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THE PREDICTIVE NATURE OF COPPER FUTURES PRICES AND IMPLICATIONS FOR MARKET EFFICIENCY

by

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ABSTRACT

Questions concerning the relationship between copper futures prices and spot prices prompted this research. Three functions of copper futures prices were identified. First, futures prices perform an allocative function because they disseminate information which influences buy and sell decisions. Second, futures prices perform a predictive function when traders look at futures prices as forecasts of subsequent spot prices. Third, evidence suggests futures prices perform a stabilizing function by reducing the variability of spot prices. These functions influence price formation and comment on the efficiency of copper prices in conveying information.

The predictive function of futures prices was selected for empirical research. The hypothesis developed was that futures prices are unbiased predictors of subsequent spot prices; hence, the basis ratio of the futures price at time t and the spot price at time t+n should not be statistically different from one. From 1980 to 1985, the data collected supported the hypothesis in 4 out of 18 time periods.

The validity of the basis ratio model as a measure of forward pricing performance was examined by expressing the

basis ratio as a linear equation and comparing it with four moving average models and three regression equations. An analysis of the mean forecast errors suggested both the moving average models and the regression equations were superior predictors of copper spot prices when compared to the basis ratio model. This result implies that other variables, such as the convenience yield, price of storage, risk premium, and return to capital, are interacting with the futures price and sending information to market participants regarding subsequent spot prices.

The divergence of the basis ratio from the hypothesized value of one could also be explained by copper supply shocks during the study period, the notion that copper futures prices are not fully reflecting all available information, or that the market for information is in a disequilibrium situation. These issues could be explored further by increasing the study period and expanding the basis ratio tests to other commodities.

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Chapter 1

INTRODUCTION

Following the recent suspension of trading in tin by the London Metal Exchange, the existence of commodity trading and its relationship to financial markets have come under public scrutiny. The possibility that the International Tin Council will be unable to fulfill its commitments has brought forth forecasts that major metal prices may plummet 30% to 50% (Business Week, 1985). More interesting than the tin crisis itself may be the fact that associated commentary and forecasts are coming from the popular press, not from the academic journals.

The topic of commodity trading currently seems to be one of public interest as well as the one that continues to fascinate theorists in finance and economics. And while scores of studies have been published describing the workings of the commodity and stock markets, perhaps the state of affairs in international tin trading is a reminder of much more to be learned.

An article appearing in the December 31, 1985, edition of the Wall Street Journal, page 11, confronted the debate of the validity of the efficient-market hypothesis and the potential for traders to make profits over the long run.

Those who support the market efficiency viewpoint argue that stock prices follow a random walk and that traders cannot make a profit over the long run. This viewpoint has been developed primarily by theorists and academic observers of the market. The other school, composed mostly of the traders themselves and professional money managers, believe that the market is not unbeatable and that long run profit potential is evident.

Such theoretical debates serve to remind practitioners and scholars alike of the need to question and understand the institutions created to facilitate business transactions. A more thorough knowledge of the economics of commodity trading may have prevented the present international turmoil in tin trading.

The research in copper futures trading discussed in this paper seeks to add to the general body of knowledge regarding metal commodity trading and to contribute to the resolution of the debate of the market efficiency hypothesis. Using copper as an example, a literature review has been undertaken to explore the concept of a copper futures contract and to comment upon the factors and institutions which determine the contract's price. This literature review has identified three functions of copper futures prices: the allocative function, the predictive function, and the stabilizing function. These functions are discussed in detail in Chapter 2 and together help illustrate the intricate workings of the modern commodity market.

The efficient market hypothesis has been examined through several empirical tests. These tests stem from discussions of the predictive function of copper futures prices or the basic notion that a futures price is an unbiased predictor of the subsequent spot price. Test results allow inferences to be made about the nature of information flows in the market and the ability of investors to make consistent profits. Chapter 3 presents the empirical hypothesis test statement and a discussion of the methodology employed. The hypothesis test may be found in Chapter 4, and the results in Chapter 5.

Although the research undertaken focuses upon only one function of the futures price and only one metal, understanding of the entire commodity trading scheme comes about from familiarity with all the components. The thesis summary, conclusions, and suggestions for further research are contained in Chapter 6.

Computer calculations are in the appendixes.

Chapter 2

THE THREE FUNCTIONS OF COPPER FUTURES PRICES

The existence of a futures contract market for a commodity has been identified as performing at least one of three general functions. First, a futures market may facilitate the buying and selling of the commodity by providing an agora for hedging and speculation. Second, the futures price itself may convey information and signals to the market such that it is useful in predicting subsequent spot prices. And third, for a commodity with a spot price of large variation, a futures market might act as a stabilizing force in the cash price. These three functions have been developed and debated by economic theorists since the beginning of futures trading as early as 1850 (Working 1953). This chapter outlines the evolution of these three general functions of the role of commodity futures prices with respect to copper and explores implications for market efficiency.

The Allocative Function

The copper futures market helps to allocate copper supplies and alternative capital investments because it encourages buying and selling of the commodity. A decision by a trader to purchase a copper future contract influences the delivery of the commodity from the producer to the end-user; therefore, such a transaction exhibits an allocative function for copper over time. Furthermore, the buying of a copper future pledges the investment to the copper market in the short run. Since the same investment is not available to other markets (such as those for T-bills, housing, or automobiles, etc.), the mere act of making an investment decision influences the allocation of all resources over time.

Two basic types of investment decisions will be discussed at length below: the copper spot market transaction and the futures contract transaction. The spot market buying or selling of copper is based upon the current posted spot price at time t, SP_t. Although spot market transactions may be deliverable at a later date, the price represents the going price at time t.

