facing futures traders.

Their work keys on the recognition of two main elements. First, perfect hedges generally assumed in the literature do not exist. That is, a futures market on the very commodity that a hedger is trying to hedge rarely exists. Rather, the typical hedge is placed via a cross-hedge where the agent enters futures contracts on commodities similar to his own. The agent hedging his spot commodity; therefore, cannot obtain a perfect hedge. How well he can hedge is a function of how closely the prices of related futures contracts move with the price of his spot position. Second, Anderson and Danthine allow for the fact that futures markets participants generally face a set of related contracts, and certainly a whole broad range of even non-related contracts, to enter. The futures decision, then, can be viewed from a portfolio perspective.

The analysis is similar with an agent holding a spot position in a commodity. They assume the "existence and availability of n different futures contracts differentiated by delivery month; delivery location; and type, quality and amount of good delivered, but all being traded at the two dates relevant to the agent's plan." The eventual prices are unknown; however, the agent does perceive the expected prices, the variance of the prices, and the set of covariances between the prices. Again, a profit function is built based on the spot position and the vectors of futures prices and po-

sitions. Their model is fairly general and allows for long and short hedgers via the signs of the initial futures positions, and speculators can be considered by assuming that they have no cash position. Again, the mean and variance of the profits are critically important as they use a general utility function restricted to mean and variance. Agents choose the best available portfolio that maximizes a linear function of mean and return. The input being the vector of expected returns and the covariance matrix.

The general result that they arrive at is that hedgers will not, as a rule, choose the risk minimizing position. Instead, their position decision is like any modern portfolio decision. As opposed to entering just one contract, they will enter a "multiplicity" of contracts to take advantage of the gains to portfolio forming. They note, though, that either transaction costs or indivisibilities in contract size may limit the number of contracts the trader enters. Finally, the production decision of the trader is determined by his total position in the futures market and the expected future prices.

The general structure in which Anderson and Danthine consider futures usage is very similar to the underlying structure developed in this research. Both place an emphasis on the idea that agents' futures decisions are the result of optimal decision making in a portfolio setting. Their method and their results are, though, really quite different from those in this research. They use vector analysis and are interested primarily in fairly broad results. This work is interested in developing comparative static results that help tie together the various relationships between the variables and, in particular, lead to statements regarding how certain variables affect futures usage. These statements then lead to an empirical analysis.

Anderson and Danthine (1983) extends this work to a multiple period model of hedging where agents can alter their futures position within the period they are holding the cash position. Marcus and Modest (1984) include uncertainty in production along with the traditional uncertainty in price. Their work is oriented mainly toward the production decision and does not alter any of the futures results which are the concern of this research.

2.4 Empirical

2.4.1 Introduction

The empirical work, like that in this dissertation, is performed with an eye toward suggesting what variables seem important in determining a successful contract. While the empirical work in this dissertation stems directly from the theoretical work, the empirical work to date, with a few exceptions, draws only nominally on existing theoretical work or even the theoretical structure developed within these papers. Rather, the work draws more heavily on the recent descriptive literature outlined earlier in this review. The genesis of most of the empirical work seems to be the early 1980's. The studies essentially view the relationship between contract usage, either volume or open interest, and specific features of the contract. As the work stems mainly from the earlier descriptive literature, there is a strong emphasis on the role of the underlying contract spot variability and the relationship between better

hedging ability of a new contract and the existing liquidity advantage of an existing contract.

2.4.2 Cornell

Bradford Cornell's (1981) study centers on both of these ideas. He hypothesizes that uncertainty motivates futures market use, while recognizing that an innovation's success is also dependent on existing related contracts. That is, high variability of the underlying spot commodity is not alone sufficient to warrant the success of an innovation if an existing contract, with a liquidity advantage, is already hedging that spot well enough. The thrust of his empirical section is, though, on the effect of changes in the underlying spot variability upon contract volume. Specifically, he regresses the average daily log price relative for a two month period on the two-month average daily volume. Using time series analysis on different types of contracts, his results show a consistently significant positive relationship between volume and price variability. The coefficient of determination on his regressions run from 10.2% to 70%, with most below 30%. Additionally, he finds the relationship to be relatively contemporaneous as leading and lagging coefficients strongly tended towards insignificance.

The implication of the strong correlation between price variability and trading volume is that contracts should be written on commodities with high price variability. However, this is not clear with an existing, established, related contract. Cornell considers the case of the 1977 introduction of the 90-day Commercial Paper contract in the face of competition from the existing 90-day T-bill contract which was well established

and certainly a very close competitor. Cornell maintains that the newer entry could survive if there were hedging or speculating opportunities based on the spread between the 90-day Commercial Paper rate and the 90-day T-bill rate. He found that the two rates were too highly correlated with little variability in the spread between the rates and thus little interest in the contract.

2.4.3 Fieleke

In a study of foreign currency futures, Fieleke (1985) follows a similar route in considering the underlying variance to be critical to contract use; however, he notes that while the direction of the effect is clear on the hedger, the effect upon the speculator is not clear as increased variance decreases their ability to forecast prices. Fieleke uses the contract's average open interest for the month as the dependent variable. In addition to variance of the exchange rate, he also uses U.S. imports during the month and the total contract volume for the month as independent variables. U.S. imports serves as a measure of the underlying hedging needs, and it is believed that as imports increase so too will open interest. Contract volume serves as a measure of the spread of knowledge about the futures market, and higher volume lowers the cost of entering contracts by decreasing the price bivalence. Open interest should be positively associated with volume. In a time series analysis of five different foreign currency contracts, the coefficient on volume and imports are of the correct sign and significant. Contrary to Cornell's result, though, the coefficient on the spot variance changes signs and is often insignificant. One should note that Fieleke did not test speculators and hedgers separately and thus the variance effect could be confounded.

2.4.4 Rutledge

Several other papers exist that are more complete in regard to theoretical model formulation and expansion of the variables considered. Rutledge (1972) incorporates into his work the existing literature that treats futures decisions in a risky portfolio framework. Working with the soybean complex, the theoretical arguments lead to the hypothesis that the levels of hedged and unhedged stocks held are a function of the mean vector of expected cash prices and basis changes, and the variance-covariance matrix of expected cash prices and basis changes. The basis is defined as the cash price minus the futures price.

Specifically, Rutledge tests, through time-series analysis, the ratio of hedged stocks to unhedged stocks as a function of the mean cash prices and basis, the variance of the cash price and basis, and the correlation between the cash price and the variance. The variables are computed for each season, which runs from Oct. 15 to June 30, based on semi-monthly cash and futures quotations. Tests are run for the soybean, soybean oil and soybean meal contracts for the seasons running from 1955-1967. He uses the lagged dependent variable as an independent variable to allow for portfolio adjustment over time.

The results indicate that an increase in anticipated basis variability, or a decrease in anticipated cash price variability will lead to a decrease in hedging. The first result is logical in that if the ability to hedge, as measured by the basis variability, de-

creases, then open interest should decline. It is interesting to note, though, that despite invoking portfolio oriented theoretics, the empirical section was limited to a single asset at a time.

2.4.5 Behr and Ward

Behr and Ward (1982) performed certainly the most complete analysis of contract usage in terms of the number of explanatory variables considered. The empirical section is based on a theoretical model of traders maximizing the net benefit of a contract's use. While the net benefits are not actually observable, their structure serves as a vehicle to consider futures market activity.

Behr and Ward use both volume and open interest statistics as their dependent variables. Recognizing that a unique, although not mutually exclusive, set of exogenous variables will affect each trader, they represent the speculator's and the hedger's demand in separate equations. Specifically, Behr and Ward develop a simultaneous model seeking to explain cross-sectional differences in hedging, speculation, and volume. The link between the theoretical model and the development of the empirical model, particularly the selection of independent variables, is tenuous; rather, the independent variables seem to be drawn from those attributes considered important in the earlier descriptive literature.

The hedger's open interest is a function of price risk, futures performance, industry concentration, firm numbers, government support, market maturity, and product perishability. Price risk and futures performance (basis risk) have been seen in pre-

vious studies. Industry concentration is a measure of how competitive the market is, and firm numbers is a measure of the number of possible market participants. The remaining variables have all been cited in the literature as affecting participation.

The speculator's position is a function of price risk, product perishability, market maturity, opportunity cost, and spreading opportunities. Opportunity cost is measured via interest rates and measures the opportunity cost of speculative capital used in futures markets. Spreading opportunities measure the opportunities of speculators to use other contracts in the strategies.

Volume is determined via product perishability, number of exchange pits, spreading opportunities, exchange ranking, and time adjustment. The time adjustment reflects that the markets are more accessible to users now; thus, for given levels of speculation and hedging, more volume is expected.

The theoretical model indicates that the hedging, speculative, and volume activities are related and, thus, represent a simultaneous system. The short and long positions are added together to get the aggregate hedger's and speculator's positions as the reasons for either speculating or hedging are similar whether one is going long or short. Their estimations were run, using annual data in 16 cross-sections, with a modified three-stage least square estimate with a cross-sectional error component. The periods run from 1961 to 1978.

For hedgers, there is a small decline in usage as the basis risk increases, and the impact of price variability is small over wide ranges in variability. As would be expected, price supports inhibit usage, and industry concentration is more important

than the number of firms. Speculation increases with price risk and market liquidity, and declines as interest rates rise. Volume is positively associated with exchange ranking, time, and spreading opportunities. Finally, hedging and speculation increase as liquidity increases and hedging affects volume; however, curiously, there is no significant relation between volume and speculation.

2.4.6 Anderson and Danthine

The contribution to this broad area by these two authors has primarily been theoretical. However, in Anderson and Danthine (1980), they undertake a preliminary study of optimal futures positions using a portfolio framework. While this paper is not concerned with contract usage, their portfolio approach to an empirical question is fairly unique, and of interest to this study.

The authors essentially ask how the optimal futures position is altered given the ability to cross-hedge. While their study should be described as preliminary, their work takes actual prices, assumes some level of risk and a hypothetical spot position and considers the optimal futures positions. They note that it differs from the standard single-contract hedge. Despite its flaws, this work is significant for the authors actually estimate a variance-covariance matrix from real prices and treat the optimal position as depending on this estimation. As is typical of the other work by Anderson and Danthine, the empirical research in this study is guided by a very similar underlying structure to that used here by Anderson and Danthine. While their results are modest and their interest and overall approach is quite different from this work, it is comforting to see that these authors use the same fundamental empirical foundation.

2.4.7 Black

A study by Black(1986) is very well done; yet, is confined to the introduction of new contracts. It is a direct analysis of the classical problem of the hedger's need to balance the improved hedging ability of a new contract to the increased liquidity costs of the innovation. A new contract may provide a better hedge than an existing contract; however, the existing contract may have such a price advantage from higher liquidity that there is no net incentive for the hedger to enter the new contract. The new contract will succeed if the benefits of risk reduction exceed the costs of less liquidity.

Black, for empirical purposes, considers the volume of an innovation to be a function of how well the existing cross-hedge contracts serve the hedgers of the underlying spot commodity of the contract being introduced and of the liquidity of the existing cross-hedges. Black recognizes that other explanatory variables exist. A new contract needs sufficient price volatility and a good-sized cash market. She expects that the variables will "interact in their influence on volume." That is, the partial derivatives of each variable are a function of the levels of the other variables. Hence, her tests use a log-log model.

Empirically, for each commodity underlying a futures innovation, the best cross-hedge is identified. Hedging effectiveness is measured by the coefficient of determination resulting from regressing the cash price on the futures price. Having found

the best cross-hedge for the commodity underlying an innovation, a relative risk residual is formed that measures how much better the new contract hedges that commodity than the best existing cross-hedge. She then uses a cross-sectional model, formed from the set of recent financial-contract innovations, of average daily volume of trading as a function of this relative residual risk, liquidity of the cross-hedge, cash price volatility, and cash market size. Despite the inclusion of speculators in her volume statistic, who are not motivated by the cross-hedging features, her results are quite strong. They indicate that the relative risk residual, price volatility, and market size are the primary explanatory variables. The equation had a coefficient of determination of .85.

2.5 Summary

The extent of the literature in this area reflects the strong interest that exists in examining the question of what leads to a successful contract. The existing body of theoretical work on futures usage provides a strong basis on which to build the theoretical work in this research. The existing literature, however, is not strongly oriented toward developing the relationship between contract/market features and contract success. The goal of this project is to develop a theoretical model of contract usage and to link the theory to an empirical examination of the effect of exogenous variables upon contract usage.

A strong link between the theory and empirical analysis is ostensibly the goal of the theoretical work developed in the extant empirical pieces; however, typically these

works lack a strong connection from their developed theory to their empirical tests. Perhaps more important, though, is the general failure of those empirical works to truly frame their tests in a portfolio setting. Thus, on a purely empirical basis, the tests performed in this research are unique for their emphasis upon a portfolio framework.

Chapter III

Theory

3.1 Introduction

The purpose of this chapter is to develop the theoretical section of this dissertation. Much of the initial impetus behind this research was the recognition that most of the existing literature considering the question of contract success, including most of the empirical work, lacks strong theoretical support. Too often, a contract's reason for success, or lack of success, is described in terms of a set of observations, such as too little variance or, say, easier delivery mechanisms of one contract over another. As no structure is given to the problem, one is hard pressed to understand how the cited observations affect the contract's use and which observations matter and which do not.

The intent of this section of the study is to provide a conceptual framework in which to consider the effect of various exogenous variables on contract usage, and through this framework, develop refutable hypotheses regarding contract use. By the very nature of developing a model, there will exist restrictive assumptions and neglected

considerations. However, a model serves as a tool to reach toward answers to the questions being explored, and whether or not the theory developed through the model in this section is supported is an empirical question and the focus of the following two chapters.

The mathematical model developed here is firmly grounded in traditional micro-economic theory. It can be labeled "choice theoretic" as it is based upon the decisions of agents participating in the futures markets as they strive to maximize their expected utility of profits. The profit function is derived from the outcome of production decisions and the positions taken in the futures markets. The production decisions and the futures positions are the choice variables in the model.

Like any economic model that falls within the neo-classical paradigm, the concern is with the changes in the agent's decisions, or their choice variables, as their opportunities are altered. These opportunities, or exogenous variables, are those factors which affect behavior, and are observable (see Silberberg, 1978). In a sense, the opportunities could correspond to the various lists of attributes that have been traditionally assigned as necessary to successful contracts. Since the futures use by the agents is a choice variable, the basic question being asked is how the futures use responds as these attributes change. The tool of comparative statics is used to determine the direction of these responses. The directional, or marginal, changes lead to a set of testable hypotheses that culminate the theoretical section.

3.2 *Firm Decision Making in an Uncertain World*

In order to facilitate the development of the model, this section begins with a brief development of the literature regarding firm behavior in an uncertain world. This earlier work forms much of the basis for the initial set-up of the model. The first case considered is that of the firm making its production decision when the price at which it will eventually sell its output is uncertain. The next case considers the same problem; yet, now, the firm can enter futures markets.

3.2.1 Firm Decision Making With No Futures Markets

Some of the earliest work in this area involved a fairly rigorous analysis of the competitive firm facing price uncertainty (see Sandmo, 1971). The analysis generally assumed that when the firm makes its production decision, it faces an uncertain output price which is represented by a subjective probability distribution. Thus, the traditional goal of profit maximization is clouded by this uncertainty. Instead, the goal of the firm is to maximize expected utility of profits with the firm's attitude toward risk and return being summarized by a von-Neumann-Morganstern utility function. Traditionally, a utility function for a firm is considered inappropriate due to problems with group utility functions; however, Sandmo defends the use of a utility function in this analysis by noting that there are still many firms in which decisions are primarily made by one person, or the preferences of the set of decision makers are sufficiently alike as to allow the existence of a group utility function.

The utility function of the firm is a continuous, concave and differentiable function of profits such that

$$U'(\pi) > 0$$

$$U''(\pi) < 0$$

The firm's profit function can be defined as

$$\pi(x) = px - C(x) - B$$

where p is the price of output which is assumed to be a random variable with density function $f(p)$, $C(x)$ is the variable cost function with $C'(x) > 0$ and $C(0) = 0$, B represents fixed costs and x is the firm's production level.

The expected utility of profits can be written as

$$E[U(px - C(x) - B)],$$

where $E[\cdot]$ is the expectations operator.

In this model, the firm's only decision variable is the production level. The competitive firm chooses production so as to maximize the expected utility of profits.

Several general results follow from the above model:

1. The optimal level of production will occur with the marginal cost less than the expected spot price. If the traditional assumption of upward sloping marginal

cost curves holds, this result implies that the firm will produce less in a world of uncertainty than in a world of certainty.

2. Using the Rothchild-Stiglitz Mean-Preserving-Spread, which can be described as a stretching of the probability distribution around a constant mean, as a measure of risk, it can be shown (see Ishii, 1977) that non-increasing absolute risk aversion is a sufficient condition for the change in output caused by an increase in the uncertainty of price to be negative.
3. A change in fixed costs will affect the output decision unless the assumption is made that the measure of absolute risk aversion for the firm is constant.

3.2.2 Firm Decision Making with Futures Markets

The above model was extended (see Holthausen, 1979 and Feder, Just and Schmitz, 1980) to allow the firm to engage in futures contracting as a means of diminishing the price uncertainty faced by the firm. At the time the firm makes its production decision, it also has the ability to enter a futures market on the commodity the firm produces. Thus, the firm can respond to uncertainty not only by adjusting its production decision but also through altering its level of futures contracting. In this manner, the authors have incorporated futures trading in a generalized theory of production under price uncertainty. What is of interest in this work is that direct consideration is given not only to the production decision but also to the decision on the extent of futures trading.

In this framework, the producer makes his production decision and simultaneously is able to enter the futures market for delivery of his product on the date he would otherwise sell his product on the spot market. Since the producer's final output is assumed non-random, he has the ability to completely hedge his output and thus eliminate all risk. The producer, though, has several options. He can choose not to hedge his entire output and thus expose himself to some level of price risk. He can sell more futures contracts than his production will allow him to fill thus putting him in the position generally ascribed to the speculator. He can enter into no futures contracts or even agree to accept delivery of the product he is producing. One can see that this work is quite similar to that of Stein and Anderson and Danthine. One can also see how the distinction between hedger and speculator blurs depending on the position taken by the producer. He can be considered a hedger as he holds a position in a spot commodity; yet, his position may actually add risk to his portfolio much like the typical description of the speculator.

In this model, profit is described by

$$\pi = p(x - F) + P_0F - C(x) - B$$

where again x is production, p is the price of output, B is fixed costs, and $C(x)$ represents the cost function, F is the volume of futures contracts entered into and P_0 represents the known futures price. Note that p represents the price the firm's output can be sold at on the spot market at the time of its production, and is unknown to the firm at the time it sets its production decision. The futures price, P_0 , represents the price at which the firm is obligated under the futures contracts to sell (or buy) its output at the time of production and is known to the firm at the time it makes its

production decision. Using the general assumptions of the earlier model, the firm's objective is again to maximize the expected utility of profits:

$$E[U(p(x - F) + P_0F - C(x)) - B]$$

The following results can be obtained:

1. If a futures market exists, the production decision is not affected by changes in the perceived distribution of future spot prices or by the degree of the decision maker's risk aversion. Output is positively affected by changes in the futures price and negatively affected by changes in input cost.
2. With futures markets, a complete separation exists between the production decision and the futures trading decision. Production is decided as if the current futures price is the only relevant price.
3. Since the output level is known with the existence of a futures market, the decision in a sense becomes a portfolio selection problem with risk arising from taking a futures position which corresponds to more or less than the output level (i.e., a position greater or smaller than a complete hedge of the production).

3.2.3 Summary

The modelling of firm behavior in an uncertain world is relevant and useful because the level of futures contracting is a choice variable in the model. Thus, from this work one finds rigorous models of firm behavior in which the level of futures demand is endogenously determined. These models are limited, however, in that consideration

is given to only one side of the market and the framework is not broad enough to allow examination of those variables which actually induce futures market participation. The interest of this research is in further developing the model of firm behavior in an uncertain world and exploring the theoretical implications of the model.

3.3 Model

The model developed in this research considers two types of agents acting within an economic framework with markets for two futures contracts that are closely related to each other and to a distinct commodity which is traded on a separate spot market. The use of two futures markets is for ease of exposition, and the number considered could easily be greater without affecting the thrust of the model. More generally, one of the futures contracts can be considered a portfolio of other futures contracts. Depending on the needs of the agent, he can enter either, or both, futures markets and additionally may enter the spot market.

The model is structured in this manner to overcome several limitations in the earlier work incorporating futures markets. The original model of firm decision making in an uncertain world allows the hedging firm to engage in what is termed as perfect hedging. The producer in hedging his production has available a futures contract on the exact product that he is producing. The expiration of the futures contract coincides with the time that the producer would otherwise be selling his output on the spot market, and he can enter futures contracts equal to the exact amount of his known production. Perfect hedging rarely exists; rather, most hedging is performed

through what is termed cross-hedging. Cross-hedging results from a mismatch of actual needs with any of the following:

1. **Actual commodity-** Generally, a producer does not have access to a contract that is actually written on his exact commodity. Even if he does produce a commodity that has a contract, there are many varieties and grades within a commodity, and the commodity may be located in many different locations. Contracts do not exist to cover all these possibilities, and thus cross-hedging is fairly common.
2. **Time positions are terminated-** Producers cannot assume that the contracts expiration will equal the time they will sell their production. Contracts generally trade with limited delivery months. Typically, the number ranges from four to six.
3. **Amount of good-** Contracts generally trade in very specific unit sizes with no room for divisibilities.

3.3.1 Producer

The first type of agent, referred to as the producer, produces the commodity traded on the spot market. At the time of his production decision, the price at which he will eventually be able to sell his output is uncertain. It is assumed that the producer's output level is non-random and he has constant absolute risk aversion.

The model is constructed to directly deal with the first form of cross-hedging, that of a mismatch between the good the agent is seeking to hedge and the underlying good of the futures contract used for the hedge, by allowing the producer to hedge his output only via a related contract. The success of the hedge is mainly determined

by how well the movement in the futures position tracks the movement in the spot position. The model also allows for the second form of cross-hedging, that of a mismatch between when the producer would otherwise end his hedge and the expirations of available futures contracts, by simply not requiring that the producer liquidate his futures position only at the contract's expiration. As opposed to requiring that the producer close his futures position by delivering the commodity underlying the futures contract at the agreed upon price, the agents will liquidate via an offsetting transaction at what is currently an uncertain price.

The third form of cross-hedging, that of a mismatch of the size of the producer's production and the size of available futures contracts, is beyond the scope of this model due to the needed assumption of perfect divisibilities in using a standard expected utility maximization approach.

The profit function for the producer is described as

$$\pi = YS_1 - C(Y) + (F_2 - S_2)Q_2 + (F_3 - S_3)Q_3 - T_2|Q_2| - T_3|Q_3|$$

Y is the producer's production level decision which is sold on the spot market at price S_1 , a random variable unknown to the farmer at the time the production decision is made. $C(Y)$ represents the producer's non-stochastic cost function with both positive first and second derivatives with respect to Y . Q_2 and Q_3 represent the volume of futures contracts the producer enters into in each of the two related futures markets. F_2 and F_3 , which are known to the producer at the time of his production decision, are the respective futures prices. S_2 and S_3 are random variables representing the spot prices underlying the two related futures contracts. T_2 and T_3 represent the variable transaction costs for entering into the futures contracts. In order to

properly consider the transactions costs if Q is negative, T is multiplied by the absolute value of Q .

Describing the producer's profit function in this manner assumes that he closes out his futures contracts at their expiration. This can be relaxed by rewriting the profit equation as

$$\pi = YS_1 - C(Y) + (F_2 - F'_2)Q_2 + (F_3 - F'_3)Q_3 - T_2|Q_2| - T_3|Q_3|$$

where F'_2 and F'_3 represent the futures prices at the time the contract is closed out via a reversing transaction. For the purpose of exposition, it does not matter which form is considered. Empirically, however, there is a distinction.

The producer is a typical micro-agent in that he faces perfectly competitive input and output markets. The producer chooses Y , Q_2 , and Q_3 so as to maximize his expected utility of profits.

$$\max \int_0^\infty \int_0^\infty \int_0^\infty U(\pi_p) dG(\bar{S}_1, \bar{S}_2, \bar{S}_3)$$

Where $U()$ is the producer's increasing concave utility function and G is the joint probability distribution of the random variables.

3.3.1.1 Supply Curve

A matter for consideration regarding the producer developed in this model is the producer's supply function for futures contracts. The traditional notion of futures

contracting is that the producer of the raw material enters into futures contracts agreeing to deliver his production at some specified price. If the price is high enough, which Garbade describes as exceeding his expectation of the futures spot price, he will hedge his entire production level. As Working points out, at some point the hedger can be induced to contract to deliver beyond his anticipated production, which pushes him into 'speculator' status. Whichever view is taken, one can imagine that, for the producer who can perfectly hedge his production, there corresponds to each futures price an amount of futures contracts that the producer is willing to "supply" to the market. Thus, one can imagine a supply curve.

The question naturally arises as to whether or not a similar supply relation exists for the producer in this model. This model is more complicated than that considered by Garbade or Working as production is a choice variable which feeds into the futures decision, and there is no perfect hedging. However, one would expect, intuitively, that the supply curve would still exist. Indeed, as will be shown later,

$$\frac{\partial Q_2^*}{\partial F_2} > 0$$

$$\frac{\partial Q_3^*}{\partial F_3} > 0$$

The producer's supply curves in the model are upward sloping.

3.3.1.2 Short and Long Producers

As the model has been presented up to this point, it has been assumed that the producer is interested in hedging that commodity which he produces. Although the producer can take any long or short position he chooses, a "short producer" has still been modeled. A short producer is one whose wealth, without his futures position, is directly related to movements in the spot price of the commodity that he has an interest in hedging. However, in the market place, there are also "long producers" whose wealth is inversely related to movements in the spot price. For instance, a wheat farmer would be a short producer and a baker would be a long producer of wheat.

The long producer can be modeled by describing his profit function as

$$\pi = F(Y) - S_1 Y + (F_2 - F'_2)Q_2 + (F_3 - F'_3)Q_3 - T_2|Q_2| - T_3|Q_3|$$

Where $F(Y)$ is a revenue function and Y now represents the input variable. Notice there is little substantive difference between the long producer's objective function and the short producer's. One is simply the opposite image of the other. For example, the variance of π for a given Y will be identical in either type of producer. Indeed, all of the results are equal for the two producers. Note that the long producer would have a downward sloping demand curve.

3.3.2 Trader

The second type of agent is described as a trader. He has no initial endowment of any good and his behavior is indistinguishable from that commonly described as a "speculator." He behaves as if his only source of income is trading in futures markets.

The availability of more than one related futures contract in the model affords the agents, particularly the trader, the opportunity for diversification of their positions. Although a futures contract differs fundamentally from a traditional financial asset in that it ideally has no cost at its inception, the lessons from diversification theory are applicable in futures markets as in traditional markets. In practice, "floor traders" are known to contract in more than one futures contract.

The profit function for the speculator therefore is

$$\pi_t = (S_2 - F_2)_t Q_2 + (S_3 - F_3)_t Q_3 - T_2 |_t Q_2| - T_3 |_t Q_3|$$

His objective is to maximize his expected utility of wealth

$$\max \int_0^\infty \int_0^\infty \int_0^\infty U_t(\pi_t) dG(\tilde{S}_1, \tilde{S}_2, \tilde{S}_3)$$

It has been observed that the trader in this specification can literally enter contracts without limit. To control for this, it is possible to add a wealth constraint to his profit function; however, this term, as a fixed variable, would have no affect upon his marginal decision. That is the results are the same regardless of adding a wealth constraint.

3.3.2.1 Demand Curve

As the literature has generally emphasized the idea of the short producer supplying contracts to the market, the trader is typically described as demanding these contracts. The traditional notion, put forth by Keynes (1930), is that on the other side of the market stands the trader who agrees to accept the producer's production, and his risk. That is, the trader is generally described as taking on the price risk that the producer wishes to get rid of. In a similar manner to the producer, one imagines that to each futures price there is an amount of forward contracting that the trader is willing to "demand" on the market. Thus, one can imagine a demand curve existing for the trader.

Again, the question arises as to the nature of the demand curve for the trader. It will be shown later that the slopes of the traders demand curves in the model are indeed negative, or downward sloping.

$$\frac{\partial_t Q_2^*}{\partial F_2} < 0$$

$$\frac{\partial_t Q_3^*}{\partial F_3} < 0$$

Figure 1 on page 46 provides a diagram of the model.

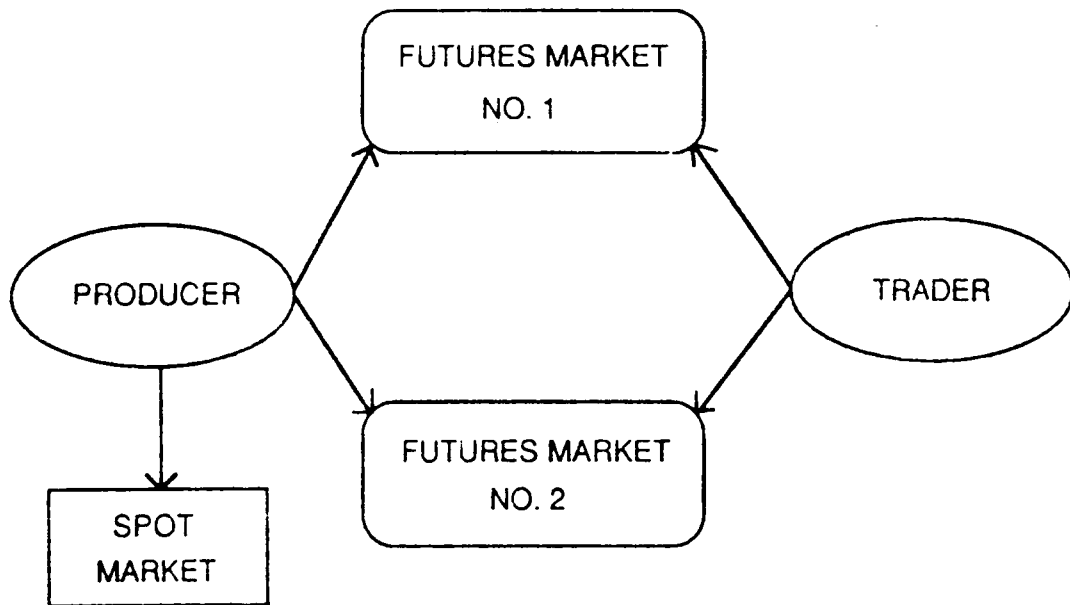


Figure 1. Diagram of Market Setting

3.4 Comparative Statics

The first point of interest is in the response of the supply and demand functions caused by changes in the exogenous variable. The tool to analyze these questions is comparative statics. This section analyzes the comparative statics. Consider the first-order conditions of the producer with respect to Y , Q_2 , and Q_3 . The first order conditions are:

$$\int_0^\infty \int_0^\infty \int_0^\infty U'(\pi_p)(\bar{S}_1 - C'(Y))dG(\bar{S}_1, \bar{S}_2, \bar{S}_3) = 0$$

$$\int_0^\infty \int_0^\infty \int_0^\infty U'(\pi_p)(F_2 - \bar{S}_2 - T_2)dG(\bar{S}_1, \bar{S}_2, \bar{S}_3) = 0$$

$$\int_0^\infty \int_0^\infty \int_0^\infty U'(\pi_p)(F_3 - \bar{S}_3 - T_3)dG(\bar{S}_1, \bar{S}_2, \bar{S}_3) = 0$$

Assuming that the producer behaves according to the appropriate marginal conditions, one can solve for the following explicit choice functions as a function of the exogenous variables in the model:

$$\dot{Y} = Y^*(G(\bar{S}_1, \bar{S}_2, \bar{S}_3), F_2, F_3, T_2, T_3, C)$$

$$Q_2 = Q_2^*(G(\bar{S}_1, \bar{S}_2, \bar{S}_3), F_2, F_3, T_2, T_3, C)$$

$$Q_3 = Q_3^*(G(\bar{S}_1, \bar{S}_2, \bar{S}_3), F_2, F_3, T_2, T_3, C)$$

Y^* , Q_2^* and Q_3^* represent the level of production and related futures contracts needed for the first order conditions to hold, given any set of exogenous variables. Substituting Y^* , Q_2^* and Q_3^* back into the first order conditions converts those three conditions to identities. As identities, and assuming that the determinant of the Jacobian matrix

is not zero, they can be differentiated implicitly with respect to the various exogenous variables providing solutions for those partial derivatives.

Up to now the exogenous, or given, variables have been listed as the various spot and futures prices, the production costs and transaction costs. While the producer's and trader's supply and demand response to changes in these variables is of interest in the analysis, the changes in the distribution of the underlying spot prices and the relationships between the spot prices, which are also exogenous variables to the agents, are also of interest. To examine those relationships, one first must expand the first-order conditions.

First, note that the first-order conditions for the producer can be rewritten as:

$$E[U'(\pi_p)(\bar{S}_1 - C'(Y))] = 0$$

$$E[U'(\pi_p)(F_2 - \bar{S}_2 - T_2)] = 0$$

$$E[U'(\pi_p)(F_3 - \bar{S}_3 - T_3)] = 0$$

These can be rewritten as:

$$EU'(\pi_p) E(\bar{S}_1 - C'(Y)) + \text{cov}[U'(\pi_p), (\bar{S}_1 - C'(Y))] = 0$$

$$EU'(\pi_p) E(F_2 - \bar{S}_2 - T_2) + \text{cov}[U'(\pi_p), (F_2 - \bar{S}_2 - T_2)] = 0$$

$$EU'(\pi_p) E(F_3 - \bar{S}_3 - T_3) + \text{cov}[U'(\pi_p), (F_3 - \bar{S}_3 - T_3)] = 0$$

The first-order conditions can be expanded by using a property that has been demonstrated by Rubinstein. He shows that if x and y are bivariate normal and $g(y)$ is any at least once differentiable function of y , then

$$\text{cov}(x, g(y)) = E(g'(y))\text{cov}(x, y)$$

Using this result and assuming that $\tilde{S}_1$, $\tilde{S}_2$, and $\tilde{S}_3$ are jointly normal, then the first-order conditions can be rewritten as

$$EU'(\pi_p) E(S_1 - C'(Y)) + EU''(\pi_p)\text{cov}(\pi, \tilde{S}_1) = 0$$

$$EU'(\pi_p) E(F_2 - \tilde{S}_2 - T_2) + EU''(\pi_p)\text{cov}(\pi, -\tilde{S}_2) = 0$$

$$EU'(\pi_p) E(F_3 - \tilde{S}_3 - T_3) + EU''(\pi_p)\text{cov}(\pi, -\tilde{S}_3) = 0$$

We can then divide through by the first derivative of the utility function and expand the covariance term to further break down the first-order equations to

$$E(\tilde{S}_1 - C'(Y)) + \Delta[Y\sigma_{11} - Q_2\sigma_{12} - Q_3\sigma_{13}] = 0$$

$$E(F_2 - \tilde{S}_2 - T_2) + \Delta[-Y\sigma_{12} + Q_2\sigma_{22} + Q_3\sigma_{23}] = 0$$

$$E(F_3 - \tilde{S}_3 - T_3) + \Delta[-Y\sigma_{13} + Q_2\sigma_{23} + Q_3\sigma_{33}] = 0$$

Where

$$\Delta = \frac{EU''(\pi_p)}{EU'(\pi_p)}$$

and

$$\sigma_{11} = \text{variance of } S_1$$

$$\sigma_{12} = \text{covariance of } S_1 \text{ with } S_2$$

etc. Note, that Δ is a negative constant under the assumption of constant absolute risk aversion.

The Jacobian , the matrix of second partials for the system is

$$H = \begin{bmatrix} Z & -\Delta\sigma_{12} & -\Delta\sigma_{13} \\ -\Delta\sigma_{12} & \Delta\sigma_{22} & \Delta\sigma_{23} \\ -\Delta\sigma_{13} & \Delta\sigma_{23} & \Delta\sigma_{33} \end{bmatrix}$$

Where $Z = \Delta\sigma_{11} - C''(Y)$

The determinant of H is negative by the second-order conditions. Notice that aside from the multiplication by Δ and the $-C''(Y)$ in Z , H is closely related to a variance-covariance matrix, which must be positive definite.

3.5 Comparative Statics Results

These results provide the response of the producer's choice variables to changes in the various exogenous variables.

3.5.1 Results for Spot Price Variance

As previously noted, the production of a firm with perfect hedging ability is unaffected by a change in the variability of the product's spot price. However, one would expect in a world with imperfect hedging that the results correspond more closely to the original work dealing with production decisions made in an uncertain world with no hedging. That work showed that output fell as the uncertainty in price increased. The same would be expected in this model. Additionally, as the variance in the spot price increases, one would imagine that the firm would have a greater interest in hedging since it now faces greater price risk. Thus, the firm's demand for futures contracts would increase. However, this is not obvious. If production falls, this would tend to move the demand in the other direction. Finally, if the demand for futures contracts did increase, it is not clear, given the structure of the model, which contract(s) would see the greater demand.

The response to a change in the variability of the spot price of the commodity produced by the producer can be described, in matrix notation, by the following system.

$$[H] \begin{bmatrix} \frac{\partial Y^*}{\partial \sigma_{21}} \\ \frac{\partial \sigma_{21}}{\partial \sigma_{22}} \\ \frac{\partial \sigma_{21}}{\partial \sigma_{33}} \\ \frac{\partial \sigma_{21}}{\partial \sigma_{23}} \end{bmatrix} = \begin{bmatrix} -\Delta Y \\ 0 \\ 0 \\ 0 \end{bmatrix}.$$

Each relationship can be solved for as

$$\frac{\partial Y^*}{\partial \sigma_{11}} = \frac{(-1)^2 - \Delta Y[(\Delta \sigma_{22})(\Delta \sigma_{33}) - (\Delta \sigma_{23})(\Delta \sigma_{23})]}{|H|} < 0$$

Assuming the appropriate second-order conditions hold, then, as expected, the firm's production level decreases as the variance in the spot market increases. The next two relations cannot be signed directly from the S.O.C. alone.

$$\frac{\partial Q_2^*}{\partial \sigma_{11}} = \frac{(-1)^3 - \Delta Y[(- \Delta \sigma_{12})(\Delta \sigma_{33}) - (- \Delta \sigma_{13})(\Delta \sigma_{23})]}{|H|}$$

$$\frac{\partial Q_3^*}{\partial \sigma_{11}} = \frac{(-1)^4 - \Delta Y[(- \Delta \sigma_{12})(\Delta \sigma_{23}) - (- \Delta \sigma_{13})(\Delta \sigma_{22})]}{|H|}$$

The notation will be simplified by describing

$$\frac{\partial Y^*}{\partial \sigma_{11}} \text{ as } \frac{-\Delta Y H_{11}}{|H|}$$

where

$$H_{11}$$

is the cofactor of the element in row 1 and column 1 of H.

While the second two comparative statics cannot be signed directly, certain statements can be made regarding their signs. As the interest is in closely related contracts, it is assumed that the covariance terms are positive. First, note that the comparative static results indicate that

$$\text{sign}(\sigma_{13}\sigma_{32} - \sigma_{12}\sigma_{33}) = \text{sign} \frac{\partial Q_2^*}{\partial \sigma_{11}}$$

and,

$$- \text{sign} (\sigma_{12}\sigma_{33} - \sigma_{32}\sigma_{13}) = \text{sign} \frac{\partial Q_2^*}{\partial \sigma_{11}}$$

and, in regard to Q_3^*

$$\text{sign} (\sigma_{12}\sigma_{23} - \sigma_{13}\sigma_{22}) = \text{sign} \frac{\partial Q_3^*}{\partial \sigma_{11}}$$

and

$$- \text{sign} (\sigma_{13}\sigma_{22} - \sigma_{12}\sigma_{23}) = \text{sign} \frac{\partial Q_3^*}{\partial \sigma_{11}}$$

It can also be shown by using the second-order conditions that if

$$(\sigma_{13}\sigma_{23}) \geq (\sigma_{12}\sigma_{33}) \text{ then } (\sigma_{22}\sigma_{13}) > (\sigma_{12}\sigma_{33}) \quad (1)$$

and

$$(\sigma_{12}\sigma_{23}) \geq (\sigma_{22}\sigma_{13}) \text{ then } (\sigma_{12}\sigma_{33}) > (\sigma_{13}\sigma_{23}) \quad (2)$$

Then if

$$\frac{\partial Q_2^*}{\partial \sigma_{11}} > 0 \text{ then } \frac{\partial Q_3^*}{\partial \sigma_{11}} < 0$$

and

$$\frac{\partial Q_3^*}{\partial \sigma_{11}} > 0 \text{ then } \frac{\partial Q_2^*}{\partial \sigma_{11}} < 0$$

Without knowing the signs of Q_2^* and Q_3^* , the signs of the derivatives would not tell whether a contract's use would expand or contract as the variance in the spot price changes. If, for instance, Q_2^* is negative and so is the derivative, then the use of the contract expands. If Q_2^* is positive and the derivative is negative, then the contract's use decreases. Some additional insight can be gained from considering the adjusted unbiased futures price, where the futures price equals the expected spot price plus transactions costs, the first order conditions can be represented by

$$[D] \begin{bmatrix} Y^* \\ Q_2^* \\ Q_3^* \end{bmatrix} = \begin{bmatrix} -E(S_1 - C'(Y)) \\ 0 \\ 0 \end{bmatrix}$$

where D is Δ times a variance-covariance matrix, or

$$D = \begin{bmatrix} \Delta\sigma_{11} & -\Delta\sigma_{12} & -\Delta\sigma_{13} \\ -\Delta\sigma_{12} & \Delta\sigma_{22} & \Delta\sigma_{23} \\ -\Delta\sigma_{13} & \Delta\sigma_{23} & \Delta\sigma_{33} \end{bmatrix}$$

Solving this system of equations, one has at the optimum

$$Y_{unb}^* = \frac{(-1)^2 [-E(S_1 - C'(Y))H_{11}]}{|D|} > 0$$

$$Q_{2unb}^* = \frac{(-1)^3 [-E(S_1 - C'(Y))H_{12}]}{|D|}$$

$$Q_{3unb}^* = \frac{(-1)^4 [-E(S_1 - C'(Y))H_{13}]}{|D|}$$

Using Q_{2unb}^* and a rearrangement of the earlier comparative result one sees that

$$\frac{\partial Q_2^*}{\partial \sigma_{11}} = \frac{Q_{2unb}^* D(-\Delta Y)}{|H|[-E(S_1 - C'Y)]}$$

Thus, the sign of the change in Q_2^* brought about by a change in σ_{11} hinges on the sign of Q_{2unb}^* , since all else is signable in the equation through either the second order conditions or earlier work. In fact, one sees that

$$\text{sign of } \frac{\partial Q_2^*}{\partial \sigma_{11}} = \text{sign of } (-Q_{2unb}^*)$$

and a similar result holds for the change in Q_3^*

$$\text{sign of } \frac{\partial Q_3^*}{\partial \sigma_{11}} = \text{sign of } (-Q_{3unb}^*)$$

If, say, Q_{2unb}^* is greater than zero, then the partial of Q_2^* with respect to σ_{11} is negative, and vice versa.

The major result that falls out of this analysis is that if the optimal position at the equilibrium price for Q_2 is the same sign as Q_2 at the unbiased price, then the futures position, be it long or short, shrinks as the variance of the underlying spot increases. This result is at odds with the traditional argument that the result should be the other way.

The question arises as to whether or not the signs are the same. Indeed, it is the case in this model that the sign of Q_2^* is the same as the sign as Q_{2unb}^* . This can be seen by considering where the supply and demand curves for the agents in the model intersect the price axis. From the first order conditions, first consider the value for

F_2 for the short producer at the point where it crosses the axis (see Figure 2 on page 57)

At this point

$$F_2^{SP} = S_2 + T_2 + \Delta Y \sigma_{12} - \Delta Q_3^{*SP} \sigma_{23}$$

The concern here is whether F^{SP} cuts the axis above or below the expected spot price (plus transactions costs). The $\Delta Y \sigma_{12}$ term is signable; however, the entire term is not signable without knowing the sign of Q_3^* , and the magnitude of the variables involved. Thus, whether or not the producer's supply curve cuts the axis above or below the expected spot price is unclear.

A similar problem exists for total demand curve created by combining the trader and the long producer which cuts the price axis at

$$F_2^{LP,T} = E(S_2) + T_2 - 1/2(\Delta Y \sigma_{12}) + 1/2(\Delta Q_3^{*T} \sigma_{23}) + 1/2(\Delta Q_3^{*LP} \sigma_{23})$$

However, since $Q_3^{*T} + Q_3^{*LP}$ must equal Q_3^{*SP} in equilibrium, then the above equation can be rewritten as

$$F_2^{LP,H} = E(S_2) + T_2 - 1/2(\Delta Y \sigma_{12} - \Delta Q_3^{*SP} \sigma_{23})$$

One can observe that if either F_2^{SP} or $F_2^{LP,T}$ lies above the unbiased futures price, then the other must lie below it (see Figure 3 on page 58 and Figure 4 on page 59)

Therefore, whether or not equilibrium Q_2^* is long or short, the unbiased price always lies on the same side as the equilibrium value. The intuition behind this result is that the two types of producers are essentially solving symmetrical decisions with only the spot positions differing. Thus, they tend to take opposite positions. That is, if one

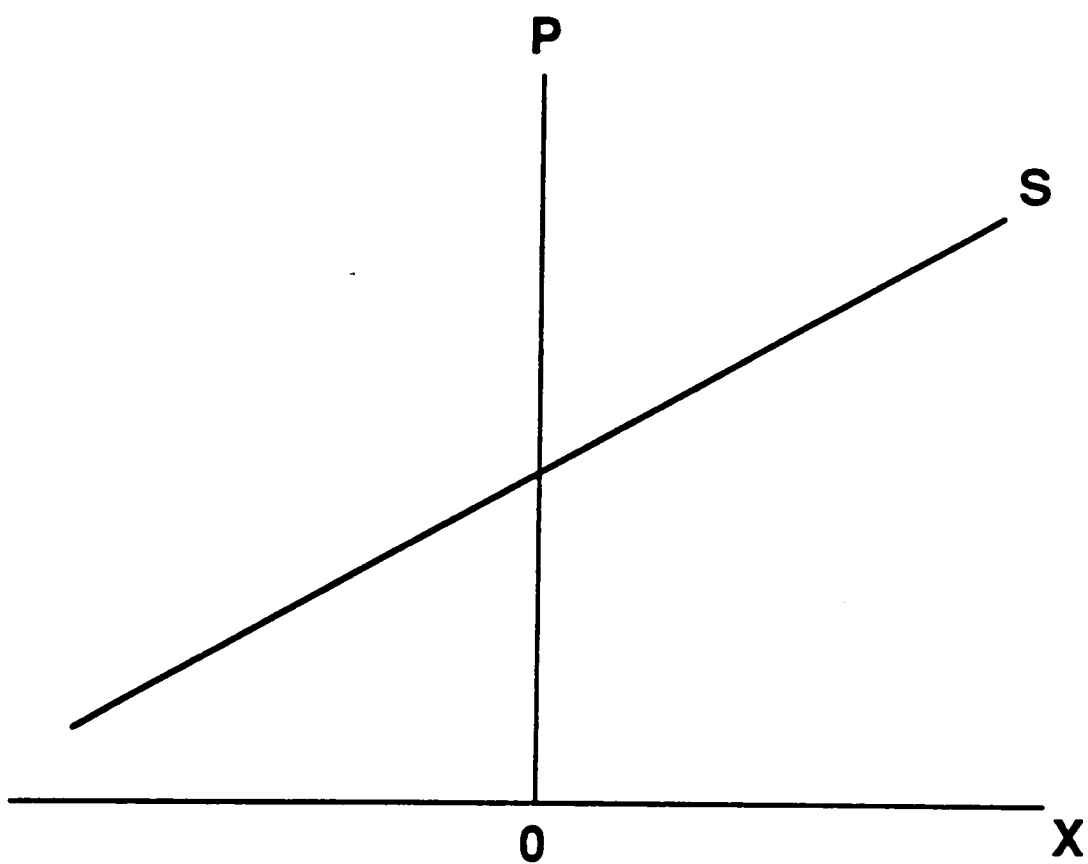


Figure 2. Short Producer's Supply Curve

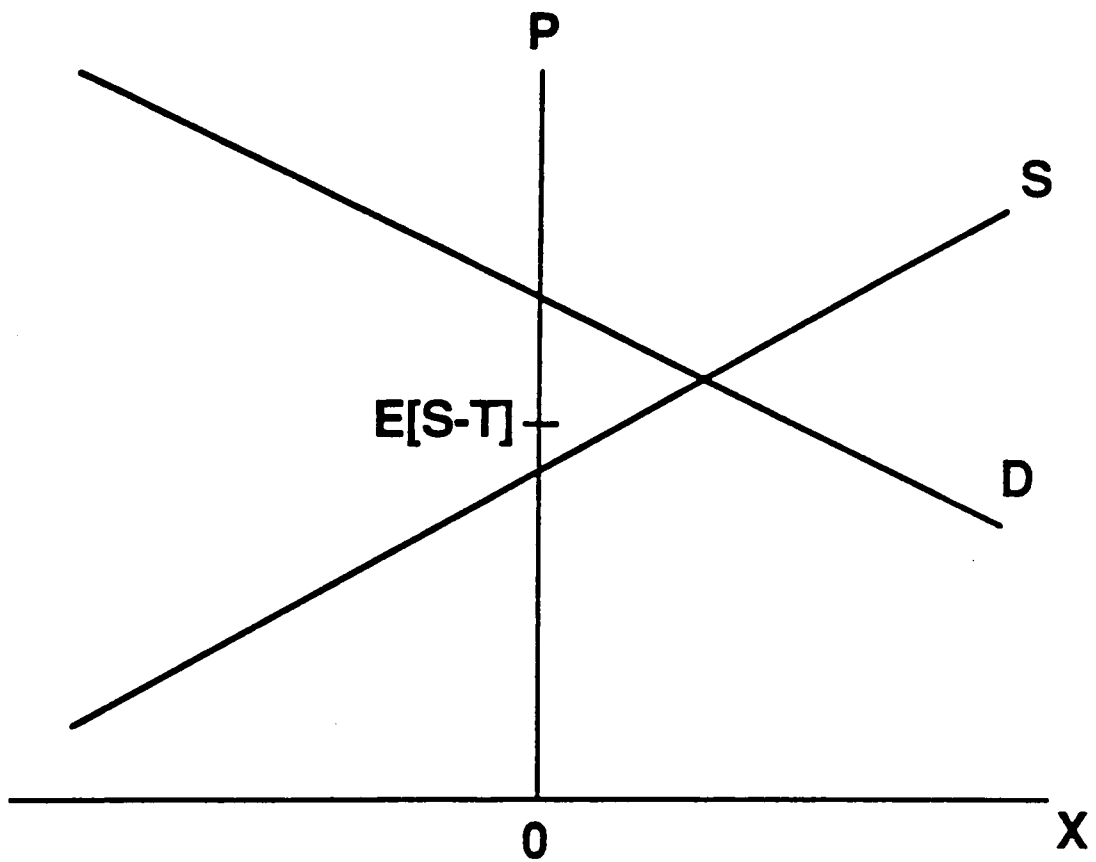


Figure 3. Equilibrium 1

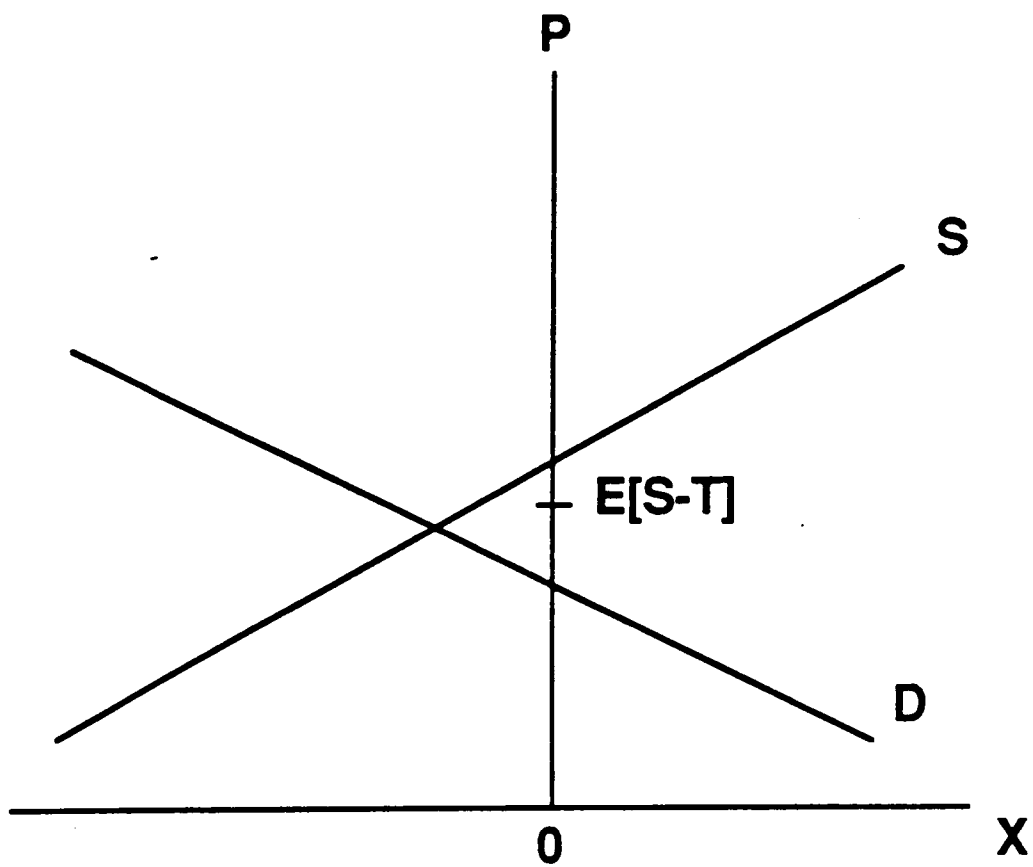


Figure 4. Equilibrium 2

goes long, then the other will go short. The trader tends toward the middle and only serves to reinforce the result.

An additional result falls out of this analysis. Recall that if

$$(\sigma_{13}\sigma_{23}) \geq (\sigma_{12}\sigma_{33}) \text{ then } \frac{\partial Q_2^*}{\partial \sigma_{11}} > 0$$

which implies that Q_{2unb}^* is less than zero. However, if

$$(\sigma_{13}\sigma_{23}) \geq (\sigma_{12}\sigma_{33}) \text{ then } (\sigma_{22}\sigma_{13}) > (\sigma_{12}\sigma_{33})$$

which implies that

$$\frac{\partial Q_2^*}{\partial \sigma_{11}} > 0 \text{ and } Q_{3unb}^* > 0$$

Thus, if either condition (1) or (2) above hold, then one can state that the producer will take opposite positions in the two futures contracts. If one considers the producer's overall position in a portfolio context, this result is reasonable for positively correlated assets. The producer may not take opposite positions, though, if there is some 'residual' uncertainty left in the hedged spot position which an additional short position could reduce.

3.5.2 Results for Covariance Between Spot and Futures Prices

Also of interest to this research is the change in the decision variables in response to the change in the correlation between the price of the producer's product and the

price of the good underlying one of the futures markets. The producer is traditionally thought of as using the related contract as a vehicle to hedge his output. The ability of a futures contract to serve as a hedge generally depends upon how well the contract price tracks the movement of the spot price. Here, the interest is in the response of the producer to a change in how well one of the related futures contracts serves as a hedge. One would expect that if the producer is using a forward contract as a hedge, then as the covariance increases, so will production and the number of that futures contract used. Looking at a change in the covariance between the spot price of the producer's good and the price of the good underlying the second futures contract one has

$$\frac{\partial Y^*}{\partial \sigma_{12}} = \frac{(-1)^2 \Delta Q_2^* H_{11} + (-1)^3 \Delta Y H_{21}}{|H|}$$

$$\frac{\partial Q_2^*}{\partial \sigma_{12}} = \frac{(-1)^3 \Delta Q_2^* H_{12} + (-1)^4 \Delta Y H_{22}}{|H|}$$

$$\frac{\partial Q_3^*}{\partial \sigma_{12}} = \frac{(-1)^4 \Delta Q_2^* H_{13} + (-1)^5 \Delta Y H_{23}}{|H|}$$

Since only H_{11} and H_{22} are signable via the second-order conditions, the signs of all three of these relations are generally indeterminate. Additionally, the same basic results occur with the covariance between market 1 and market 3.

However, consider again the comparative static result,

$$\frac{\partial Y^*}{\partial \sigma_{12}} = \frac{(-1)^2 \Delta Q_2^* H_{11} + (-1)^3 \Delta Y H_{21}}{|H|}$$

Suppose Q_{2unb}^* is positive, then $\frac{\partial Q_2^*}{\partial \sigma_{11}} < 0$ and H_{21} must also be less than zero. Thus, it can be observed that for Q_2^* greater than zero, $\frac{\partial Y^*}{\partial \sigma_{12}} > 0$ If Q_2^* is negative, then the comparative static is negative.

More can be said, though, if Q_{2unb}^* is positive, then by the same logic

$$\frac{\partial Q_2^*}{\partial \sigma_{12}} = \frac{(-1)^3 \Delta Q_2^* H_{12} + (-1)^4 \Delta Y H_{22}}{|H|} > 0$$

The same sign of the comparative static also holds for Q_2^* less than zero.

These results indicate that if the producer has a positive position in Q_2^* , then as the covariance increases, the production level and the use of the second futures contract will increase. If his position in the second contract is negative, then production and his position in the futures contract decrease as the covariance increases. This is reasonable if the portfolio concept is kept in mind and recognition is made that a negative position in a related contract is a "long" contract. That is, the producer is agreeing to deliver on a related commodity as well as his own production. Nothing can be said regarding the remaining contract without knowing more details about the relative magnitudes of the various variances and covariances.

Additional insight into the general response of the producer's supply as the covariance changes can be gotten from viewing this response in the neighborhood around where the supply curve cuts the price axis. While this is not a solid proof of what occurs at all optimum positions, it has been used in other work as an indication of the supply response at other optimums and does indicate whether there is a greater or lesser incentive to get involved in using a futures contracts as a "first

step." From the comparative statics, one observes that at the futures price for which Q_2^* is zero, the change in the quantity of Q_2^* brought about by a change in σ_{12} is positive. This indicates the response at that point and it is as expected.

3.5.3 Results for Variance of the Futures Price

One can also consider the change in the choice variables brought about by a change in the variance of the price of a commodity underlying one of the futures contracts. If the variance underlying one of the futures contracts increases, it does, in a sense, become riskier and less desirable to a risk-averse producer. In the traditional hedging view, the asset has become riskier without an improvement in hedging ability. In a more general portfolio sense, the increased variability is generally undesirable without compensating effects in the covariance terms or the expected return.

The question also arises as to what the effect would be upon the production and the other contract as the variance of one contract increases. Related contracts serve as hedging substitutes to the producer. Thus, one might expect that as the demand for one contract decreases, the demand for its substitute increases. This is not obvious, though, since both may actually decline if production declines sufficiently in the face of worsened hedging opportunities. If they are gross substitutes, though, it is clear in this model that the other contract will increase. If there were more than two contracts, one cannot tell which contract(s) will actually increase; however, if one of the two contracts in this model represents a portfolio of other contracts, the effect on the substitute portfolio of contracts is clear. The comparative statics indicate the producer's position in Q_2^* unambiguously decreases as the variance of that contract in-

creases. It can be shown that the change in the production level as the variance changes, or $\frac{\partial Y^*}{\partial \sigma_{22}}$, is negative regardless of whether Q_2 is positive or negative. The same results would hold for an increase in the variance of market 3. The comparative statics are

$$\frac{\partial Y^*}{\partial \sigma_{22}} = \frac{(-1)^3(-\Delta Q_2^*)H_{21}}{|H|}$$

$$\frac{\partial Q_2^*}{\partial \sigma_{22}} = \frac{(-1)^4(-\Delta Q_2^*)H_{22}}{|H|} < 0 \text{ here for } Q_2^* > 0$$

$$\frac{\partial Q_3^*}{\partial \sigma_{22}} = \frac{(-1)^5(-\Delta Q_2^*)H_{23}}{|H|}$$

3.5.4 Results for Covariance Between the Two Futures Prices

The change in the choice variables brought about by the change in the covariance in the prices of the two goods that underlie the two futures markets can be described by the following relations. Each of these signs is generally indeterminate without specific information on the relative magnitudes of the model parameters.

$$\frac{\partial Y^*}{\partial \sigma_{23}} = \frac{(-1)^3(-\Delta Q_3^*)H_{21} + (-1)^4(-\Delta Q_2^*)H_{31}}{|H|}$$

$$\frac{\partial Q_2^*}{\partial \sigma_{23}} = \frac{(-1)^4(-\Delta Q_3^*)H_{22} + (-1)^5(-\Delta Q_2^*)H_{23}}{|H|}$$

$$\frac{\partial Q_3^*}{\partial \sigma_{23}} = \frac{(-1)^5(-\Delta Q_3^*)H_{23} + (-1)^6(-\Delta Q_2^*)H_{33}}{|H|}$$

3.5.5 Results for Spot Prices, Futures Prices, and Transactions Costs

One can also look at the changes in the choice variables brought about by changes in the various futures prices, spot prices, and transactions costs. One can anticipate that transaction costs will be an important aspect of the empirical section. The changes brought about by a change in the expected spot price of the produced good is as follows. One should expect that the amount produced increases as the spot price increases. If the amount produced increases, then one could expect the producer to engage in more hedging, yet, it is not clear which futures contract increases.

$$\frac{\partial Y^*}{\partial E[\bar{S}_1]} = \frac{(-1)^2(-1)H_{11}}{|H|} > 0$$

$$\frac{\partial Q_2^*}{\partial E[\bar{S}_1]} = \frac{(-1)^3(-1)H_{12}}{|H|}$$

$$\frac{\partial Q_3^*}{\partial E[\bar{S}_1]} = \frac{(-1)^4(-1)H_{13}}{|H|}$$

Note that

$$\frac{\partial Q_2^*}{\partial E[\bar{S}_1]} > 0 \text{ if } Q_{2unb}^* > 0$$

and

$$\frac{\partial Q_2^*}{\partial E[S_1]} < 0 \text{ if } Q_{2unb}^* < 0$$

The same results hold for Q_3^* with respect to $E(S_1)$. This result indicates that as Y increases from an increase in its expected spot price, then the futures markets supply will increase (either more short or more long) in response to this increased production.

The change in the variables brought about by the change in the expected spot price of the commodity underlying futures market 2 is as follows. If the producer's position in Q_2^* is positive then as the mean of S_2 increases one would expect his positive position in that contract to decrease as he expects it to become a more expensive hedge to close out (that is, the return on that asset declines). However, if his position in Q_2^* is negative, then an increase in the expected spot price makes the contract more desirable. The sign is as expected for either a positive or negative position.

$$\frac{\partial Y^*}{\partial E[S_2]} = \frac{(-1)^3(1)H_{21}}{|H|}$$

$$\frac{\partial Q_2^*}{\partial E[S_2]} = \frac{(-1)^4(1)H_{22}}{|H|} < 0$$

$$\frac{\partial Q_3^*}{\partial E[S_2]} = \frac{(-1)^5(1)H_{23}}{|H|}$$

Note that

$$\frac{\partial Y^*}{\partial E[S_2]} > 0 \text{ if } Q_{2unb}^* < 0$$

and

$$\frac{\partial Y^*}{\partial E[S_2]} < 0 \text{ if } Q_{2unb}^* > 0$$

It is reasonable that production responds in the same direction as the level of usage of a potential hedge.

It is not necessary to sketch out the remaining related comparative statics. The response of Q_2^* will be similar for T_2 , of the opposite sign for F_2 , and indeterminate for any other price or transaction cost. Y^* and Q_3^* will follow similar patterns with the "own-price" relation being determinant and the "cross-price" relation being indeterminate. Those signs that can be determined are, though, in the expected direction.

3.6 Summary of Comparative Statics Results for the Producer

The interest is in the hypotheses that result from the comparative statics. To summarize the important results regarding futures positions, one has that:

1. The futures usage declines as the variance of the spot commodity increase. This is an indirect effect in that increased spot variance leads to lower production, which creates less of a hedging need.

2. If the futures position is positive, the futures usage and production will increase as the covariance between the spot and the futures price increases. If the position is negative, the futures usage and production decline as the covariance increases.
3. Futures usage declines as the variance of the contract increases.
4. Futures usage decreases as transaction costs increase.

3.7 Trader

The trader's choice variables are Q_{2t} and Q_{3t} and his first order conditions are

$$\int_0^\infty \int_0^\infty U'(\pi_q)(S_2 - F_2 - T_2)dG(S_1, S_2, S_3) = 0$$

$$\int_0^\infty \int_0^\infty U'(\pi_q)(S_3 - F_3 - T_3)dG(S_1, S_2, S_3) = 0$$

The following explicit choice functions can be specified as

$$Q_{2t} = Q_{2t}^*(G(S_1, S_2, S_3), T_2, T_3, F_2, F_3, C)$$

$$Q_{3t} = Q_{3t}^*(G(S_1, S_2, S_3), T_2, T_3, F_2, F_3, C)$$

As was done with the producer, the trader's first order conditions can be expanded as

$$E[\dot{S}_2 - F_2 - T_2] + \Delta(Q_{2t}^*\sigma_{22} + Q_{3t}^*\sigma_{23}) = 0$$

$$E[\bar{S}_3 - F_3 - T_3] + \Delta(Q_{2t}^* \sigma_{32} + Q_{3t}^* \sigma_{33}) = 0$$

Where the Jacobian matrix of second partials is:

$$H_T = \begin{bmatrix} \Delta\sigma_{22} & \Delta\sigma_{23} \\ \Delta\sigma_{32} & \Delta\sigma_{33} \end{bmatrix}$$

Which is positive definite by the second-order conditions.

3.7.1 Results for Futures Prices

One can solve for similar comparative static results. For instance, the change in the decision variables , Q_{2t}^* and Q_{3t}^* , brought about by a change in F_2 can be described by the following system.

$$H \begin{bmatrix} \frac{\partial Q_{2t}^*}{\partial F_2} \\ \frac{\partial Q_{3t}^*}{\partial F_2} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

Thus, one can solve for:

$$\frac{\partial Q_{2t}^*}{\partial F_2} = \frac{\Delta\sigma_{33}}{|H|} < 0$$

and

$$\frac{\partial Q_{3t}^*}{\partial F_2} = \frac{-\Delta\sigma_{23}}{|H|}$$

Note that if the covariance between S_2 and S_3 is positive (i.e., "competing contracts"), then the second partial is positive. This result falls out due to the two-contract case. However, if the "other" contract is considered a portfolio of other contracts, then one has a statement regarding the general direction of other related contracts.

The change in Q_{2t}^* brought about by F_2 and T_2 will be negative with changes in $E(S_2)$ positive. Indeterminacy, at least from the second-order conditions, will result for the cross prices. The same results hold for Q_{3t}^* .

3.7.2 Results for Covariance Between the Two Futures Prices

Solving for the change with respect to the covariance between 2 and 3 one gets

$$\frac{\partial Q_{2t}^*}{\partial \sigma_{23}} = \frac{-(\Delta^2)_{Q_{3t}^*} \sigma_{33} + \Delta^2 Q_{2t}^* \sigma_{23}}{|H|}$$

$$\frac{\partial Q_{3t}^*}{\partial \sigma_{23}} = \frac{-(\Delta^2) \sigma_{22} Q_{2t}^* + \Delta^2 \sigma_{23} Q_{3t}^*}{|H|}$$

Both are indeterminate.

3.7.3 Results for Futures Variance

The changes with respect to the change in the variance of the futures price underlying one of the futures contracts are as follows. One would expect that if traders are

risk averse that if the variance underlying one of the futures contracts increases, then the contract becomes less desirable to the trader who was holding a positive position. Further, if the covariance between the contracts is positive, as before, one would expect an increase in the other contract.

$$\frac{\partial Q_{2t}^*}{\partial \sigma_{22}} = \frac{Q_{2t}^* \Delta^2 \sigma_{33}}{|H|} < 0$$

$$\frac{\partial Q_{3t}^*}{\partial \sigma_{22}} = \frac{-Q_{2t}^* \Delta^2 \sigma_{23}}{|H|} > 0 \quad \text{if both } Q_{2t} \text{ and } \sigma_{23} > 0$$

The signs are as expected.

3.8 Summary of the Comparative Statics Results for the Trader

For the trader, two main results fall out.

1. Trading decreases as the transactions costs increase
2. Trading decreases in contracts as their variance increases. Trading should shift toward the other contracts in the family.

3.9 SUPPLY AND DEMAND ANALYSIS

The analysis up to this point has described the supply and demand curves and how these curves shift in response to changes in the exogenous variables. Of final importance to this study, however, is the interaction of these curves. It is the interaction that determines the equilibrium level of contracting, and it is the equilibrium level that determines how successful a contract is. It is certainly important to develop hypotheses regarding how one trader will respond to a given change in an exogenous variable. However, if the other agent in the model responds in the opposite way, then the effect upon the equilibrium is not clear. For instance, one often sees in the literature statements that the change in a certain variable will lead to increased contract usage because hedgers will have a greater need to enter futures contracts. Assuming that the hedger's supply curve does shift out in response to the change in the variable, it is not clear that the contract usage actually increases if the trader's curve shifts inward due to the change in the variable. It is incorrect to only consider one side of the market when the variable of interest is the equilibrium value.

In this model it is the interaction of all three agents that determines the equilibrium level of usage. The critical question in developing a set of refutable hypotheses centers on unambiguous movements in the equilibrium value. In a sense, the analysis requires combining the comparative statics results of the agents in the model. As it turns out, it is either the case that any of the variables involving the spot price, such as σ_{11} or σ_{12} , do not affect the trader (since he has no stake in the spot position) and one can thus observe the comparative statics of the producers alone, or the trader's and the producer's supply and demand curves shift in the same direction for

the other variables (this is apparent from observing the relevant comparative statics results). In either case, the comparative statics results already listed lead to statements regarding unambiguous shifts in the equilibrium. This leaves a final set of hypothesis.

1. The overall usage of a futures contract decreases as the variance of the spot commodity increases.
2. If the futures position of the producer is positive, then overall usage of a futures contract will increase as the covariance between the spot and the futures price increases. If the position is negative, the futures usage declines as the covariance increases.
3. Overall usage of a futures contract declines as the variance of the contract increases. Trading should shift toward other contracts.
4. Overall usage of a futures contract decreases as transaction costs increase.
5. Changes in futures usage depend upon changes in terms such as H_{12} and H_{33} .

Chapter IV

Empirical Analysis

4.1 *Introduction*

Traditionally, there has been a great emphasis in the fields of economics and finance on the idea that a theory's validity and value rest upon its empirical support. However, work in these fields suffers from the dilemma of the need to test one's theory on one hand, and the virtual impossibility, on the other, of perfectly and unambiguously performing these tests. As a result of this inability to 'cleanly' test one's model, the transition from theoretical work to empirical work often leaves parts of the theory lying in the wake.

Given that one cannot perfectly test a theoretical model, one cannot say that empirical tests provide either perfect support or perfect lack of support. For this research, it is suggested that support for the theoretical model can come on two levels. If one were to describe a pecking order for this, a strong form of support would be implied by the empirical verification of the specific hypotheses laid out in the previous chapter with respect to both sign and significance. Additionally, strong support would also

be implied by the significance of variables, for which the sign is an empirical issue, if the variables were not previously considered in the literature on contract success. The theory still has value for merely suggesting that a role for the variable exists.

A semi-strong form of support would be implied by the statistical significance of variables that support the general framework of the theoretical model and its emphasis upon a portfolio framework. The significance of variables supporting the cross-contracting framework is important even if the direction of the relationship indicated by the model may not be verified, or the direction of the relationship may be contrary to that determined in the model. The incorrect sign can always be due to problems in accurately testing the model.

4.2 *Overview of the Empirical Section*

The purpose of this chapter is to develop the way in which the theoretical model will be empirically tested. The results of the tests are the subject of the next chapter. The theoretical model, as described in the previous chapter, establishes a general framework for the empirical work in this dissertation. As a basic description, the theoretical model describes the utility maximizing behavior of the major individual participants in a futures market as changes occur to the set of variables they face in making their participation decisions. The model places the participants in a very broad and general market setting that corresponds well with the most recent theoretical work in this area, such as Anderson and Danthine, and the mathematical analysis

is a very natural extension of the work on decision making in an uncertain world originated by Sandmo and Feder, Just, and Schmitz.

The very structure of the theoretical model leads very naturally to empirical testing. Theoretically, it looks at changes in one set of variables that are caused by changes in another set of variables. Empirically, the same thing can be done. The participants described in the theoretical model correspond well to the real-world participants, whose behavior is empirically observable. This observable behavior is the basis for the dependent, or endogenous, variable. Finally, the exogenous variables drawn out in the theoretical section are also generally observable in an empirical sense. In essence, the theoretical section provides a map for the empirical section. The work in this section first develops the variables suggested by the theoretical section, and discusses their specific measurement. Following that, is a discussion of how these variables are used in the statistical tests. Concluding this chapter is a discussion of the contracts used and the data sources.

4.3 *Variable Development*

4.3.1 *Scope*

The theoretical section makes its first contribution to the empirical section in its emphasis upon a portfolio approach. Actually, though, this contribution presents a problem that needs to be handled before discussing the variables. The agents in the

model face two futures contracts. Conceivably, though, any contract traded on any commodity in any exchange could be employed by the agents. Therefore, while only two futures contracts are described in the theoretical model for simplicity, one could argue that in practice traders or producers face literally hundreds of 'related' contracts. Empirically, then, all these possible contracts need to be accounted for. However, the number of exogenous variables in the variance-covariance matrix alone would be well into the hundreds. Thus, there is a need to somehow scale down the size of the problem being faced.

The situation is actually more tractable because traders traditionally work their spreads within smaller groups of very closely related contracts. Producers also tend to economize by employing contracts within these specific small groups. That is, despite a fairly broad universe of contracts available, agents in futures markets tend to limit their scope and stay within these groups. These groups of closely related contracts are often referred to as families, and examples include the grain family or the metals group. The contracts within these families are treated as though they constitute the complete set available to traders and producers. It is assumed that the corn producer is not hedging his production via, say, the gold contract. Rather, he is only entering contracts within the grain family. This is a somewhat greater limitation on the trader as opposed to the producer.

4.3.2 Variables

Having focused the empirical interest on one family of contracts at a time, one can now turn to the measurement of the variables in the empirical model. The compar-

ative statics are, in essence, the core of the theoretical section. They are the tool used to explore the mathematical model. Thus, they logically form the basis of the empirical section. First, they are used as a basis for developing the set of dependent and independent variables. Consider, as an example, the following comparative static result from the previous chapter.

$$\frac{\partial Q_2^*}{\partial \sigma_{11}} = \frac{(-1)^3(-\Delta Y)[(-\Delta\sigma_{12})(\Delta\sigma_{33}) - (-\Delta\sigma_{13})(\Delta\sigma_{23})]}{|H|}$$

as a first linear approximation, this can be rewritten as

$$dQ_2^* = (\Delta^3)(Y)\left[\frac{\sigma_{13}\sigma_{32} - \sigma_{12}\sigma_{33}}{|H|}\right] d\sigma_{11}$$

This implies that the change in the futures usage (dQ_2) brought about by the change in the spot variance($d\sigma_{11}$) is some function of parts of the variance-covariance matrix, a measure of production for the spot commodity, and the unobservable risk aversion coefficient.

4.3.2.1 Dependent Variables

First, consider the left-hand side of the equation. In the theoretical model, the futures position of an agent is the number of contracts which the agent has outstanding. This corresponds in practice to 'open interest' statistics. Open interest statistics describe the number of contracts entered into and not yet liquidated or delivered upon at the time the statistics are collected. These statistics, then, become the dependent variables; it is their behavior that will be explained. Open interest statistics are generally

published on a daily basis by the exchanges. However, their reporting is merely a total level with no regard to the size of the position by the type of user.

The Commodity Futures Trading Commission, though, publishes monthly statistics for many commodities with the open interest of large traders broken down into whether the contract is being used to hedge or not and within the two groups of traders whether the position is long or short. These statistics are far superior for the purposes of this research as they correspond quite well with the endogenous variables described for the individual agents in the theoretical model. Empirically, then, the open interest statistics published by the CFTC will correspond to Q_2^* etc. from the theoretical model.

In the theoretical model, an emphasis is placed on the ability of agents to take short or long futures positions in order to reach their optimal overall position. Previous empirical work generally has combined the long and short positions. This is not done here in the interest of capturing movements from long to short positions and vice versa. For instance, suppose that a hedger moves from a long to a short position due to changes in the exogenous variables. If one simply adds the long and short positions together, then the dependent variable would not change when indeed a change was occurring. Because of this concern, which is highlighted in the theoretical model, long and short positions will be used as the dependent variables in separate models.

4.3.2.2 Independent Variables

The right-hand side of the comparative static suggests the nature of most of the exogenous variables in the empirical testing. Also included in the exogenous variables are transactions costs. Note, that most of the variables that fall out of the comparative statics results are members of the variance-covariance matrix. Specifically, this work will consider the following two sets of variables from the variance-covariance matrix:

1. The individual members of the variance-covariance matrix. The effect of these variables upon the open interest positions is certainly the main concern of this research. These variables form the basis of many of the hypotheses formed in the previous chapter.
2. The various cofactor matrices divided by the hessian matrix appear frequently in the comparative statics. Despite their lack of obvious interpretation at first sight, their inclusion is for the proper specification of the empirical model. However, the variables are not without a well-known interpretation. Consider, for instance the following variable

$$H_{12}/H$$

The value for this variable is very close to the value, b , determined in the regression

$$S_1 = a + b F_2 + c F_3 + \varepsilon$$

The analogous coefficient in a regression with only one independent variable has been called the estimated hedge ratio and holds an important position in futures literature in determining the optimal level of hedging. It is interesting, and perhaps empirically important, that the model should highlight the importance of the corresponding multi-variate coefficient in determining contract usage. When more than one futures contract is in the agent's set of vehicles, the parameter of relevance according to the theoretical model is related to the coefficient from a multiple regression. This result is also arrived at in work by Anderson and Danthine (1980).

In addition to these two types of variables, these following variables serve to capture the other terms in the theoretical model that appeared important in determining a contract's usage.

The transactions cost component plays a role in the theoretical model, yet the costs are not explicitly delineated. Although there are several traditional components of transaction costs, this work will focus on the contract's liquidity and on the availability and costs of spreading opportunities. That is, the transactions costs measured here do not reflect the out-of-pocket costs, rather, the bid/ask spread. A contract's liquidity will be measured by its volume of trade. The monthly total volume of the month proceeding the open interest date will be used as the measure. The liquidity factor is of particular interest as it is often cited as the critical element in a contract's dominance. However, there are certainly exceptions and thus this research has a strong curiosity in the effect liquidity has on contract usage after accounting for other factors.

The spreading opportunities, which are probably more relevant for the trader than the producer, center on the ability to access closely related contracts. If one imagines a trader attempting to institute a gold-silver spread, it is quite possible that the liquidity in one contract affects his behavior in the other. Is the trader more likely to enter a gold contract when he knows that he can "lay it off" easily in the silver pit. Suppose one exchange has a viable silver pit and another a slow pit. Then the trader on the latter has to incur either the costs of going across exchanges or the less liquid pit. The spreading opportunities are measured by the liquidity of related contracts. Inclusion of this variable picks up the trader's spreading opportunities.

The final variable suggested by the model as being important in the level of open interest is the Y variable. Simply, it is the level of production for the spot commodity. Its measurement will be taken up in the Data section of this chapter.

In sum, then, the variables suggested by the theoretical model to be used in the empirical work, can be described as

Open Interest = $F(\text{variance-covariance variables, transaction costs, production})$

4.3.3 Developing the Variance-Covariance Variables

There is a problem with the form of the data that prevents continuing straight from a discussion of the variables to a discussion of the actual specification of the empirical tests. A major contribution to the empirical work stems from the general structure of the model, and its emphasis on cross-contracting. This emphasis forces one to

empirically recognize that, say, the wheat open interest statistic, which is an aggregate measure, need not contain only the positions of wheat hedgers.

Although the CFTC data provides a measure of the position of hedgers in specific futures contracts, it does not indicate the specific spot commodity which is being hedged. The hedger's short open interest statistic on the corn contract may reflect the interests of several different agents. One cannot know whether the hedgers are wheat producers who are cross-hedging or corn producers hedging. Unfortunately, with aggregate data one cannot empirically isolate the position changes of the corn producer or any other producer. That is, it is possible that

$$Q^*(\text{wheat contract, hedger}) = f(\text{wheat hedger, corn hedger, barley hedger})$$

The problem arises in that the theoretical model assumes that there is a single spot commodity. This spot market price is used in computing the members of the variance-covariance matrix which play a role in the comparative statics. The inability to determine exactly what spot commodity is being hedged makes computation of the variance-covariance matrix problematic. With it unclear as to which is the real spot commodity, the question arises as to which spot price is used to compute the variance-covariance matrix. It seems natural when considering, say, the wheat contract, to assume that the wheat spot price is principally driving the wheat futures usage level. However, to assume this, *a priori*, flies in the face of the model which is based upon a very general theory of cross-hedging.

The theoretical model, however, suggests a solution to this problem. Suppose that there are only two contracts in the family being considered, corn and wheat. Note

that for, say, the corn producer there are comparative static results showing the change in both his position in the corn contract and his position in the wheat contract brought about by a change in an exogenous variable.

If one is empirically viewing the wheat contract, then one has to consider the comparative static result obtained from the corn producer that dealt with his participation in the wheat contract, as well as the more obvious comparative static dealing the wheat producer's participation in the wheat contract. Thus, in this case, for a change in the dependent variable, Z

$$\frac{\partial Q_{wheat}^*}{\partial Z} = \frac{\partial Q_{wheat \text{ producers position in wheat}}^*}{\partial Z} + \frac{\partial Q_{corn \text{ producers position in wheat}}^*}{\partial Z}$$

Similarly, when observing the corn open interest statistic, the change in the wheat producer's corn position brought about by the change in the exogenous variable also needs to be considered, along with the changes in the corn producer's corn position. This example demonstrates how the theoretical model delineates quite clearly that for each producer of the spot commodity, and for every exogenous variable that this producer faces, there is a response in regard to each of the other futures contracts. Thus, when one considers an aggregate open interest statistic, any of the variables faced by any of the producers can conceivably have an effect on that open interest level.

This inability to discern the exact spot commodity in the open interest statistic can be controlled by considering the spot price of each commodity in the family as potentially the correct spot price. One could then build a variance-covariance matrix based upon each spot price. The question then becomes whether or not variables

from one of the matrices are empirically important in determining the level of open interest.

Returning to the example, imagine that one is viewing the corn futures contract. Suppose, for some reason, that wheat cross-hedgers dominate the corn contract, and it is the covariance between the wheat spot price and the corn futures contract that is moving the open interest for corn. Then, the critical variable would come from the matrix constructed using wheat as the spot price. In these tests, this possibility is allowed for by constructing a variance-covariance matrix using wheat as a spot and seeing if variables from this matrix have any affect on the corn open interest. In this manner, although one can not determine exactly which spot is underlying a futures contract, each is tested to see if it has significant explanatory power for the open interest. Note that this is not a problem from the trader's perspective as it is assumed that he holds no spot position.

4.3.4 Estimation of Variance-Covariance Matrix

To explain the development of the variables based on the variance-covariance matrix, imagine now that there are three futures contracts in the world, A, B, and C, with futures prices represented by F_A , F_B , F_C . Underlying the three futures contracts are three spot contracts with spot prices S_A , S_B , S_C . The first step is to obtain the daily spot and futures prices for each contract.

This file is the main input file. The next step is to use this data and develop the variance-covariance estimates. Each estimate is made using daily prices during each

one month period. Three matrices are computed using each of the three spot prices as the base. Thus, three separate variance-covariance matrices are estimated for each month.

matrix 1 is formed from $S_A \ F_A \ F_B \ F_C$

matrix 2 is formed from $S_B \ F_A \ F_B \ F_C$

matrix 3 is formed from $S_C \ F_A \ F_B \ F_C$

In this example, each of the three variance-covariance matrices would be four-by-four. Specifically, looking at the variables in matrix 1

σ_{11} = variance of spot price A

σ_{12} = covariance between spot price of A and futures price of A

σ_{13} = covariance between spot price of A and futures price of B

σ_{22} = variance of futures price of A

σ_{33} = variance of futures price of B

σ_{23} = covariance of futures price of A and futures price of B

Similar sets of monthly variances and covariances are formed from the other two matrices. In this manner, every variable that may affect each of the producers is estimated. It should be noted, though, that many of the relationships are clearly redundant.

Over time, a series of the monthly variance-covariance estimates is acquired. Each month's variance and covariance estimates are also used as inputs to develop monthly hessians and cofactor matrices. Hence, the daily prices are used to develop the components of the three monthly variance-covariance matrices and the components of the matrices are then used to compute values for the monthly hessian and cofactor matrices.

The same procedure is followed for the trader with the exception that only futures prices are employed and no spot price is used so there is only one matrix formed for the variance-covariance variables. The remaining variables, though, are the same as the producer. That is, the trader's variance-covariance matrix is a subset of the producer's.

4.4 *Model Structure*

Most generally, the interest of this research is in performing a time series analysis with the monthly open interest statistics being dependent on the variables from the variance-covariance matrix, aggregate production, and the transaction costs as measured by liquidity and spreading opportunities.

4.4.1 Equation Structure

The empirical equations are an extension of the total derivatives formed via the comparative statics.

$$\text{change in open interest} = dQ^* = \frac{\partial Q^*}{\partial \sigma_{11}}(d\sigma_{11}) + \frac{\partial Q^*}{\partial \sigma_{12}}(d\sigma_{12}) + \dots$$

where, for example, $\frac{\partial Q^*}{\partial \sigma_{11}}$ represents the comparative statics developed in the previous chapter.

As previously discussed, technically, these equations are very long since the tests are performed with aggregate data. Returning to the example of the family of contracts that consists only of corn and wheat. It should be noted that, for instance,

$$\text{change in wheat open interest} = dQ_{\text{wheat hedger}}^{\text{wheat}} + dQ_{\text{corn hedger}}^{\text{wheat}}$$

Where, for instance, $dQ_{\text{wheat hedger}}^{\text{wheat}}$ represents the change in the wheat producer's wheat open interest position brought about by changes in all of the exogenous variables, i.e., the total derivative.

This clearly leads to an empirical problem with the number of independent variables. In a group of three contracts alone, each contract's open interest is a function of twelve unique variances and covariances and along with that are an even greater number of hessians and submatrices plus the the variables for volume and aggregate demand. This large number of independent variables is a sufficient problem with a large number of observations; however, this research is not so fortunate to have a very large number of open interest observations.

One of the costs of using the CFTC data is that it is monthly and our number of observations is limited. Thus there is the problem of paring down the set of independent variables. Since each variable is theoretically relevant, but the number of independent variables needs to be limited, a careful application of the SAS stepwise and SAS forward elimination is justified to determine which subset of variables contains the most explanatory power.

4.4.2 Equation Form

Another consideration is the form of the equations. In viewing the comparative statics result, one sees that the various exogenous terms enter multiplicatively. Consider the following comparative static result from the previous chapter

$$\frac{\partial Q_2^*}{\partial \sigma_{11}} = \frac{(-1)^3 - \Delta Y [(-\Delta\sigma_{12})(\Delta\sigma_{33}) - (-\Delta\sigma_{13})(\Delta\sigma_{23})]}{|H|}$$

Which can be rewritten as

$$\Delta Q_2^* = [(\Delta) \times (Y) \times (H_{12}) \times (1/|H|)] \times \Delta\sigma_{11}$$

The theoretical model suggests that these variables are interactive with each other. Empirically, then one can expect to see, say, the size of the aggregate production affect the effect that a change in σ_{11} has on Q_2^* .

As such, a log-log model is a reasonable beginning specification to account for the suggested form. There is a problem in that not every variable that would be included in the regression equation is actually multiplied by each other in the theoretical form. The comparative static results are multiplicative; however, the total derivative is formed by adding together the individual comparative statics results. Thus, to arrive at the final form of the test equation the sets of multiplicative terms are being added together. Strictly speaking, it is not proper to take the log of an equation of this form; however, it is a reasonable first order approximation.

An additional problem with the log-log form is that, although the estimation uses the levels of the variables over time and not the changes over time, it is possible for certain exogenous variables to be negative. For instance, the variances cannot be negative; however, the covariances can be. If the value of the variable to be logged is negative, then the negative of the log of the absolute value of the variable is used. This approach correctly preserves the changes in the variables as long as the value of the variable to be logged does not fall between -1 and $+1$. In this range, the ordering is not preserved. In tests in which values falling between -1 and $+1$ occur, the variables are multiplied by a fairly large constant which eliminates the order preserving problem that occurs between -1 and $+1$.

Another factor to consider concerns the timing of the agents' behavior. It is not, of course, clear whether agents act upon contemporaneous or past information. As it is an empirical question, both lag and non-lag specifications are considered in the empirical testing.

A final consideration from the theoretical model concerns the simultaneity of the equations. The theoretical model treats the decisions to enter the two futures contracts as made simultaneously, or as a system of equations. The effect empirically of treating simultaneous equations as single equations is the autocorrelation in the residuals. Ultimately, the extent to which the simultaneity is a problem is an empirical question. The model points out, however, that the problem exists and should be considered.

4.5 *Data and Families Considered*

While the form of the data limits, or defines, the types of tests performed, the existence of the data determines which of these tests are performed. As this research is interested in tests that are as general as possible, and as such the interest is in families that satisfy the idea of closely related contracts with some contracts in the family that did well and others that did not. Further, there should be minimal seasonal components and government price interference. While there are several families that met these standards, data availability proved to be limiting.

The most limiting data feature was that the futures positions for contract of interest was either not kept by the CFTC or that the contract was not listed long enough, or on a regular enough basis, to acquire a meaningful sample size. The second major limitation was the non-availability of daily spot prices. For instance, the Forest Products family appeared as though it would meet all the conditions with the exception

that daily spot prices are not in the public domain. A further limitation of the CFTC data occurred because the CFTC kept no open interest statistics at all for most of 1982. This meant that usable contracts also had to have a sufficient number of observations either before or after this period.

Despite these problems, several groups remained as reasonable candidates. The first is the Financial Instrument family in the 1978-81 period, which covers the period of their genesis, and the Financial Instrument family in the 1983-85 period which was a period of rapid growth, and the Metals group for the 1983-1985 period. These sets of contracts best meet our requirements as they tend to be non-seasonally produced, closely related, contain successful and unsuccessful contracts, have minimal government interference, and have the necessary data available.

4.5.1 Financial Instruments (1983-1985)

4.5.1.1 Contracts

The members of this family are from the Financial Instruments group in the period following the continuation of the open interest statistics by the CFTC. Five distinct contracts are used in these tests. The first three contracts are short-term, the fourth is medium term, and the fifth is long term. This set of contracts, in this period, provide a mix of successful and unsuccessful innovations and established contracts.

1. Treasury-Bill, U.S. 90 days, Contract (T-Bill) on the International Monetary Exchange(IMM)- This contract has existed since the original innovation of financials and in this period maintained a steady rate of usage.
2. Certificate of Deposit Contract, 90 day, (CD) on the IMM- This contract was introduced in 1981 and, in the 1983-1985 period, experienced strong growth and then fell off substantially.
3. Eurodollar, 3 month, Contract (Euro) on the IMM- This contract was innovated after the 90-day CD contract and experienced rapid growth in this period.
4. GNMA, Mortgages, Contract (GNMA) on the Chicago Board of Trade (CBT)- This contract was one of the originally inaugurated financial contracts. In the period considered here it gradually died out.
5. Treasury Bond Contract (T-Bond) on the CBT- This was another original financial futures. It is the primary long-term contract and is the most used of all the financial contracts in this period.

4.5.1.2 Data Sources

1. Futures Prices- All futures prices for contracts traded on the IMM were obtained from the IMM Yearbook which later was absorbed into the Chicago Mercantile Exchange Yearbook when the IMM became a subsidiary of the CME. Futures prices for CBT contracts were obtained from either the CBT tapes or the Chicago Board of Trade Statistical Annual. The CBT tapes were used to obtain the futures

prices on all CBT contracts of interest up to midway through 1984. All data not obtained from these tapes was entered by hand.

For each contract there are a set of futures prices corresponding to the different delivery months. The futures price used for this study is the price that corresponds to the contract with the closest delivery month, or the 'near-by' contract. This price was used with two exceptions. The first is when the date for which the price is being gathered occurs in the delivery month. In that case, the next near-by contract is switched to. This is an attempt to avoid any odd-pricing behavior that occurs in the month the contract expires. The second exception is when the near-by contract does not fall on the traditional cycle. Most contracts are traded with traditional delivery months; typically, four a year. Occasionally, exchanges will add contract months. These added contracts are not usually heavily used and do not reflect the price at which most participants are trading. In this case, the next traditional delivery month contract is used.

2. Spot Prices- The 3 month CD, 90-day U.S. T-Bill, and 3-month Eurodollar rates were obtained from the IMM Yearbook or the Chicago Mercantile Exchange Yearbook. The GNMA spot rate was gathered from the 'GNMA 8%' rate available in the CBT Statistical Annual and the 'U.S. T-Bond, 9%' from the same source was used for the T-Bond spot rate.
3. Contract Volume- All contract volume data was obtained from the respective statistical annuals.
4. Aggregate Production- The aggregate variables for T-Bills and T-Bonds are from the table 'Summary of Public Debt Outstanding' from the publication of "Monthly

Statement of the Public Debt of the United States.” The GNMA aggregate variable is obtained from the table ‘GNMA Activity’ available in the CBT Statistical Annual. The GNMA variable was used in its incremental form in these tests. Little additional explanatory power was added in further tests when the ‘Activity’ variable was summed to arrive at a stock figure. Thus, the form of the GNMA production variable seems, at this point, to be an appropriate proxy of the GNMA production level. CD’s were measured by the money supply variable M3 minus M2 as reported in the Fed Bulletin. Eurodollars were measured by Large Denomination Time Deposits from the same publication.

4.5.2 Metals

4.5.2.1 Contracts

This family consists of the metals contracts traded in the 1983-1985 period. Contracts for gold, silver, and copper are traded on the Commodity Exchange (Comex), and contracts for gold and silver are traded on the CBT.

1. Gold Contract on the Comex- Trading began in this contract at the end of 1974. It has been the dominant gold contract since its inception and maintained its position during the 1983-1985 period.
2. Silver Contract of the Comex- Trading began for this contract in 1933. Through the period under consideration, this contract has done well and has been the dominant silver contract trading.

3. Copper Contract on the Comex- Trading began for this contract in 1953. Through the period under observation it has been a successful contract.
4. Gold Contract on the CBT- This contract was introduced at the end of 1974. It maintained a modest level of usage; however, it began to die out and was no longer listed in the CFTC open interest statistics by April of 1985.
5. Silver Contract on the CBT- This contract was introduced in 1969. It maintained a reasonable level of usage through the period under consideration; however, it was typically second in use to the Comex silver contract.

4.5.2.2 Data Sources

1. Futures Prices- All futures prices were gathered from either the Comex Statistical Yearbook, the CBT Statistical Annual, or the CBT tapes.
2. Spot Prices- The daily spot price for gold was obtained from the Handy and Harman Base Price available in the Comex Statistical Annual. The daily silver spot price came from the Handy and Harman Base Price also available in the Comex Statistical Yearbook. The daily copper spot price came from the 'Refiner's Scrap #2' series also available in the Comex Statistical Annual.
3. Contract Volume- Monthly average contract volume were obtained from the respective statistical annuals.
4. Aggregate Production- The gold aggregate production variable was measured 'Gold Depository Stocks-total' available in the Comex Statistical Annual. The

measurement for silver used the 'Silver Depository Stocks' available from the same publication. The measure for copper came from the 'Copper Warehouse Stocks' available in the same publication.

4.5.3 Financial Instruments (1978-1981)

4.5.3.1 Contracts

The members of this family consist of the financial futures in the period prior to the discontinuation of the open interest reporting requirements by the CFTC. The concern of these tests is with the three main contracts that dominated this period. One contract dominated in either the short, medium, or long term periods. Unfortunately, the competitors for these contracts did not do well enough to be listed for a long enough period in the CFTC open interest statistics. Each of these contracts was introduced above.

1. Treasury Bill, U.S. 90 days, Contract (T-Bill) on the International Monetary Exchange(IMM)-
2. GNMA, mortgages, Contract (GNMA) on the Chicago Board of Trade(CBT)-
3. Treasury Bond Contract (T-Bond) on the CBT-

4.5.3.2 Data Sources

1. **Futures Prices-** All daily futures prices were obtained from either the IMM Yearbook, the CBT Statistical Annual, or the CBT tapes.
2. **Spot Prices-** The 90-day T bill rate was obtained from the 'New York Money Market Daily Closing Market Yield' available in the IMM Yearbook. The GNMA daily spot price was obtained from the 'GNMA 8%' available in the CBT Statistical Annual. The T-Bond spot rate came from 'U.S. Treasury Bond 8%' available in the CBT Statistical Annual.
3. All monthly volume statistics came from the respective statistical annuals.
4. **Aggregate Production-** The aggregate production level for the 90-day T-Bill and the T-Bond were obtained from the 'Maturity Distribution and Average Length of Marketable Interest-Bearing Public Debt Held by Private Investors' available in the Treasury Bulletin. The measure for the GNMA is obtained from the 'GNMA Activity' available in the CBT Statistical Annual.

Chapter V

Results

5.1 *Introduction*

The purpose of this chapter is to present the results of the tests developed in the previous chapter. The emphasis of the empirical work is on estimating the time-series response of the open interest statistics to the various exogenous variables. In the three groups of contracts discussed in the last chapter there are a total of 13 contracts observed. For each contract, the open interest statistic is broken down into long and short positions for the trader and long and short positions for the hedger. Thus, for each contract discussed in the previous chapter, there are actually four separate independent variables and, hence, four separate regressions. There are a total of 52 regression estimates.

The results of the estimations strongly support the theoretical model and its emphasis upon a portfolio framework. While there is strong indication that the fundamental question of what factors determine the usage of a futures contract should be approached from the portfolio perspective, the results do not indicate a specific set of

variables across the many equations that uniquely determine usage. That is, one can not observe the results and say that a contract can succeed only if a set of very specific relationships hold. The failure of the tests to delineate a clear universal framework to describe futures usage is disappointing; however, there still exists a fair amount of underlying structure to the estimates, and the set of estimations yields quite useful, and somewhat surprising, results which are certainly unique to this study and lay a strong foundation for future research in this area.

The results of the regression estimates are presented in table form in the appendix. For presentation purposes, the results of these estimations are broken down, first, by the three groups developed in the previous chapter, and within each group, the estimation results for the observed contracts are presented for each type of producer. The results of treating the equations in a family as a system of equations are presented at the end of the regression results.

5.2 Estimation Technique and Variable Selection

5.2.1 Variable Selection

As discussed in the previous chapter, the underlying structure behind the empirical tests is such that there are potentially many exogenous variables that can have an impact upon a contract's open interest. One approach to this situation would be a straightforward regression of all the possible independent variables against the relevant open interest statistic. However, given the limited number of observations

available, such a procedure would yield meaningless results. Another possibility is to rely upon one's intuition, or perhaps conventional wisdom, to help select the set of independent variables with the most explanatory power while maintaining a sufficient number of degrees of freedom to yield statistically significant results. However, selecting variables in this manner would be improper in light of the theoretical section and, as it turns out, not a particularly accurate way of determining which variables wield the most explanatory power.

In light of the need to select the primary contributing independent variables from a large group of theoretically justified variables and with no other means of *apriori* paring down the number of independent variables, a cautious use of computer generated selection techniques seems to be a reasonable solution. Both Stepwise and Forward selection techniques were used to delineate those variables with the most explanatory power. Typically, the set of variables selected by the Stepwise technique was a subset of the set selected by the Forward procedure. The different sets were considered to determine which set more efficiently explained the changes in open interest.

The overall robustness of this technique was considered and the procedure fared well. Typically, the significance of the set of variables stayed the same after deleting observations. If the variables most commonly associated with explaining open interest, such as underlying spot variance or contract volume, were missing from the set of variables yielded by the selection technique, they were added to the regression to observe their impact upon the regressions. With the other variables in the equations, the added variables continued to be insignificant, and did not affect the significance of the existing variables.

The equations used for the empirical analysis employed the variables selected by these techniques. Not all of the variables chosen in this way are significant in OLS estimates because the selection process was allowed to "err" on the side of identifying too many variables. However, despite their insignificance, they were kept in the estimations in order to maintain consistent variable selection across the many equations estimated. Finally, while there are problems associated with these selection techniques, one would expect that over the 52 applications the individual selection errors in the techniques would be dominated by the underlying true factors. If a variable is important in explaining open interest across many equations, it should be selected in most of the cases.

5.2.2 Equation Form

In all of the equations presented in the tables, the natural log of both independent and dependent variables was employed. The equations were also estimated using a lagged independent variable form and a non-lagged form. Obviously, the theoretical model makes no statements as to when the agents incorporate the information into their futures decisions. The non-lagged form emphasizes contemporaneous decision making and the lagged form indicates a delay in the incorporation of the data. For each equation, the stronger estimate of the two, particularly in terms of maintaining the OLS assumptions, was used. The form of test for each equation is indicated along with the estimation results in the tables at the end of the chapter. The non-lagged form is labeled simply as 'log.' In terms of frequency, the lagged form was used for

30 of the 52 equations, and strongly used in the financials for the 1983-85 period (15 of the 20 contracts). The non-lagged format was used in the remaining 20 equations. There seems to be no dominance of the form used for any one type of trader.

5.3 *Violations of OLS Assumptions*

Standard tests were performed to determine the extent of violations of the OLS assumptions and to consider their effect upon the empirical results. A situation of collinearity between the explanatory variables occurred in a few of the equations as measured by the Variance Inflation Factors. The problems stemmed primarily from the production variables used for the financials group. It is probably the case that the level of government debt outstanding was growing consistently across the different types of government debt instruments. Despite the presence of collinearity in these equations, the problem variables still generally appeared significant in the regression estimates and, thus, correcting for the collinearity seemed unnecessary.

Tests were also performed to determine the extent of the presence of heteroscedasticity in the error terms, which is conceivably more of a problem with failed contracts. Neither scatter plots of the squared error terms or tests using the Goldfeld-Quandt technique detected significant heteroscedastic disturbances.

Autocorrelation of the error terms, however, appears to present more of a problem to the empirical analysis. The standard Durbin-Watson test was used to detect first-order autocorrelation. For equations with D-W statistics in the grey zone, or worse,

the least squares estimates were approximated using a technique similar to the Cochrane-Orcutt method in an effort to correct for the autocorrelation.

In re-estimating the equations, the general indication is that the overall impact of the autocorrelation is not that significant. The R^2 coefficients tended not to decline significantly between the OLS and the Cochrane-Orcutt estimates, and the variables significant in the OLS estimates tended to remain so when re-estimated. This was not the case for all of the equations, though. Thus, for equations with clear first-order autocorrelation and for equations for which the re-estimation yielded meaningful changes in the significance of any independent variables, the results of the re-estimations are presented in the table immediately following the table with the OLS regression estimate.

5.4 OLS Regression Results

5.4.1 Overview

There are a total of 52 regression results in this section. In only two of those estimations were there no variables which provided significant explanatory power. The first is the trader-long position in the CBT gold contract group which did not yield a statistically significant overall F-statistic at the 5% level. Additionally, the traders-short open-interest equation for the Eurodollar contract yielded absolutely empty results. The remaining 50 contracts, though, provided statistically significant estimation

results. Of those, the results for the CBT gold contract are of questionable value as the number of observations is only 24.

5.4.2 R-squared results

A summary of the R^2 results appears in table 1 on page 145. One can observe that the type of trader for which this empirical model consistently yielded the most explanatory power is the long hedger. In all but five of the contracts, the long hedger yields the highest R^2 of the four types of agents. In four of the five contracts where the long-hedger is beaten, the difference between the higher R^2 and the long hedger's R^2 is negligible. Thus, in only one case of the 13 contracts, is the explanatory power for the long hedger equations clearly smaller than any other equation. Additionally, the explanatory power of the short trader dominates the long trader in 8 of the 13 contracts with the exceptions largely confined to the short term financials group in 1983-85. In the traditional context of hedgers being short in the futures contract and traders being long, it is odd that the most explanatory power in this model rests with the long hedger and the short trader. Obviously, though, this is not at odds with the very broad structure developed in this work's theoretical section and recent developments in the financial futures.

The consistency of the high explanatory power across a wide variety of contracts lends confidence to the results and to the generality of the approach employed here. For example, the explanatory power in the Comex silver and copper equations is comparable to the explanatory power in the financials. It does appear that long-traders and short-hedgers open interest statistics have more "noise" in them or that

the theory is not as accurate at depicting the influences on their behavior (again, with the prominent exception of the short-term financials).

The most explanatory power provided by the model is in the financial instruments group for 1983-1985. One could argue that the improvement in explanatory power over the financial instruments for the 1978-81 period reflects the maturity of the market. It is more probable, though, that the better results in the latter group are due to a better and more comprehensive definition of the contracts which are in the actual family, or group. The 1983-85 group contains more members of the family than did the earlier period (due to data availability problems), and so the portfolio approach is better reflected in the parameter estimates.

One can also observe that the model yields strong explanatory power for the failing contracts included in the 1983-85 financials. That the model does not breakdown on failing contracts suggests that a difference in the explanatory power does not provide a way of predicting future failures.

Thus, one implication of this study is that the level of explanatory power cannot be employed to discriminate failing from successful contracts. The economic model does as good or better at explaining participants' behavior in failing or unpopular contracts. One can also note that most of the exceptions to the relationships discussed above regarding the model having the most explanatory power for the long hedger and the short trader occur with the failing contracts. That is, in a majority of the failing contracts, the best explanatory power is achieved in the equations for traders who are long and hedgers who are short. It is as though they are an exception to the rule.

The other declining contracts among all the contracts are the CBT gold and silver contracts. The R^2 values obtained for these contracts are not impressive. Part of this may be explained by the nature of the dependent variable data. As a contract begins to fade out, the positions reported will have little change, or even have a run of no open interest at all. This was certainly the case for the CBT gold contract. Thus, one can imagine that regression results will not be too strong for such a contract.

This is one disadvantage of using CFTC open interest statistics. The CFTC statistics are useful in the sense that they correspond to the positions in the theoretical section, and they are broken down by the type of trader. Judging by the different significant variables in the equations for different agents in the same contract, the lack of significance of some classes of variables between trader and hedger, the different signs on the same or similar variables across equations, and the different explanatory power of the regressions across the types of agents, it is apparent that it is useful and appropriate to break out the different positions. Combining or netting the short and long positions or traders and hedgers would produce unreliable and misleading coefficient estimates.

However, there are problems associated with using these statistics for studying contracts that never did well or are declining quickly. The data clearly breaks down for a contract towards its final decline. Using volume as the dependent variable may help overcome this problem in future research. Additionally, a contract that does not do well is not continually reported on by the CFTC. This biases the definition of the empirical family toward containing the more successful contracts. Again, it would be

interesting to examine in future research whether using volume would help overcome this bias.

5.4.3 Variable Summary

Analyzing the results of a single regression is usually a fairly straightforward process. Describing the results of 50 regressions, though, becomes complicated. This process is even more difficult when the equations are not estimated with the same sets of variables. Indeed, one can easily become overwhelmed in the many tables of results in the Appendix. The purpose of this research was to be as general as possible, and as such, to focus on as many contracts as was empirically possible. The sacrifice of generality is that the statements made tend to be less specific. One may see that a variable was insignificant in explaining open interest in one equation and significant in another. This is not at all inconsistent as the two estimates are viewing different traders in different situations. What one should consider in this situation is the pattern, or lack of pattern, in the estimation results.

In observing the nature of the significant exogenous variables across the tests, there is strong support for the theoretical model on all levels. The results indicate that the portfolio framework is clearly an appropriate way to consider the determinants of open interest. Perhaps, though, an equally important result in these tests is the indication that the variables so often mentioned in the literature as essential to contract success, such as spot variance, own volume, and spot to futures covariance, do not seem to play as critical a role when the open interest is modeled in a portfolio setting.

The regression results presented in this chapter are strong enough, for the most part, to stand on their own merits as individual estimations. However, as a group of estimates their seeming weakness is that they do not yield what could be described as a clear, or universal, pattern across the many contracts. By a clear pattern, that is, one cannot observe the test results and specifically say that a contract having a certain set of traits will be heavily, or lightly, used. Although it is not at all obvious that one should expect to see such a pattern, it would indicate much stronger empirical results if, for instance, one could note that certain variables were consistently significant in all failing contracts, or perhaps, that the long and short trader's estimations for the same contract contained the identical set of significant variables. Such statements cannot be made from these regressions. Instead the conclusions drawn here rely on the more general patterns of results which will be discussed.

That is not to say, though, that there exists no sense of inter-relationships across the equations. Consider, as an example, the short-term Financial Instrument contracts traded in the 1983-1985 period: T-Bill, CD, and Eurodollar contracts (see tables 27 through 32 on pages 171 through 176). These three contracts can be described as very closely related contracts as each has underlying it a 90-day debt instrument. Over this period, the Eurodollar contract literally exploded in use while the T-Bill contract slowly began to fall off and the CD contract quickly failed.

Notice that in both the short and long Eurodollar open interest equations that the CD production variable yields a very strong positive influence. In both the long and short producer's CD open interest estimate, the influence of the CD production variable is strongly negative. The same applies for the T-bill producer's short equation. Thus, in 5 of the six equations, this one aggregate measure of debt outstanding appears

highly significant. Further, as it increases, the CD and T-bill contracts decline and the Eurodollar contract increases.

The Eurodollar production variable is significant in four of the six equations. Interestingly, three of the four are the short equations. The volume in the CD contract appears significantly in both the hedger long and short for both the CD contract and the Eurodollar contract. It as though the rapidly failing CD contract is spilling into the rapidly succeeding Eurodollar contract. Notice also that a measure of the covariance between the T-bill contract and the CD contract, the two failing contracts, appears significantly in five of the six hedger equations. The exact interpretation of this variable is difficult; yet, it is remarkable that it should be significant to virtually all of the hedgers in these three contracts.

If one considers the two remaining hedgers in the financials group in 1983-85 (see tables 29 and 33 on pages 173 and 177) it can be noted that both long and short GNMA hedgers respond significantly to the variance of T-Bonds, GNMA volume, and H_{11} . Both of the T-bond hedgers also respond significantly to GNMA volume.

Similar effects run through the five relevant regressions for the traders in these contracts (recall that the short Eurodollar trader inexplicably yielded no results). Notice, that the variance of the GNMA contract enters significantly in four of the five equations. Its effect is negative except for the Eurodollar long estimate. Recall, that the Eurodollar contract is the one contract to succeed. Notice also that the covariance between CDs and T-bonds enters significantly in three of the five equations.

In sum, while there is not universal consistency across the equations, there is clearly an element of consistency across the equations given in this example. One could continue in this vein; however, the interpretations to be made from it are questionable, and certainly border upon the storytelling approach that this research wished to avoid. Thus, the conclusions drawn in this research will rest more upon an overall summary of the empirical results.

5.4.4 Specific Variable Results

This section will consider the outcomes of the variables described in the theoretical section. The approach in this section is to summarize the presence of the various types of variables across the fifty remaining regression estimates. The discussion is ordered to first consider the three main variables attributed to contract usage in the literature: spot price variance, futures price variance, contract volume. This is followed by discussion of the exogenous variables more particular to these tests and the portfolio framework.

5.4.4.1 Variance of the Spot Commodity

There are two results in this section which are of interest. The first is that the variance of the spot commodity appeared significant in determining hedger's open interest at the ten percent level in only four of the 26 equations: the hedger-short T-bill(1978-81), the hedger-long GNMA(1978-81), the hedger-long T-bond(1978-81), and

the hedger-long GNMA(1983-85). Only the estimate for T-bond contract is significant at the 5% level. The GNMA(1983-85), however, is fairly close to significant at this level ($Prob > |T| = .057$). For future reference, contracts with a probability below .055 will be rounded downward. Further, the T-bill contract did not remain significant at 10% after adjusting for autocorrelation.

While the number of times the variable appears significant is approximately twice what would be expected by chance in a sample of 26, the relative infrequency with which the spot variance appears (compared to other variables with a much less prominent place in the literature) seriously draws into question the role of spot price variance in futures decision making. It is possible, however, that the effect of the spot variance is being transmitted through other variables in a manner which is difficult to detect. It is also possible that the method of estimating the spot variance for this research is inadequate. However, all of the members of the variance-covariance matrix were estimated in the same manner with similar data and other members of the matrix appeared significantly in the estimated equations with much greater frequency (which will be discussed later).

One curious result is that in three of the four hedger's equations with a significant spot variance, open interest actually declined as the variance increased. This is the outcome predicted by the theoretical model. As can be recalled, while the increased variance increases the producer's incentive to hedge, the increased risk also brings about a reduction in production levels which decreases the need to hedge. The net effect in the theoretical model is that futures contracting declines as the spot variance increases. Observing this in three of four equations certainly does not provide definitive proof for the hypothesis developed in the theoretical section, but it does

strongly support the concept that if there is a role for spot variance, it is negative which is in contrast with accepted dogma. In general, though, the spot variance may not be as crucial as thought in determining contract success. This is particularly so when other variables are accounted for.

5.4.4.2 Contract Volume

Open interest has traditionally been closely associated with volume. Further, the building of volume is often given as the prime essential for a successful contract. The results of this empirical work indicate that volume is, indeed, a fairly important variable in explaining contract usage; however, the results show that the importance of own-volume (as opposed to a related contract's volume) is somewhat overemphasized.

Own contract volume appeared significant at the 10% level in thirteen of the equations, and significant at 5% in ten of those thirteen equations (for the 5% level, this is four times more than expected by chance). Again, while certainly as prominent as the most important of the other variables considered in this study, own-volume does not have as dominant an effect as one would have expected according to conventional wisdom.

In all of the estimations of financials contracts where volume is significant, the relationship between volume and open interest is, as expected, positive. In the metals group, though, volume explains the open interest much less frequently as only three of the contracts have volume significant at 10% and only one of the three at 5%.

More interestingly, though, the signs indicate that open interest declines as volume increases. While this is curious, it is not entirely unexpected. One can observe even from casual observation of open interest and volume statistics for the metals group that over the period observed these two variables do not move together. It may be the case that once volume reaches a certain level, it ceases to affect open interest. This is questionable as the gold and silver contracts on the CBT which both experienced strong declines over this period also did not seem to respond to own volume.

Finally, an unexpected observation from the estimations is that volume is most typically not significant in the equations for traders who have a short position (again with the notable exception of the T-bill and CD equations in 1983-85, see table 24 on page 168. Recalling that the trader short equations had the greater explanatory power, this result is somewhat surprising because it suggests that traders care the least about volume/liquidity in establishing a position; however, traders (especially those on the trading floor) may already experience sufficient liquidity that the variations in liquidity as measured here are not significant to the decision to take a position in a contract. (Also recall that the CFTC requires reporting of positions larger than some cutoff.) Nonetheless, these factors reduces one's confidence in the general pre-eminence of a role for own-volume (and by implication "liquidity") as essential to contract success in all families.

5.4.4.3 Cross Volumes

The cross volumes (volume statistics for related contracts) appeared prominently in the regression results. While direct comparison to own volume is not clear (because

for, say, a family of three contracts there are twice as many cross volumes as own volumes), the results still indicate the prominence of this variable. In 24 equations (which is approximately three times the number expected purely by chance at the 5% level) at least one of the variables measuring a related contract's volume appeared significant at the 5% level. In seven of these 24 equations, the volume of two related contracts appeared significantly (this pushes the variables incidence well above four times that expected by chance).

This is strong support for volume, in general, as essential to contract success and also strongly supports the viewing of futures usage in a portfolio setting. Interestingly, the significant cross volume terms are virtually evenly divided among the four types of participants. That each participant considers cross-volumes supports the contention made in this dissertation that the volume of related contracts serves as a measure of the transactions costs faced by the various agents. It measures the ease with which they can enter related contracts. If the agents were not viewing their participation in a portfolio view, it is unlikely that the cross-volume would be such a prominent variable.

5.4.4.4 *Variance of the Futures Contract Price*

The variance of the futures contract price appeared significant in only three (trader-long copper, trader-short GNMA 1978-81, and trader-long T-bill 1978-81, see table 3 on page 147, table 15 on page 159, and table 13 on page 157) of the 24 trader's open interest equations, and all at the 5% level. In all four of the cases the relationship is such that open interest declines as the variance of the futures price increases. The

idea that traders move away from a contract as it gets more risky is hypothesized by the theoretical model, and is at odds with the existing conventional wisdom (except Felieke, 1985) which holds that traders are only attracted to contracts with wide price swings in order to earn profits. This result appearing significantly in three contracts is not absolutely strong support (although pure chance would have the variable, of either sign, appear only 1.3 times); however, it does indicate, as hypothesized by the model, that trader's hesitate to hold positions in volatile contracts.

In the producer's equations, the results are mixed. For six of the equations, the futures price variance is significant at the 10% level and of the six, three are significant at the 5% level. Two of the three equations significant at the 5% level actually show open interest to increase as the futures variance increases, and the remaining significant variables show the relationship in the expected direction. Interestingly, the two contracts with the sign in contrast to that expected are both GNMA contracts(hedger-long 1978-81 and hedger-short 1983-85, see table 16 on page 160 and table 33 on page 177).

5.4.4.5 *Futures Price Variance of Related Contracts*

The futures price variance of a related contract appears significantly (at 5%) in seventeen open interest equations. In two of the equations, a related contract's variance appeared twice. The model hypothesized that this variable would be significant for as the risk of a related contract changes, it will alter the portfolio decision of the agents. The theoretical model indicated that how the open interest responds to the change in a related contract's variance was an empirical question. It is a variable

whose importance is drawn out in the model and its frequent appearance (over twice what would be expected by chance) is only weak support for the model. Additionally, the appearance of this variable seems distributed between types of producers and there is no dominance of one sign over the other.

5.4.4.6 Production

The results indicate that the level of production is an important variable in determining contract usage. The usage of the term 'production' stems from its development in the theoretical section. While the term seems odd in reference to the financials, it is meant to indicate the amount outstanding and available to be hedged. The own production was quite prominent as it appeared significant at the 5% level in 18 of the regression estimates (nearly seven times more than expected by chance). However, given the difficulty of measuring production variables, particularly for the financials, it is probably more helpful to observe the own and cross-production variables together. A production variable appears significant in 27 of the regression estimates. In ten of these 27 equations, the production variable appears significant twice, and in one equation it appears three times.

The seeming importance of the own and cross production levels (greater than three and seven times that expected by chance, respectively) suggest strongly that a crucial element to a contract's usage is the interrelationship of the aggregate production levels. For example, recall the financials during the 1983-85 period (see section 4.3.1 of this chapter). One could argue from these results that it was not the frequently cited changes in interest rate volatility that generated the levels of usage; rather, it

was changes in the levels of the outstanding public and private debt that moved usage. This result is certainly consistent with conventional wisdom. A final interesting point is that the production variables appear frequently in the trader's equations. Technically, the traders should not be concerned with production levels. A possible explanation is that the production levels may be influencing the hedger's open interest which in turn influences the traders.

5.4.4.7 H Variable

Certainly one of the more interesting aspects of these results is the overall significance of members of the group of H variables in the estimations. Recall that the members of the H group are simply the determinants of the variance-covariance matrix and its sub matrices. At least one of the H variables appeared significant at the 5% level in 23 of the equations, and in two of these 23 equations one of the H variables appeared significant twice (trader-long T-bill 1978-81, hedger-short GNMA 1983-85, see table 13 on page 157 and table 33 on page 177) and in another two of these equations one of the H variables appeared significant at the 5% level three times (hedger-short T-bond 1978-81, trader-short T-bill 1983-85, see table 19 on page 163 and table 24 on page 168. This variable is suggested in the model as being critical in the interaction of the open interest statistic and the various exogenous variables. Simply, it reflects the interaction of the system of related equations. Its importance in so many of the estimations lends strong support for the theoretical model as this variable has not previously been considered in contract usage.

The H variables are widely distributed over the contracts between producers and traders. The signs are mixed.

5.4.4.8 Covariance

Empirically, there are three types of covariance terms. The first, and the one traditionally thought of, is the covariance between the futures price and the underlying spot commodity. In this research, as was noted in the previous chapter, it is really no different, with aggregate data, than the second type of covariance which is that of the futures price and the spot of any related contract. The first is mentioned separately as it plays a role in the conventional wisdom. This own-own covariance shows up significantly at the 10% level in five of the hedger's equations and significantly at the 5% level in three of the five equations. This is approximately the number which could be expected to appear significant in a purely random sample and thus provides no support for a role of the own-own covariance and therefore no role for one of the important factors, 'basis risk' discussed extensively in the literature.

The definition of the second type of covariance is expanded a bit to allow for the trader's lack of a spot variable. The second type of covariance is defined as the covariance between the either the futures price of the contract or the spot price of the commodity that underlies the contract versus either the futures price of a related contract or the spot price of the commodity underlying the related contract. At least one of these covariance terms appeared significant in 18 equations at the 5% level. In three of these 18 equations, two of these terms appeared and in one of these 18 equations, four of these terms appeared significant at the 5% level. The general im-

portance of this variable indicates the importance of the relationship of other variables in the futures decision.

The third type of covariance can be defined as the covariance between either the futures price of a related contract or the spot price of the commodity underlying it versus either the futures price of another related contract or the spot price underlying it. More simply it is the covariance of two prices behind two contracts appearing in the open interest equation of a third contract. At least one of these covariances appears significant at the 5% level in 14 equations with one of these equations having two significant cross-covariances. The relative importance of the covariance of two related contracts is a variable not before considered in empirical work, and its statistical significance is strong support of the model structure.

It is somewhat surprising to note that the vast majority of the significant second and third types of covariance terms can be found in the two hedger equations and not the traders equations. Eighteen of the 26 hedger equations contained at least one significant cross covariance; whereas, only seven of the trader's equations contained at least one significant cross variance. This is somewhat counterintuitive as one would expect the traders to be paying more attention to the movements between two related contracts. It should be noted, though, that the H variables do play a strong role in the trader's equations and may be picking up the interrelations between related prices for the trader.

Another interesting question to ask is what would happen to one contract if the hedging ability of a related contract improves. Suppose the hedging ability of the silver contract to hedge silver gets worse, would that positively affect activity in the

the gold contract. Thus, how do changes in the covariance of the spot price of one commodity to the futures price of the contract on that commodity affect a related contract. In five of the 26 equations, this covariance appears significantly at the 5% level. In two of the equations, one of these variances appears twice. Note, though, that all five of the equations are in the metals contracts. There is no apparent reason for this not to occur outside of the metals contracts. Perhaps the price series used are such that this event is picked up only in the metals tests. Additionally, five of the seven of these variables are negative.

5.5 *System of Equation Results*

A method similar to Zellner's Seemingly Unrelated Regressions was used to estimate the system of equation results. This technique was used as no dependent variable appears as an independent variable in any other equation in the family. This is by design, as there is no formal equation for production, the production variable is treated as an exogenous variable in the open interest equations. Given this, it is possible to obtain reduced forms for the open interest equations which implies that no endogenous variables would appear on the right-hand-side of these equations. The results from these estimations are mixed. In some cases, it appears that there are small gains to the overall results from treating the equations in a family as a system. In others, there is no indication that a system is appropriate. The SYSREG results begin at table 35 on page 179.

For the Financial Instruments during 1978 to 1981 all three of the contracts considered from that family are estimated as a system. For the Financial Instruments during 1983 to 1985, two systems were considered. The first consisted of the three short-term contracts and the second consisted of the two longer contracts combined with the T-bill contract. For the metals, the three contracts traded on the Comex were treated as a system and the two contracts traded on the CBT were treated as a system. For sets of contracts where the system approach yielded improved results over the OLS estimates, the results are presented in the tables following the OLS estimations.

5.6 Conclusion

The tests used in this section were derived from the theoretical model. The testing approach taken was unique to all known existing tests and was designed to test the hypotheses and variables suggested by the theoretical model as well as the overall portfolio structure implied by the model. The overall strength of the regression results indicate that the approach taken in this empirical section indeed had merit.

In terms of individual variables, there are no absolute statements that can be made across the fifty-two regressions. No single variable appeared significantly in each equation. Nor, should one expect any of the variables to do so. The results do, however, make strong statements regarding the relative importance of the variables across the fifty-two equations and for the theoretical model, in general. A major observation from this work is that the underlying spot variance did not have nearly the influence the traditional literature suggests that it would. Another surprising result

is the limited role played in the changes in open interest by a contract's own volume. According to conventional wisdom, this variable should also have been much more prominent. One variable, production, which is prominent in the literature and in the theoretical model, however, receives strong support in this empirical work.

Strong support for the theoretical model was yielded in the prominent appearance of variables derived from the determinant of the variance-covariance matrix and its submatrices. Initially, it is quite surprising that such a variable would be significant in explaining changes in the open interest statistics. In a sense, changes in the H variables represent changes in the interrelationships between the futures and spot prices in the entire group, or family, under consideration, and it seems to be a fairly complex variable. Recall, though, that it is quite similar to the multi-contract, portfolio analog of the variable used to determine the optimal hedge ratio in a single contract context. It is a variable that has, heretofore, not been considered in empirical work on contract success. Additional strong support for the model is in the importance of the covariance between the prices of two related contracts appearing significant in the open interest equation of a third contract. This is also a variable that has not been considered in empirical analysis to date, and its presence is strong support of the portfolio format. Strong support for the model is suggested by the lack of response, or the negative response, of traders to an increase in a contract's price variance. This is another result at odds with conventional wisdom and certainly worth further inquiry.

Overall support for the theoretical model can be seen in the strong overall significance of terms in the various open interest estimates that concern related contracts. That activity in one contract affects another can be seen in the presence of the many

cross-variances and cross-volume terms that appear significantly in the estimates. The strong effect of the covariance terms is further support of the theoretical model and its portfolio framework. In sum, one can see the clear pattern that decisions are made in a multi-contract, portfolio setting, and not just in a single futures contract, single spot commodity setting which has been the underpinning of traditional analysis of futures markets.

Chapter VI

Summary, Conclusion, and Extensions

6.1 *Introduction*

The purpose of this research was to determine which factors, if any, are important in determining the usage of futures contracts. In doing so, it was intended that the research be as general as possible. That is, the interest was not in the specific features of a specific contract that led to its being used or not used. Rather, believing that certain fundamental economic factors affect all futures usage, the intent was to explore the relationship between usage and a set of exogenous variables common to all contracts. Defining this set of common variables and mapping out the path of the empirical investigation began with the development of a theoretical model describing futures usage.

6.2 Theoretical Model

The intent of the theoretical section is to develop a general model describing futures usage. The model developed in this research is firmly grounded in traditional microeconomic theory. It is based upon the decisions of various types of agents as they strive to maximize their expected utility of profits. The underlying structure of the theoretical section is quite similar to existing work which considers decision making in an uncertain world. In this work, the producer must set his production level without knowing the eventual selling price of his output. Instead, the producer must take this price uncertainty into account as he makes his production decision. In later work, however, this model is extended to allow the producer, as he sets his production level, to enter a futures market on the commodity he produces. In the futures market he agrees today to buy or sell the commodity at some future date. The key being that he locks in today a price on a future transaction.

In this case it is quite apparent that if the producer can establish today a price at which he can sell his output when it is produced, then the production decision collapses to the same production decision as a world of certainty, except the futures price is used as the price on which to determine the optimal level of production. The futures decision is treated separately from the production decision. It is as though the producer had no stake in the spot commodity. Of particular interest in these models is that along with the production decision, the futures decisions are also choice decisions in the model. Simply, this is of interest because the response of choice decisions to exogenous variables can be explored via the tool of comparative statics.

The model developed in this work differs from the previous work in that it does not assume that the producer can perfectly hedge the commodity he is producing, nor does it assume that length of the futures contract will just equal his production period. Thus, in a sense this model is a blend of the two earlier models. The producer can enter futures markets at the time he makes his production decision; however, it is not possible for him to totally eliminate the price risk associated with his production decision. Additionally, this model allows the producer to enter more than one futures contract. He may enter any futures contract in any amount, long or short, as he chooses. The portfolio orientation is an important feature of the model and the empirical tests. It is also very similar to the general structure that Anderson and Danthine stress in their work.

Thus, the general structure of the model developed in this work is that as the producer establishes his production levels and his futures positions, he has, in effect, created a portfolio of risky assets. Given his expectation of the prices to prevail in the future and the transaction costs of contracting in futures markets, the agent makes his portfolio decision to maximize his expected utility of profits. The variables he decides on are the production level and the futures positions. The exogenous variables in this case are the prices and the transactions costs. At this point, it is possible to determine the comparative static responses of the endogenous futures positions to changes in these exogenous variables. In order to explore the determinants of futures usage in more detail, this research breaks out the relationships between the various spot and futures prices.

In this manner the set of exogenous variables is expanded to include the variance-covariance matrix along with the transactions costs as the exogenous variables in the model. The transactions costs are measured by the volume, or liquidity, of the contract and the volume of the related contracts. The comparative statics of this expanded set of exogenous variables can be determined.

This model further expands the existing work by framing the problem in an equilibrium setting. Too often, a contract's success or failure is described in terms of how one variable affects the hedger and perhaps how another variable affects the speculator. It is possible, though, that the variable of interest may move the hedger in one direction, as supposed, and the trader, unexpectedly, in the other direction. Thus, the net effect on the the level of usage is unclear. This model considers the interaction of three types of agents to determine the level of contract usage. The first is the producer of a commodity with an interest in hedging his production. The second is a producer who uses the commodity as an input to his production process. His interest is in hedging the cost of the input. Finally, the third is the trader who holds no spot position; rather, he enters the futures markets to profit from price changes on the positions he holds. In viewing the comparative statics results of all three types of agents and considering their interaction, the following hypotheses result from the theoretical model.

1. The overall usage of a futures contract decreases as the variance of the spot commodity increases.
2. If the futures position of the producer is positive, then overall usage of a futures contract will increase as the covariance between the spot and the futures price

increases. If the position is negative, the futures usage declines as the covariance increases.

3. Overall usage of a futures contract declines as the variance of the contract increases. Trading should shift toward other contracts.
4. Overall usage of a futures contract decreases as transaction costs increase.
5. Changes in futures usage depend upon changes in terms such as H_{12} and H_{33} .

6.3 Empirical Structure and Results

The general structure of the empirical section is based upon the theoretical section and its emphasis upon a portfolio framework. The purpose of the empirical section is to test the model laid out in the theoretical section. The form is very similar to existing empirical work in which the measure of usage, either volume or open interest, is typically regressed against the various factors thought to explain usage. The strongest level of support would come from the support of the hypothesis laid out in the theoretical section or from the relevance of variables not previously used in empirical work. Additional support for the model would come from the significance of variables that strongly support the portfolio framework. Finally, there exists in the mainstream literature several variables which are routinely considered critical in determining contract usage. These variables are included, to a major extent, in these tests. Thus, an additional interesting feature of this empirical work lies in the testing of these often touted variables in a portfolio framework.

The design of the tests is straightforward with the first step being to designate a family of contracts as the entire universe available to the agents. For instance, it is assumed that the gold producer is not hedging his production via the T-bill contract. To assume otherwise would make the problem needlessly huge. Having designated a family of contracts, the open interest statistics collected by the CFTC are used as the measure of contract usage. These statistics have the advantage of corresponding to the usage described in the theoretical section, and they are broken down with respect to trader and producer (or, hedger), and within the two classes by short and long positions. Thus, for each contract considered there are really four open interest positions observed. These open interest statistics constitute the dependent variables used in the regression.

The independent variables are formed from the members of the variance-covariance matrix, the volume measures and the levels of production for the commodities underlying the futures contracts. The members of the variance-covariance matrix are estimated for each month using the daily spot and futures prices of the members in the family under consideration. Three different groups were chosen for observation. These groups were chosen to satisfy the idea of closely related contracts with some contracts in the family that did well and others that did not. Additionally, there should be minimal seasonal components and government interference. The three groups observed are the Financial Instruments for the 1978-81 period, the metals contracts for the 1983-85 period, and the Financial Instruments for the 1983-85 period. The split in the financials is due to the CFTC not collecting the open interest statistics during 1982.

There were a total of 13 contracts observed in the three groups. As the open interest statistics provided by the CFTC are broken down into the four positions, there are a total of 52 regression estimates. The overall results from the estimates are strong and there is support for the model and for its emphasis upon a portfolio framework. Surprisingly, the variables traditionally associated with determining contract success, such as own-volume and spot variance, appear to be far less significant in open interest determination than would be expected. The results did not, however, delineate a specific set of variables, across the many equations, that uniquely determine usage. While not finding a clear universal framework, if one even exists, the results still indicate a fair amount of underlying structure.

In general, across the 52 equations, the model had the most explanatory power for the long hedger. In only one case of the 13 contracts observed is the R^2 for the long hedger clearly smaller than any other equation. Further, the explanatory power of the short trader tends to dominate the long trader. The exceptions to these two observations are concentrated in the 1983-85 short-term financial contracts. The model also yields equally successful results for failing contracts as it does for successful contracts. Finally, the explanatory power of the model is strongest for the Financial Instruments group for the 1983-85 period. One could argue that since this group contains a better and more comprehensive inclusion of the contracts actually in the family than the other two groups considered, it better fits the portfolio approach taken in these tests.

The intent of this research was to be quite general, and as such, as many contracts as possible were observed. It is difficult, though, to describe the results of 52 regressions, particularly when the equations are not estimated with the same sets of variables. The sacrifice of observing many open interest positions is that the conclusions drawn tend to be fairly general. A variable may be significant in one estimation and insignificant in another. This is not unexpected as the estimates are considering different traders in different situations. What one should consider is the pattern, or lack of pattern, across the 52 estimations. From the patterns, one can draw conclusions regarding the effect of the exogenous variables on contract usage.

A primary result of these tests is the indication that the variables so often mentioned in the literature as the primary determinants of a contract success are not nearly as prominent as expected. The variance of the spot commodity appeared significant at the 10% level in only four of the 26 equations for hedger's open interest. While this is almost twice what would be expected by chance, it is still remarkably absent from so many of the equations given its traditional status. Additionally, based on the conventional wisdom, it was anticipated that own contract volume would be a dominant variable throughout all of the open interest equations. However, own volume appeared significant at the 10% level in only 13 equations and significant in ten of those thirteen equations at the 5% level. Granted, the number of times that own volume appears significant at the 5% level is four times that expected by chance and this variable is certainly as prominent as any of the other variables considered, it still lacks the overall impact one would have expected from traditional thought. Finally, the conventional wisdom holds that a large variance in the futures price is essential to attracting traders, while the theoretical model claims just the opposite. In any

event, the variable appeared significantly at the 5% level in only three of the traders' open interest equations. All three were of the sign hypothesized by the model.

The overall patterns across the equations also lend support for the theoretical model and the portfolio approach, in general. One of the more interesting results is the overall significance of members of the group of H variables in the estimations. These variables are analogous to the regression coefficients used by Anderson and Danthine in their simulations. At least one of the H variables, which are simply the determinants of the variance-covariance matrix and its submatrices, appeared significant at the 5% level at least once in 23 of the equations. The overall significance of this variable strongly supports the portfolio approach. Similar support is obtained from the frequent appearance of the cross-volume term in the results. In 24 equations (four times more than would be expected by chance), at least one of the variables measuring a related contract's volume appeared significant at the 5% level.

The futures price variance of **related** contracts appears significantly (at the 5% level) at least once in seventeen open interest equations. The model hypothesized that this variable would be significant because as the risk of a related contract changes, it will alter the portfolio decision of the agents. The appearance of this variable nearly seven times more than expected by chance is strong support for the role of related contracts in a portfolio context.

The results regarding the covariance terms are also interesting. The covariance between the futures price and the underlying commodity spot price, a traditionally popular variable as it measures an extensively discussed form of basis risk, appeared with no greater frequency than would be expected by chance. The covariance be-

tween either the futures price of the contract or the spot price of the commodity that underlies the contract versus the futures price of a related contract or the spot price of the commodity underlying the related contract appeared significant at least once in 18 of the 52 equations. That is, a variable measuring the co-movement between prices associated with the contract being observed and a related contract appeared with some consistency, approximately three times more frequently than would occur by chance. Finally, a production variable, own or cross, appeared significant at least once at the 5% level in 27 of the equations (approximately twice as often as expected by chance).

In sum, there are no absolute statements that can be made regarding specific variables from these empirical tests. Certainly, there is strong support for the theoretical model and the portfolio approach. Variables unique to the structure developed in the theoretical section appear with prominence throughout the results with more frequency than some traditional variables discussed extensively in the literature. Their overall influence across the 52 regressions indicates that the approach taken in this research has merit. Further, the lack of significance of 'traditional' variables or the relative infrequency with which they appeared significant draws into question the value of the conventional wisdom in the portfolio framework. Finally, the inability to discern a definitive set of variables that explain contract usage is certainly a weakness of this study. It is not clear whether it results from a fundamental inability of the empirical tests to produce consistency at this level or perhaps that a general approach to determining what variables are important will not yield such a set of variables across different families of contracts.

6.4 Implications and Extensions

The question naturally arises as to what the results imply for an exchange developing a contract. The implications are first that an exchange would be misguided in pursuing a contract based on price volatility. The prevalence of the idea that volatility is so important is remarkable. Instead, the exchange should consider the size of the underlying market and its potential for growth. Along with the underlying market, consideration should also be given to the size of the underlying markets of related contracts, as well as the volume in these markets. That is, the portfolio framework should always be invoked, and, for instance, concern should be given to the size of potential cross-hedgers and how easily hedgers in the potential contract can spread across other contracts. It is not at all obvious from this work that the liquidity advantage is something that cannot be overcome. This is particularly so if the innovation is placed correctly in the portfolio framework, that is, it picks up cross-hedgers, serves as an improved spreading vehicle for traders, etc.

An issue on which further work could be done is the refinement, if possible, of the underlying structure of the equations. If significant progress can be made, the role which could be played by a potential contract in a portfolio could be much more precisely determined, and thus a better estimate of its survivability could be made prior to innovation.

A further test could use the portfolio framework to obtain a better contrast between the roles of the hedgers and speculators in usage. It is clear from this work that they respond differently to the exogenous variables. A more detailed examination of this

issue which allowed for more direct comparisons could yield valuable information. Finally, despite the lack of a clear present theoretical basis, the portfolio analysis approach could be applied to the other commonly used measure of contract usage, volume, to try to avoid any reporting biases or other problems inherent in the CFTC's open interest data. This would mean loss of the ability to separately examine hedgers and traders (long and short) which was important to this study, but the tradeoff of better quality of the data may be worth further exploration.

Reading List for Dissertation

- Anderson, Ronald W. and Jean-Pierre Danthine. "Hedging and Joint Production: Theory and Illustrations." *Journal of Finance*, 35 (1980) pp. 487-501.
- Anderson, Ronald W. and Jean-Pierre Danthine. "Cross Hedging." *Journal of Political Economy*, 89 (1981) pp. 1182-1196.
- Anderson, Ronald W. and Jean-Pierre Danthine. "Hedger Diversity In Futures Markets." *The Economic Journal*, 93 (1983) pp. 370-389.
- Anderson, Ronald W. and Jean-Pierre Danthine. "The Time Pattern of Hedging and the Volatility of Futures Prices." *Review of Economic Studies*, 50 (1983) pp. 249-266.
- Baron, David P. "Price Uncertainty, Utility, And Industry Equilibrium in Pure Competition." *International Economic Review*, 11 (1970) pp.463-480.
- Batlin, Carl Alan. "Production Under Price Uncertainty with Imperfect Time Hedging opportunities in Futures Markets." *Southern Economic Journal*, 49 (1983) pp.681-692.
- Behr, Robert M. and Ronald W. Ward. "A Simultaneous Equation Model of Futures Market Trading Activity." *Review of Research in Futures Market* , 3 (1983) pp. 194-217.
- Black, Deborah G. "Success and Failure of Futures Contracts: Theory and Empirical Evidence." *Monograph, Graduate School of Business Administration, New York University*, (1986-1).
- Britto, Ronald. "The Simultaneous Determination of Spot and Futures Prices In A Simple Model With Production Risk." *The Quarterly Journal of Economics*, 99 (1984) pp. 351-365.
- Carlton, Dennis W. "Futures Markets: Their Purpose, Their History, Their Growth, Their Successes and Failures." *The Journal of Futures Markets*, 4 (1984) pp. 237-274.

- Chance, Don M. and M. Wayne Marr and G. Rodney Thompson. "Hedging Shelf Registrations." *The Journal of Futures Markets*, 6 (1986) pp. 11-27.
- Cornell, Bradford. "The Relationship Between Volume and Price Variability in Futures Markets." *The Journal of Futures Markets*, 1 (1981) pp. 303-316.
- Feder, Gershon. "The Impact of Uncertainty in a Class of Objective Functions." *Journal of Economic Theory*, 16 (1977) pp. 504-512.
- Feder, Gershon and Richard E. Just and Andrew Schmitz. "Futures Markets and the Theory of The Firm Under Price Uncertainty." *The Quarterly Journal of Economics*, 94 (1980) pp. 317-328.
- Fieleke, Norman S. "The Foreign Currency Futures Market: Some Reflections on Competitiveness and Growth." *The Journal of Futures Markets*, 5 (1985) pp. 625-631.
- Flack, Virginia F. and Potter C. Chang. "Frequency of Selecting Noise Variables in Subset Regression Analysis: A Simulation Study." *The American Statistician*, 41 (1987) pp. 84-86.
- Garbade, Kenneth D. "Securities Markets." Mc Graw-Hill, New York, New York, 1982
- Garbade Kenneth D. and William L. Silber. "Dominant and Satellite Markets: A Study of Dually-Traded Securities." *Review of Economics and Statistics*, 61 (1979) pp.455-460
- Garbade, Kenneth D. and William L. Silber. "Technology, Communication and The Performance of Financial Markets: 1840-1975." *Journal of Finance*, 33 (1978) pp. 819-832.
- Gray, Roger W. "The Search For A Risk Premium." *Journal of Political Economy*, 69 (1961) pp. 250-260.
- Gray, Roger W. "The Futures Market for Maine Potatoes: An Appraisal." *Food Research Institute Studies*, 11 (1972) pp.331-359.
- Gray, Roger W. "The Characteristic Bias in Some Thin Futures Markets." *Food Research Institute Studies*, 1 (1960) pp. 113-130.
- Helms, Billy P. and Terrence F. Martell. "An Examination of the Distribution of Futures Price Changes." *The Journal of Futures Markets*, 5 (1985) pp. 259-272.
- Hieronimus, Thomas A. *Economics of Futures Trading for Commercial and Personal Profit*, 2nd edition, (Commodity Research Bureau Inc., New York, New York) 1977
- Holthausen, Duncan M. "Hedging and the Competitive Firm under Price Uncertainty." *American Economic Review*, 69 (1979) 989-995.
- Ishii, Yasunori. "On the Theory of the Competitive Firm Under Price Uncertainty: Note." *American Economic Review*, 67 (1977) pp. 768-769.

- Jones, Frank J. "The Economics of Futures and Options Contracts Based on Cash Settlement." *The Journal of Futures Markets*, 2 (1982) pp. 63-82.
- Keynes, J.M. *Treatise on Money*, New York, 1930, II
- Kohls, Richard L. *Marketing of Agricultural Products*, Third Edition, (MacMillan Co., New York), 1967 *Journal of Finance*, 40 (1985) pp. 241-255.
- Koppenhaver, G. D. "Bank Funding Risk Aversion, and the Choice of Futures Hedging Instrument." *Journal of Finance*, 40 (1985) pp. 241-255.
- Leland, Hayne E. "Theory of the Firm Facing Uncertain Demand." *American Economic Review*, 62 (1972) pp. 278-291
- Ma, Christopher K. "Spreading Between the Gold and Silver Markets: Is There a Parity?" *The Journal of Futures Markets*, 5 (1985) pp. 579-594
- MacMinn, Richard D., George E. Morgan, and Stephen D. Smith. "Forward Market Equilibrium." *Southern Economic Journal*, 51 (1984) pp. 41-58.
- Marcus, Alan J. and David M. Modest. "Futures Markets and Production Decisions." *Journal of Political Economy*, 92 (1984) pp. 409-426.
- McKinnon, Ronald I. "Futures markets, Buffer Stocks, and Income Stability for Primary Producers." *Journal of Political Economy*, 75 (1967) pp. 844-861
- Rothschild, Michael and Joseph E. Stiglitz. "Increasing Risk: I. A Definition." *Journal of Economic Theory*, 2 (1970) pp. 225-243.
- Rothschild, Michael and Joseph E. Stiglitz. "Increasing Risk II: Its Economic Consequences." *Journal of Economic Theory*, 3 (1971) pp. 66-84.
- Rutledge, David J. S. "Hedgers' Demand for Futures Contracts: A Theoretical Framework With Applications To The United States Soybean complex." *Food Research Institute Studies*, 11 (1972) pp. 237-256.
- Sandmo, Agnar. "On the Theory of the Competitive Firm Under Price Uncertainty." *American Economic Review*, 61 (1971) pp. 65-73.
- Sandor, Richard L. "Innovation by an Exchange: A Case Study of the Development of the Plywood Futures Contract." *Journal of Law and Economics*, 16 (1973) pp. 207-221.
- Sealey, Jr. C.W. "Deposit Rate-Setting, Risk Aversion, and the Theory of Depository Financial Intermediaries." *Journal of Finance*, 35 (1980) pp. 1139-1154.
- Shefrin H. M. "Transaction Costs, Uncertainty and Generally Inactive Futures Markets." *Review of Economic Studies*, 48 (1981) pp. 131-137.
- Silber, William L. "Innovation, Competition, and New Contract Design in Futures Markets." *Journal of Futures Markets*, 1 (1981) pp. 123-155.

- Silberberg Eugene "The Structure of Economics." McGraw-Hill, New York, New York, 1978
- Stein, Jerome L. "The Simultaneous Determination of Spot and Futures Prices." *American Economic Review*, 51 (1961) pp. 1012-1025.
- Stevens, Guy V. G. "Two Problems In Portfolio Analysis Conditional and Multiplicative Random Variables." *Journal of Financial and Quantitive Analysis*, 6 (1971) pp. 1235-1250.
- Telser, Lester G. "Why There are Organized Futures Markets." *Journal of Law and Economics* 24 (1981) pp. 1-22.
- Telser, Lester G. and Harlow N. Higinbotham. "Organized Futures Markets: Costs and Benefits." *Journal of Political Economy*, 85 (1977) pp. 969-1000.
- Thompson, Rodney G. "The Relationship Between Labor Force Participation and Service Sector Employment: A Reply to Wheat and Additional Results." *Journal of Regional Science*, 17 (1977) pp. 467-471.
- Tschoegl, Adrian E. "The Effect of Exchange Trading of Gold Options on The Volatility Of The Underlying Asset." *Economic Letters*, 9 (1982) pp. 77-80.
- Ward, Ronald W. and Lehman B. Flecher. "From Hedging to Pure Speculation: A Micro Model of Optimal Futures and Cash Market Positions." *American Journal of Agricultural Economics*, 53 (1971) pp. 71-78.
- White, Lawrence J. "Market Structure and Product Varieties." *The American Economic Review*, 67 (1977) pp. 179-182.
- Williamson, Oliver E. "Transaction-Cost Economics: The Governance of Contractual Relations." *Journal of Law and Economics*, 22 (1979) pp. 223-261.
- Working, Holbrook. "Futures Trading and Hedging." *American Economic Review*, 43 (1953) pp. 314-343.

Appendix A

Open Interest Statistics

The open interest statistics used as the dependent variable in this study were obtained from the "Commitments of Traders in Commodity Futures" published by the Commodity Futures Trading Commission (CFTC). These statistics provide month-end open interest levels for markets in which traders have positions equal to or above the the reporting levels established by the CFTC.

These statistics include separate open interest statistics for both reportable and nonreportable positions. However, for the reportable positions, the holdings are broken down into commercial (hedger) and non-commercial (trader) and whether the position is long or short. These statistics show the aggregate positions reported by all traders with positions exceeding the reportable level.

Reporting Levels

1979

1. Treasury Bonds 25 contracts

2. GNMA 25 contracts

3. Treasury Bills 25 contracts

1981

1. Treasury Bonds 25 contracts

2. GNMA 25 contracts

3. Treasury Bills 25 contracts

1983

1. Treasury Bonds 150 contracts

2. GNMA 100 contracts

3. Treasury Bills 50 contracts

4. Eurodollars 50 contracts

5. CDs 50 contracts

6. Copper 100 contracts

7. Gold 200 contracts

8. Silver 100 contracts

Appendix B

Empirical Results

Table 1. Summary of Adjusted R-squared Results

Contract	Trader-L	Trader-S	Hedger-L	Hedger-S
Gold-Comex	.38	.38	.75	.51
Silver-Comex	.56	.76	.91	.92
Copper-Comex	.57	.77	.79	.67
Gold-CBT	.17	.46	.52	.20
Silver-CBT	.31	.19	.54	.38
T-bill 78-81	.53	.55	.65	.53
GNMA 78-81	.39	.44	.51	.41
T-bond 78-81	.77	.85	.93	.97
T-bill 83-85	.88	.70	.33	.76
CD 83-85	.97	.84	.93	.92
Euro 83-85	.78	-.05	.98	.87
GNMA 83-85	.85	.74	.94	.97
T-bond 83-85	.18	.71	.86	.78

Table 2. Comex Trader-long

dependent var: gold		adj R²: .3813	F statistic: 6.239	PROB>F: .0009
variable	parameter est	T value	PROB> T 	
intercept	4.138	21.93	.0001	
reporting change dummy	-.2975	-2.938	.0063	
cov silver fut,copper fut	.0824	2.150	.0397	
und asset H11	-.2583	-2.628	.0134	
und asset H	.1392	1.849	.0743	
Number of observations: 35		Durbin Watson: 2.276		lag
dependent var: silver		adj R²: .5686	F statistic: 6.601	PROB>F: .0001
variable	parameter est	T value	PROB> T 	
intercept	-1.717	-.635	.5310	
volume und asset,CBT	-.3183	-1.797	.0840	
volume gold,CMX	-.2394	-.839	.4090	
volume copper	.7761	4.141	.0003	
production und asset	.8414	2.010	.0549	
var und asset fut	.0128	.232	.8181	
var gold fut	-.0155	-.305	.7626	
var copper fut	-.2236	-3.489	.0018	
cov silver fut,copper fut	.0531	2.184	.0382	
number of observations: 35		Durbin Watson: 1.983		lag

Table 3. Comex Trader-long

dependent var: copper		adj R^2 : .5799	F statistic: 7.705	PROB>F: .0001
variable	parameter est		T value	PROB> T
intercept	-7.171		-1.301	.2044
volume und asset	.2589		1.339	.1919
volume gold,CBT	-.0732		-1.215	.2347
production und asset	-.6801		-2.386	.0243
production gold	1.829		1.896	.0687
var und asset fut	-.2202		-3.33	.0025
var silver fut	.1059		2.402	.0234
und asset H22	-.0289		-.716	.4802
number of observations: 35		Durbin Watson: 1.328*		lag
Yule-Walker Estimates, Copper				
unadjusted R^2 = .6037				
variable	parameter est		T value	PROB> T
intercept	-3.428		-.536	.5964
volume und asset	.1053		.642	.5266
volume gold,CBT	-.1172		-2.016	.0542
production und asset	-.4863		-1.546	.1343
production gold	1.334		1.208	.2378
var und asset fut	-.2094		-3.597	.0014
var silver fut	.0805		2.037	.0520
und asset H22	-.0234		-.672	.5076

Table 4. Comex Trader-short

dependent var: gold		adj R²: .3814	F statistic: 4.597	PROB>F: .0021
variable	parameter est	T value	PROB> T 	
intercept	9.771	6.309	.0001	
volume silver,CMX	-1.097	-3.853	.0006	
var silver fut	.1897	1.948	.0612	
var copper fut	.4725	3.237	.0030	
cov silver fut,copper fut	-.0222	-.686	.4983	
und asset H	-.2895	-2.572	.0155	
und asset H33	.2436	1.875	.0709	
Number of observations: 36		Durbin Watson: 2.080		log
dependent var: silver		adj R²: .7696	F statistic: 29.39	PROB>F: .0001
variable	parameter est	T value	PROB> T 	
intercept	24.66	5.166	.0001	
production und asset	1.038	3.344	.0022	
production gold	-4.147	-6.672	.0001	
cov gold fut,copper fut	-.0119	-.467	.6437	
und asset H22	.0912	3.132	.0039	
number of observations: 36		Durbin Watson: 2.136		log
dependent var: copper		adj R²: .7726	F statistic: 30.721	PROB>F: .0001
variable	parameter est	T value	PROB> T 	
intercept	-21.81	-2.671	.0119	
production und asset	1.358	3.970	.0004	
production gold	3.480	2.537	.0164	
var gold fut	.2784	2.193	.0359	
cov gold fut,silver fut	-.1831	-1.491	.1461	
number of observations: 36		Durbin Watson: 2.081		log

Table 5. Comex Hedger-long

dependent var: gold				adj R ² : .7537		F statistic: 16.297		PROB > F: .0001	
variable		parameter est		T value		PROB > T			
intercept		4.961		5.747		.0001			
reporting change dummy		.2471		7.30		.0001			
volume und asset		-.0376		-.251		.8039			
cov und asset spot,copper fut		.1231		3.859		.0006			
cov copper spot,copper fut		-.0936		-2.669		.0125			
cov copper spot,gold fut		-.0565		-2.747		.0104			
cov copper fut,gold fut		-.0412		-1.262		.2175			
und asset H		-.0010		-.077		.9390			
Number of observations: 36				Durbin Watson: 1.384*				log	

dependent var: silver				adj R ² : .9142		F statistic: 61.416		PROB > F: .0001	
variable		parameter est		T value		PROB > T			
intercept		-8.203		-2.621		.0140			
reporting change dummy		.5076		10.284		.0001			
volume gold,CMX		.5144		2.026		.0524			
volume silver,CBT		-.4315		-2.818		.0088			
volume copper,CMX		.3745		1.924		.0645			
production und asset		1.840		4.589		.0001			
cov gold fut,copper fut		.0676		2.070		.0478			
number of observations: 36				Durbin Watson: 1.552				log	

Table 6. Comex Hedger-long

dependent var: copper				adj R ² : .7993		F statistic: 23.575		PROB > F: .0001	
variable		parameter est		T value		PROB > T			
intercept		3.897		8.373		.0001			
volume und asset		-.2056		-2.468		.0200			
production und asset		.7931		10.64		.0001			
cov und asset spot,gold fut		.0283		2.207		.0357			
cov gold spot,gold fut lglsig12		.0333		1.659		.1082			
cov silver spot,silver fut		-.0984		-3.794		.0007			
und asset H		-.0200		-2.012		.0539			
number of observations: 36				Durbin Watson: 1.832				log	
Yule-Walker Estimates, Gold									
unadjusted R ² = .7165									
variable		parameter est		T value		PROB > T			
intercept		5.302		7.139		.0001			
reporting change dummy		.2345		7.139		.0001			
volume und asset		-.0991		-.773		.4465			
cov und asset spot,copper fut		.0996		3.261		.0030			
cov copper spot,copper fut		-.0755		-2.226		.0345			
cov copper spot,gold fut		-.0460		-2.477		.0198			
cov copper fut,gold fut		-.0306		-1.023		.3152			
und asset H		-.0017		-.141		.8886			

Table 7. Comex Hedger-short

dependent var: gold adj R ² : .5158 F statistic: 5.025 PROB > F: .0006			
variable	parameter est	T value	PROB > T
intercept	3.713	5.679	.0001
reporting change dummy	.0812	2.587	.0159
volume und asset	.1540	1.315	.2003
production copper	.1784	1.896	.0696
var und asset fut	-.0594	-1.894	.0699
var copper fut	-.1074	-3.05	.0054
cov und asset spot,copper fut	.1161	3.627	.0013
cov silver fut,copper fut	-.0252	-1.621	.1177
cov silver spot,silver fut	-.0890	-2.760	.0107
und aset H	.090	1.984	.0583
Number of observations: 36		Durbin Watson: 2.111	log
dependent var: silver adj R ² : .9278 F statistic: 49.54 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	6.951	2.214	.0362
bdum1	.2479	7.4567	.0001
volume und asset	-.4366	-2.835	.0089
volume silver,CBT	-.0527	-.604	.5514
volumr copper	.3351	3.515	.0017
production gold	-.2445	-.466	.6449
cov und asset spot,und asset fut	-.0412	-2.951	.0068
cov und asset spot,gold fut	.0422	2.762	.0106
cov und asset spot,copper fut	-.0363	-2.284	.0311
cov copper spot,silver fut	.0426	2.917	.0074
number of observations: 36		Durbin Watson: 2.126	log

Table 8. Comex Hedger-short

dependent var: copper adj R ² : .6784 F statistic: 8.968 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	4.717	11.85	.0001
reporting change dummy	-.0187	-.987	.3333
volume silver,CMX	-.0847	-.974	.3394
volume gold,CBT	-.0383	-2.198	.0375
production und asset	.3007	3.810	.0008
var und asset fut	-.0708	-3.443	.0021
cov silver spot,silver fut	.0264	1.811	.0821
cov silver spot,copper fut	-.0049	-.768	.4498
und asset H13	.0017	.718	.4796
und asset H22	-.0046	-.609	.5478
number of observations: 36	Durbin Watson: 1.753		log

Table 9. CBT Trader-long

dependent var: gold,CBT adj R²: .1701 F statistic: 1.943 PROB > F: .1369			
variable	parameter est	T value	PROB > T
intercept	47.48	2.658	.0160
volume copper,CMX	-6.143	-2.492	.0227
production copper	-4.523	-1.155	.2631
und asset H	.9281	1.657	.1148
und asset H11	-1.465	-1.353	.1927
und asset H22	.9296	.929	.3654
Number of observations: 24		Durbin Watson: 2.123	log
dependent var: silver,CBT adj R²: .3105 F statistic: 6.103 PROB > F: .0022			
variable	parameter est	T value	PROB > T
intercept	.5534	.661	.5134
volume silver,CBT	.5413	3.171	.0034
var gold fut	-.1251	-1.66	.1069
cov und asset spot,gold fut	-.0533	-2.801	.0087
number of observations: 36		Durbin Watson: 1.654	log

Table 10. CBT Trader-short

dependent var: gold,CBT adj R ² : .4634 F statistic: 4.313 PROB > F: .0080			
variable	parameter est	T value	PROB > T
intercept	-299.7	-4.453	.0003
volume gold,CMX	.7137	.223	.8264
production gold	48.96	4.275	.0005
production copper	-5.837	-1.775	.0938
var silver fut	2.1718	2.216	.0406
var copper fut	3.677	3.234	.0049
und asset H11	-2.924	-3.019	.0077
number of observations: 24		Durbin Watson: 1.455	lag
dependent var: silver,CBT adj R ² : .1973 F statistic: 5.179 PROB > F: .0113			
variable	parameter est	T value	PROB > T
intercept	-44.18	92.484	.0184
volume silver,CMX	.8923	.751	.4583
production gold	6.640	2.003	.0537
number of observations: 35		Durbin Watson: 2.234	lag

Table 11. CBT Hedger-long

dependent var: gold,CBT adj R ² : .5251 F statistic: 4.179 PROB>F: .0083			
variable	parameter est	T value	PROB> T
intercept	-40.49	-2.189	.0448
reporting change dummy	1.474	2.043	.0590
volume gold,CMX	6.707	2.208	.0433
var copper fut	5.507	3.36	.0043
cov und asset spot,und asset fut	5.073	1.98	.0644
cov und asset spot,silver fut	-5.040	-1.791	.0935
cov und asset fut,silver fut	-8.733	-2.816	.0130
cov silver spot,silver fut	7.638	3.525	.0031
cov copper spot,copper fut	-4.438	-2.947	.0100
Number of observations: 24		Durbin Watson: 2.025	lag
dependent var: silver,CBT adj R ² : .5497 F statistic: 7.919 PROB>F: .001			
variable	parameter est	T value	PROB> T
intercept	7.033	1.647	.1107
reporting change dummy	.3906	4.117	.0003
volume silver,CMX	.4534	1.142	.2633
production silver	-1.293	-1.919	.0652
cov gold spot,gold fut	-.2174	-2.802	.0091
cov copper spot,copper fut	.3188	3.289	.0027
und asset H44	.1010	2.041	.0508
number of observations: 35		Durbin Watson: 1.885	lag

Table 12. CBT Hedger-short

dependent var: gold,CBT adj R²: .2088 F statistic: 4.035 PROB>F: .0329			
variable	parameter est	T value	PROB> T
intercept	191.3	2.729	.0126
production gold	-29.69	-2.709	.0132
cov silver fut,copper fut	-.3324	-1.185	.2491
Number of observations: 24		Durbin Watson: 1.762	lag
dependent var: silver,CBT adj R²: .3848 F statistic: 6.317 PROB>F: .0008			
variable	parameter est	T value	PROB> T
intercept	5.660	3.608	.0011
volume und asset	.1060	1.187	.2444
production und asset	-.3788	-1.47	.1520
var gold fut	-.0653	-2.411	.0222
und asset H12	.0291	1.678	.1038
number of observations: 35		Durbin Watson: 1.808	lag

Table 13. Financials 1978-81 Trader-long

Independent var: T-bill adj R^2 : .5301 F statistic: 7.447 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	2.623	2.487	.0181
reporting change variable	-.4728	-5.106	.0001
volume und asset	1.148	3.420	.0017
volume T-bond	-.0776	-.347	.7306
var und asset fut	-.496	-3.445	.0016
cov und asset fut,GNMA fut	-.0097	-1.999	.0539
und asset H12	.0097	3.324	.0022
und asset H33	.1339	1.686	.1011
number of observations: 42		Durbin Watson: 1.162*	log
Independent var: GNMA adj R^2 : .3973 F statistic: 5.395 PROB > F: .0005			
variable	parameter est	T value	PROB > T
intercept	2.571	2.882	.0068
volume T-bill	.5145	3.894	.0004
production und asset	.4871	3.651	.0009
var T-bill fut	-.4063	-3.302	.0023
cov und asset fut,T-bill fut	-.007	-1.049	.3015
und asset H33	.1445	2.069	.0462
und asset H12	.0013	.581	.5650
number of observations: 42		Durban Watson: 1.901	log
Independent var: T-bond adj R^2 : .7789 F statistic: 47.971 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	-5.271	-4.504	.0001
volume T-bill	1.724	9.688	.0001
und asset H33	-.220	-3.261	.0024
var GNMA fut	.1838	1.560	.1274
number of observations: 42		Durban Watson: 2.0308	log

Table 14. Financials 1978-81 Autoreg

Yule-Walker Estimates, T-bill			
unadjusted $R^2 = .5551$			
variable	parameter est	T value	PROB > T
intercept	3.086	3.221	.0029
reporting change variable	-.4461	-4.258	.0002
volume und asset	.8418	2.575	.0149
volume T-bond	-.0093	-.042	.9670
var und asset fut	-.471	-4.044	.0003
cov und asset fut,GNMA fut	.0063	1.320	.1234
und asset H12	.0068	2.636	.0128
und asset H33	.1747	2.624	.0132

Table 15. Financials 1978-81 Trader-short

Independent var: T-bill				adj R^2 : .5572	F statistic: 13.583	PROB > F: .0001
variable	parameter est		T value	PROB > T 		
intercept	4.562		8.168	.0001		
production GNMA	.2817		1.884	.0677		
cov und asset fut,T-bond fut	-.0107		-1.573	.1244		
und asset H33	-.2606		-2.430	.0202		
und asset H22	.1066		.998	.3250		
number of observations: 41		Durbin Watson: 1.604		lag		

Independent var: GNMA				adj R^2 : .4438	F statistic: 8.979	PROB > F: .0001
variable	parameter est		T value	PROB > T 		
intercept	2.420		3.063	.0041		
volume T-bill	.1051		.371	.7128		
volume T-bond	.2537		1.368	.1799		
production und asset	.4719		3.545	.0011		
var und asset fut	-.1843		-3.264	.0024		
number of observations: 41		Durbin Watson: 2.464		lag		

Independent variable: T-bond				adj R^2 : .8522	F statistic: 33.936	PROB > F: .0001
variable	parameter est		T value	PROB > T 		
intercept	5.940		2.173	.0371		
reporting change dummy	.2384		3.195	.0031		
volume und asset	1.148		5.189	.0001		
volume T-bill	-.5137		-1.957	.0588		
production und asset	-1.508		-1.703	.0979		
production GNMA	.3279		2.579	.0145		
und asset H	-.013		-2.040	.0494		
und asset H11	-.0206		-.695	.4922		
number of observations: 41		Durbin Watson: 1.892		lag		

Table 16. Financials 1978-81 Hedger-long

Independent var: T-bill			
adj R²: .6512		F statistic: 11.669	
PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	13.73	3.132	.0036
volume T-bond	1.003	4.605	.0001
production und asset	.1544	.184	.8553
production T-bond	-3.311	-4.648	.0001
var und asset fut	-.0823	-1.163	.2532
cov und asset fut,T-bond fut	-.0116	-2.574	.0147
cov GNMA spot,GNMA fut	-.00007	-.024	.9811
und asset H11	-.0951	-3.387	.0018
number of observations: 41		Durbin Watson: 1.891	
lag			
Independent var: GNMA			
adj R²: .5175		F statistic: 6.363	
PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	3.618	1.567	.1270
volume T-bill	.4786	3.184	.0032
production und asset	.1033	1.067	.2938
production und asset	-.4748	-.913	.3679
var und asset fut	.1999	2.908	.0066
var und asset spot	-.1054	-1.921	.0636
cov und asset spot,und asset fut	.0139	4.367	.0001
und asset H11	-.0906	-4.056	.0003
und asset H12	-.001	.698	.4904
number of observations: 41		Durbin Watson: 1.479	
lag			

Table 17. Financials 1978-81 Hedger-long

indepdent var: T-bond		adj R^2 : .9367	F statistic: 148.90	PROB > F: .0001
variable	parameter est	T value	PROB > T 	
intercept	1.905	8.948	.0001	
volume und asset	.7562	17.567	.0001	
var und asset spot	-.1605	-5.305	.0001	
cov und asset fut,GNMA spot	.00407	1.842	.0737	
und asset H14	-.0024	-1.818	.0774	
number of observations: 41	Durbin Watson: 2.014		lag	

Table 18. Financials 1978-81 Hedger-short

dependent var: T-bill				adj R ² : .5317		F statistic: 7.487		PROB > F: .0001	
variable		parameter est		T value		PROB > T			
intercept		-13.92		-1.816		.0785			
volume und asset		2.073		4.852		.0001			
volume T-bond		-1.141		-2.782		.0089			
production und asset		2.826		1.731		.0928			
var und asset spot		-.3703		-1.731		.0927			
cov und asset spot,und asset fut		-.2321		-1.021		.3148			
cov und asset fut,T-bond fut		-.01311		-1.461		.1534			
und asset H12		.0139		.292		.7723			
number of observations: 42				Durbin Watson: 1.132*				log	

dependent var: GNMA				adj R ² : .4172		F statistic: 4.182		PROB > F: .0013	
variable		parameter est		T value		PROB > T			
intercept		-3.18		-1.313		.1989			
volume T-bill		.3677		1.621		.1151			
volume T-bond		-.503		-2.520		.0171			
production und asset		.2422		2.404		.0224			
production T-bond		1.759		2.408		.0222			
var T-bond fut		-.083		-.435		.6667			
cov und asset fut,T-bond fut		.106		.522		.6051			
cov und asset spot,und asset fut		.0079		2.642		.0128			
und asset H11		-.0296		-1.286		.2079			
und asset H12		-.0018		-.935		.3568			
number of observations: 42				Durbin Watson: 1.364*				log	

Table 19. Financials 1978-81 Hedger-short

dependent var: T-bond				adj R ² : .9748	F statistic: 221.88	PROB>F: .0001
variable	parameter est		T value	PROB> T		
intercept	-29.389		-16.507	.0001		
production und asset	1.067		3.224	.0029		
production T-bill	5.1708		9.491	.0001		
production GNMA	.5327		6.648	.0001		
cov und asset fut,T-bill spot	-.0076		-3.512	.0013		
und asset H12	.0052		2.763	.0093		
und asset H13	-.0042		-3.256	.0026		
und asset H14	.0067		4.466	.0001		
number of observations: 42		Durbin Watson: 1.987		log		
Yule-Walker Estimates, T-bill						
unadjusted R ² = .4351						
variable	parameter est		T value	PROB> T		
intercept	-8.010		-1.011	.3196		
volume und asset	1.200		2.995	.0053		
volume T-bond	-.5503		-1.435	.1611		
production und asset	1.847		1.090	.2837		
var und asset spot	-.1189		-.731	.4701		
cov und asset spot,und asset fut	-.0137		-.083	.9344		
cov und asset fut,T-bond fut	-.0070		-.973	.3378		
und asset H12	.0060		-.187	.8525		

Table 20. Financials 1978-81 GNMA autoreg

Yule-Walker Estimates, GNMA			
unadjusted $R^2 = .3806$			
variable	parameter est	T value	PROB > T
intercept	-1.019	-.403	.6900
volume T-bill	.2404	1.019	.3162
volume T-bond	-.321	-1.475	.1507
production und asset	.2102	2.011	.0534
production T-bond	1.273	1.686	.1022
var T-bond fut	-.070	-.399	.6929
cov und asset fut,T-bond fut	.0554	.300	.7662
cov und asset spot,und asset fut	.0048	1.806	.0806
und asset H11	-.0111	-.498	.6220
und asset H12	-.0016	-.956	.3467

Table 21. Financials 1983-85 Trader-long

dependent var: T-bill				adj R ² : .8884				F statistic: 46.10				PROB > F: .0001			
variable				parameter est				T value				PROB > T			
intercept				31.871				4.050				.0004			
reporting change variable				.0915				2.080				.0468			
volume CD				.0943				1.365				.1832			
volume Euro				-.1439				-2.145				.0408			
production und asset				-5.022				-3.695				.0010			
var GNMA fut				-.0623				-2.308				.0286			
cov GNMA fut,T-bond fut				.0073				1.975				.0582			
number of observations: 35				Durbin Watson: 2.069				lag							
dependent var: CD				adj R ² : .9789				F statistic: 198.624				PROB > F: .0001			
variable				parameter est				T value				PROB > T			
intercept				8.7034				.708				.4851			
volume und asset				.8641				9.769				.0001			
volume T-bill				-1.034				-3.473				.0018			
volume Euro				.2141				2.347				.0268			
production Euro				4.680				5.222				.0001			
production T-bill				-3.240				-1.322				.1978			
var GNMA fut				-.1104				-3.824				.0007			
cov und asset fut,T-bond fut				.1205				26.10				.0001			
und asset H33				-.0218				-.664				.5128			
number of observations: 35				Durbin Watson: 1.838				lag							

Table 22. Financials 1983-85 Trader-long

dependent var: Eurodollar adj R ² : .7802 F statistic: 18.23 PROB>F: .0001			
variable	parameter est	T value	PROB> T
intercept	-119.4	-6.080	.0001
volume GNMA	.9946	5.767	.0001
volume T-bill	-.7514	-2.200	.0366
production CD	54.27	4.690	.0001
production T-bond	-12.45	-2.943	.0066
var T-bill fut	.1551	1.924	.0650
var GNMA fut	.1916	4.102	.0003
cov T-bill fut,CD fut	-.2093	-2.985	.0060
number of observations: 35	Durbin Watson: 2.105		lag

Table 23. Financials 1983-85 Trader-long

dependent var: GNMA		adj R^2: .8522	F statistic: 68.273	PROB>F: .0001
variable	parameter est	T value	PROB> T 	
intercept	27.87	3.815	.0006	
volume und asset	.2723	1.534	.1347	
production T-bond	-4.550	-3.670	.0009	
und asset h11	-.2482	-2.775	.0091	
number of observations: 36		Durbin Watson: 2.505		log
dependent var: T-bond		adj R^2: .1844	F statistic: 2.978	PROB>F: .0343
variable	parameter est	T value	PROB> T 	
intercept	10.08	2.969	.0057	
volume T-bill	-2.019	-.668	.5088	
production und asset	-.7742	-1.888	.0684	
cov GNMA fut,CD fut	-.0132	-2078	.0460	
und asset H	-.0684	-1.717	.0959	
number of observations: 36		Durbin Watson: 2.161		log

Table 24. Financials 1983-85 Trader-short

dependent var: Tbill				adj R ² : .7073		F statistic: 14.961		PROB > F: .0001	
variable		parameter est		T value		PROB > T			
intercept		-10.46		-2.752		.0103			
volume GNMA		.7734		6.608		.0001			
volume T-bond		1.503		2.883		.0075			
cov CD fut,T-bond fut		.0260		2.264		.0135			
und asset H		.0168		4.078		.0003			
und asset H12		389.5		3.011		.0055			
und asset H13		-.0163		-2.373		.0247			
number of observations: 35				Durbin Watson: 2.003				lag	

dependent var: CD				adj R ² : .8489		F statistic: 39.193		PROB > F: .0001	
variable		parameter est		T value		PROB > T			
intercept		-8.163		-3.727		.0008			
volume und asset		1.554		12.696		.0001			
var GNMA fut		-.4088		-3.44		.0018			
cov und asset fut,T-bond fut		-.0854		-3.662		.0010			
cov und asset fut,Euro fut		.4420		2.311		.0282			
und asset H23		.0274		2.849		.0080			
number of observations: 35				Durbin Watson: 1.234*				lag	

Table 25. Financials 1983-85 Trader-short

dependent var: Eurodollar adj R ² : -.0512 F statistic: .724 PROB > F: .6337			
variable	parameter est	T value	PROB > T
intercept	-.4187	-.109	.9139
volume GNMA	.1142	.967	.3417
volume T-bond	.5617	1.067	.2950
cov CD fut,T-bond fut	.0013	.116	.9083
und asset H	-.0039	-.951	.3499
und asset H12	80.90	.620	.5403
und asset H13	.0044	.637	.5291
number of observations: 35		Durbin Watson: 1.673	lag
Yule-Walker Estimates, CD			
unadjusted R ² = .8062			
variable	parameter est	T value	PROB > T
intercept	-9.983	-3.499	.0018
volume und asset	1.557	9.617	.0001
var GNMA fut	-.3583	-3.258	.0029
cov und asset fut,T-bond fut	-.0810	-4.034	.0004
cov und asset fut,Euro fut	.3342	2.002	.0551
und asset H23	.0182	2.415	.0225

Table 26. Financials 1983-85 Trader-short

dependent var: GNMA		adj R²: .7410	F statistic: 14.899	PROB > F: .0001
variable	parameter est	T value	PROB > T 	
intercept	85.54	2.000	.0557	
reporting change variable	.5789	2.592	.0152	
volume und asset	.1848	.638	.5290	
production und asset	1.0003	2.505	.0186	
production T-bill	-15.09	-2.042	.0510	
var T-bond fut	-.0928	-1.323	.1970	
var T-bill fut	-.3235	-2.037	.0515	
cov Euro fut,GNMA fut	.0145	.1405	.1714	
Number of observations: 35		Durbin Watson: 1.736		lag
dependent var: T-bond		adj R²: .7114	F statistic: 21.948	PROB > F: .0001
variable	parameter est	T value	PROB > T 	
intercept	-17.73	-4.728	.0001	
volume T-bill	.8834	.3094	.0077	
production und asset	3.443	7.752	.0001	
cov T-bill fut,GNMA fut	.0084	1.777	.0857	
und asset H22	-.0718	1.676	.1041	
number of observations: 35		Durbin Watson: 1.754		lag

Table 27. Financials 1983-85 Hedger-long

dependent var: Tbill		adj R²: .3389	F statistic: 3.2431	PROB>F: .0102
variable	parameter est	T value	PROB> T 	
intercept	.1469	.090	.9292	
reporting change variable 1	-.0335	-.838	.4094	
reporting change variable 2	-.1496	-2.187	.0376	
volume und asset	.3448	2.204	.0362	
production Euro	1.237	2.705	.0117	
var und asset fut	-.0672	-1.872	.0720	
cov und asset spot,und asset fut	-.0054	-1.746	.0922	
und asset H22	-.034	-1.323	.1969	
und asset H33	.0151	.465	.6460	
Number of observations: 36		Durbin Watson: 2.006		log
dependent var: CD		adj R²: .9373	F statistic: 88.158	PROB>F: .0001
variable	parameter est	T value	PROB> T 	
intercept	33.99	2.752	.0101	
reporting change variable	.2253	2.531	.0171	
volume T-bond	-1.195	-2.034	.0512	
volume und asset	.6727	7.588	.0001	
production und asset	-16.63	-3.663	.0010	
production Euro	10.22	5.689	.0001	
cov CD fut,T-bill fut	-.1562	-3.113	.0041	
number of observations: 36		Durbin Watson: 1.848		log

Table 28. Financials 1983-85 Hedger-long

dependent var: Euro adj R^2 : .9831 F statistic: 186.526 prOB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	-21.49	-6.709	.0001
reporting change variable	.1277	5.628	.0001
volume CD	.0805	1.812	.0826
volume T-bill	.1580	1.346	.1908
production und asset	2.157	3.339	.0028
production CD	5.706	4.221	.0003
var und asset fut	-.0790	-1.733	.0959
var CD	-.1033	-.305	.7627
cov und asset fut,T-bond fut	.0441	16.766	.0001
cov T-bill spot,CD fut	.0022	1.731	.0963
und asset H11	.0284	1.966	.0610
und asset H44	-.0143	-.890	.3825
number of observations: 36	Durbin Watson: 1.768		log

Table 29. Financials 1983-85 Hedger-long

dependent var: GNMA adj R ² : .9433 F statistic: 63.894 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	-3.094	-1.9652	.0606
volume und asset	.7218	21.49	.0001
production und asset	.2580	1.297	.2066
var und asset fut	.1263	1.685	.1044
var und asset spot	.1938	1.995	.0571
var T-bond fut	-.9480	-1.198	.2420
var T-bond fut	-.1692	-3.208	.0037
cov und asset spot,T-bill fut	.0096	1.766	.0897
cov T-bond spot,und asset fut	-.0052	-1.251	.2227
und asset H11	-.1081	-3.067	.0051
Number of observations: 35		Durbin Watson: 1.789	lag
dependent var: T-bond adj R ² : .8618 F statistic: 43.400 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	-.030	-.454	.6531
production und asset	1.2658	3.306	.0025
reporting change variable	-.1981	-3.628	.0011
und asset H44	.0509	3.003	.0055
volume GNMA	-.2014	-2.750	.0102
cov T-bond spot-T-bill	-.0033	-1.614	.1175
number of observations: 34		Durbin Watson: 1.240*	lag

Table 30. Financials 1983-85 T-bond Autoreg

Yule-Walker Estimates, T-bond			
unadjusted $R^2 = .8821$			
variable	parameter est	T value	PROB > T
intercept	-2.13	-.863	.3954
reporting change variable	-.1689	-2.930	.0067
volume GNMA	-.1555	-2.109	.0440
production und asset	1.4528	3.398	.0021
cov T-bond spot-T-bill	-.0040	-1.951	.0612
und asset H44	.0432	2.971	.0060

Table 31. Financials 1983-85 Hedger-short

dependent var: T-bill adj R ² : .7636 F statistic: 10.152 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	41.53	5.435	.0001
reporting change variable	.0637	4.104	.0008
volume GNMA	-.000001	-5.873	.0001
production CD	-10.81	-4.689	.0001
production T-bond	.000007	3.410	.0025
var T-bond fut	-.020	-2.366	.0272
cov und asset spot,CD fut	-.0029	-2.444	.0230
cov und asset fut,GNMA fut	.0036	2.078	.0496
cov Euro spot,und asset fut	-.4826	-3.550	.0018
cov CD fut,Euro fut	.4274	3.136	.0048
cov und asset fut,T-bond fut	-.0073	-2.979	.0069
und asset H11	-.0550	-2.13	.0446
und asset H	.0373	1.524	.1417
Number of observations: 35		Durbin Watson: 2.211	lag
dependent var: CD adj R ² : .9278 F statistic: 63.41 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	32.71	2.52	.0180
volume und asset	1.024	6.996	.0001
volume T-bond	-.9046	-2.080	.0472
production und asset	-14.24	-2.725	.0111
production Euro	8.044	3.302	.0027
var GNMA fut	-.1678	2.886	.0078
cov T-bill spot,und asset fut	.0125	2.649	.0133
und asset H44	.0130	.317	.7535
number of observations: 35		Durbin Watson: 1.755	lag

Table 32. Financials 1983-85 Hedger-short

dependent var: Eurodollar adj R^2 : .8712 F statistic: 29.742 PROB>F: .0001			
variable	parameter est	T value	PROB> T
intercept	-23.35	-2.269	.0318
volume und asset	.2486	2.256	.0327
volume CD	.7231	6.62	.0001
volume T-bill	-1.121	-2.913	.0073
production und asset	-2.070	-1.075	.2921
production CD	28.33	4.518	.0001
production T-bill	-11.34	-2.973	.0063
cov und asset fut,T-bond fut	-.0055	-1.051	.3031
cov T-bill spot,CD fut	-.0124	-3.85	.0008
number of observations: 35	Durbin Watson: 2.597		lag

Table 33. Financials 1983-85 Hedger-short

dependent var: GNMA adj R²: .9722 F statistic: 149.37 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	.3422	.228	.8211
volume und asset	.7511	16.878	.0001
volume T-bond	-.2240	-1.139	.2651
var und asset fut	.1402	3.16	.0040
var T-bill fut	1.060	1.767	.0890
var T-bond fut	-.1052	-3.72	.0010
cov und asset spot,T-bond fut	.0077	1.975	.0590
und asset H11	.09954	2.505	.0188
und asset H44	-.1156	-3.248	.0032
bNumber of observations: 35		Durbin Watson: 2.144	lag
dependent var: T-bond adj R²: .7856 F statistic: 21.768 PROB > F: .0001			
variable	parameter est	T value	PROB > T
intercept	4.75	2.575	.0156
reporting change variable	-.2072	-4.77	.0001
volume T-bill	-.2947	-2.580	.0154
volume GNMA	-.1546	-2.641	.0134
production und asset	.4994	1.837	.0768
und asset H22	.0929	3.114	.0042
und asset H33	-.04198	-1.53	.13711
number of observations: 35		Durbin Watson: .797*	lag

Table 34. Financials 1983-85 Hedger-short Autoreg

Yule-Walker Estimates, T-bond			
unadjusted $R^2 = .7477$			
variable	parameter est	T value	PROB > T
intercept	2.654	.112	.9120
production und asset	1.182	1.222	.2716
reporting change variable	-.1602	-4.11	.0003
volume GNMA	-.1078	-2.146	.0410
und asset H22	.0847	4.009	.0004
volume T-bill	-.2653	-2.824	.0084
und asset H33	-.00449	-.456	.6365

Table 35. SYSREG RESULTS

dependent var: copper Comex Trader-short			
variable	parameter est	T value	PROB > T
intercept	-19.90	-2.692	.0115
production und asset	1.616	5.205	.0001
production gold	3.102	2.507	.0179
var gold fut	.2767	2.463	.0179
cov gold fut,silver fut	-2.554	-2.274	.0303
number of observations: 36	Durbin Watson: 2.081		log
dependent var: copper Comex Hedger-long			
variable	parameter est	T value	PROB > T
intercept	3.717	8.506	.0001
volume und asset	-.705	-2.178	.0379
production und asset	.7874	11.27	.0001
cov und asset spot,gold fut	.0290	2.403	.0231
cov gold spot,gold fut lglsig12	.0392	2.107	-.0442
cov silver spot,silver fut	-.0946	-3.8951	.0006
und asset H	-.0242	-2.553	.0164
number of observations: 36	Durbin Watson: 1.832		log

Table 36. SYSREG RESULTS

Independent var: T-bill Fin 78-81 Trader-long			
variable	parameter est	T value	PROB > T
intercept	2.426	2.550	.0156
reporting change variable	-.4223	-5.254	.0001
volume und asset	1.285	4.283	.0001
volume T-bond	-.2298	-1.18	.2461
var und asset fut	-.4829	-3.814	.0006
cov und asset fut,GNMA fut	-.0083	-1.9718	.0571
und asset H12	.0093	3.596	.0010
und asset H33	.1443	2.015	.0521
number of observations: 42	Durbin Watson: 1.162*		log
Indepedent var: T-bond Fin 78-81 Hedger-long			
variable	parameter est	T value	PROB > T
intercept	1.898	9.083	.0001
volume und asset	.7503	17.862	.0001
var und asset spot	-.1573	-5.384	.0001
cov und asset fut,GNMA spot	.0039	1.782	.0832
und asset H14	-.0030	-2.449	.0196
number of observations: 41	Durbin Watson: 2.014		lag

Table 37. SYSREG RESULTS

dependent var: T-bill Fin 78-81 Hedger Short			
variable	parameter est	T value	PROB > T
intercept	-17.91	-2.397	.0223
volume und asset	2.051	4.826	.0001
volume T-bond	-1.289	-3.207	.0030
production und asset	3.709	2.330	.0261
var und asset spot	-.3487	-1.682	.1018
cov und asset spot,und asset fut	-.2186	-.9921	.3248
cov und asset fut,T-bond fut	-.0091	-1.062	.2957
und asset H12	.0061	.1313	.8963
number of observations: 42	Durbin Watson: 1.132*		log
dependent var: Eurodollar Fin 83-85 Trader-long			
variable	parameter est	T value	PROB > T
intercept	-111.32	-6.158	.0001
volume GNMA	.9699	6.018	.0001
volume T-bill	-.6243	-1.957	.0607
production CD	48.303	4.557	.0001
production T-bond	-10.166	-2.618	.0143
var T-bill fut	.1326	1.811	.0812
var GNMA fut	.1911	4.144	.0003
cov T-bill fut,CD fut	-.1844	-2.895	.0074
number of observations: 35	Durbin Watson: 2.105		lag

Table 38. SYSREG RESULTS

dependent var: GNMA Fin 83-85 Hedger-short			
variable	parameter est	T value	PROB > T
intercept	.3422	.228	.8211
volume und asset	.7511	16.878	.0001
volume T-bond	-.2240	-1.139	.2651
var und asset fut	.1402	3.16	.0040
var T-bill fut	1.060	1.767	.0890
var T-bond fut	-.1052	-3.72	.0010
cov und asset spot,T-bond fut	.0077	1.975	.0590
und asset H11	.09954	2.505	.0188
und asset H44	-.1156	-3.248	.0032
bNumber of observations: 35		Durbin Watson: 2.144	lag

Table 39. Summary of Own and Cross Production Significance

Contract	Trader-L	Trader-S	Hedger-L	Hedger-S
Gold-Comex				
Silver-Comex	xxx	xxx	xxx	
Copper-Comex	xxx	xxx	xxx	xxx
Gold-CBT		xxx		xxx
Silver-CBT		xxx		
T-bill 78-81			xxx	
GNMA 78-81	xxx	xxx		xxx
T-bond 78-81		xxx		xxx
T-bill 83-85	xxx		xxx	xxx
CD 83-85	xxx		xxx	xxx
Euro 83-85	xxx		xxx	xxx
GNMA 83-85	xxx	xxx		
T-bond 83-85		xxx	xxx	

Table 40. Summary of Own Volume Significance

Contract	Trader-L	Trader-S	Hedger-L	Hedger-S
Gold-Comex				
Silver-Comex				xxx
Copper-Comex			xxx	
Gold-CBT				
Silver-CBT	xxx			
T-bill 78-81	xxx			xxx
GNMA 78-81				
T-bond 78-81		xxx	xxx	
T-bill 83-85			xxx	
CD 83-85	xxx	xxx	xxx	xxx
Euro 83-85				xxx
GNMA 83-85			xxx	xxx
T-bond 83-85				

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