In contrast, a futures contract locks in a price for a transaction which definitely will occur several months from time t at time t+n. At time t+n, the transaction is completed or closed, and an actual delivery date within the delivery month is agreed upon. The futures price, denoted as $FP_{t,t+n}$, has the first subscript, t, to reference the month in which the contract was written and has the second subscript, t+n, to reference the maturity time in months. For example, a three-month futures contract would be priced as $FP_{t,\ t+3}$.

Price of Storage Theory

In general the copper futures market has been described by Holbrook Working (1953) as serving "primarily to facilitate hedging and speculation by promoting exceptional convenience and economy of the transactions." This orientation is supported by a pamphlet published in 1977 by Commodity Exchange, Inc. (COMEX) which states the basic purpose of copper futures trading is threefold. The exchange provides a mechanism by which one may hedge (seek protection against the risk of adverse price movement), speculate (anticipate copper price changes for monetary gain), and buy or sell physicals (COMEX 1977).

Along with viewing futures markets as an efficient institution, Working introduced a concept known as "price of storage." The difference between the price of a futures contract and the current cash price (or the difference in prices of two futures delivery months) is defined as the price of storage. This price difference or basis may be postive or negative and provides incentive or disincentive to store the commodity (Tomek and Gray 1970).

The basis relationship may be stated as

$$FP_{t,t+n} = SP_t + Ps_{t,n} \qquad (2\text{-}1)$$

where $FP_{t,t+n}$ = futures price at time t for n periods, SP_t = spot price at time t, and $Ps_{t,n}$ = price of storage. Here the basis, $FP_{t,t+n} - SP_t$, is entirely explained by the price of storage, $Ps_{t,n}$.

The price of storage, or cost of carrying, stems from the decision to hold a commodity in inventory instead of buying or selling it. Fabricators risk losing money if they allow their inventories of copper to fall so low that they cannot handle orders that may be placed. There are storage costs, such as warehouse fees, associated with holding inventory. More importantly, the decision to hold inventories creates the risk that less expensive copper may be available in the near future while the fabricator is carrying the more expensive copper in inventory. Likewise, a copper mining concern which carries inventory risks a lower price when the copper is sold (Working 1942). Along with direct costs, such as warehouse fees, and indirect costs, such as increased risk, the price of storage is also determined by the prevailing interest rate. A high interest rate increases the cost of money available to sustain inventory carrying.

Although changes in the price of storage are small relative to the changes in the price of the commodity, Working's definition illustrates the interrelationship between commodity inventories and the futures market: the posting of intertemporal prices influences inventory carrying. And changes in inventory levels certainly help determine the allocation of the resource in the economy. Moreover, carrying inventory is both costly and necessary. Even in a world of perfect expectations, stocks of copper must be carried over time to adjust supply to a varying demand. Due to the technical limitations of adjusting the rate of production output, it may be less expensive (and is certainly more convenient) for fabricators to carry inventory than to modify output (Blau 1944).

In the aggregrate, these costs, net any gains from holding inventories, represent the price of storage. If these costs are positive, the futures price is greater than the spot price, and a contango situation exists. If the costs are negative such that gains outweigh losses, the futures price is less than the spot price, and there is backwardation.

Keynes-Hicks Hypothesis

Associated with the idea of costs of inventory are discussions of the role and nature of hedging and speculation in the commodity market. These discussions center on the essence of risk in commodity trading. According to Gerda Blau, (1944):

> commodity futures exchanges are market organizations specificially developed for facilitating the shifting of risks due to unknown future changes in commodity prices; i.e., risks which are of such a nature that they cannot be covered by means of ordinary insurance.

For an insurance company to provide coverage and to receive an adequate rate of return, unknown events against which insurance is sought must be independent of each other, and the total number of policies in effect must be very large. In commodity trading, however, risks of price movements affect holdings in a similar manner, i.e., are not independent, and a company's position is not improved by increasing its total number of commitments.

The gap caused by the lack of such insurance can be theoretically filled by a commodity futures exchange. Traders wanting to minimize risks in the cash market can neutralize these risks by assuming opposite positions in the futures market. Because the demand for hedges against selling risks will most likely not exactly equal the demand for hedges against buying risks, excess demand or supply by hedgers will exist. This "risk surplus" for which no opposite hedgers can be found can be assumed by speculators.

In contrast, speculators enter the futures market because they expect their superior foresight will make their risk-bearing profitable. Both Keynes (1930, pp. 135-144) and Hicks (1946, pp. 136-139) support this contention. Because hedgers are risk-averse, they use futures markets to avoid risk and sell inventories for future delivery at a price which covers the cost of storage. Such sales become feasible only when speculators are willing to provide this service in return for a fee (Blau 1944). This fee, or risk premium, varies according to the judgment of speculators. The difference between the price at which speculators buy copper and the price at which they later sell is the reward or premium for their services (Cootner 1960a).

The outcome of the Keynes-Hicks hypothesis just discussed is that speculators can, and do, extract a positive return for their efforts. Using this framework, a relationship between copper spot prices and futures prices may be expressed as

$$SP_t + RP_t = FP_{t,t+n} \qquad (2\text{-}2)$$

where RP_t = a risk premium. From this orientation the basis, $FP_{t,t+n} - SP_t$, is accounted for by the risk premium.

Telser's Argument

In contrast to the Keynes-Hicks viewpoint, Lester G. Telser (1960) argues that competition and free entry bid speculative profits to zero. Speculators as a group may be able to make a return in the short run but Telser questions whether this result is due to the neutralization of hedger's risk or to the losses of other speculators. Positive return for speculators as a group could be entirely attributed to the amount of successful speculative trades outweighing the amount of unsuccessful speculative trades; hence, speculators may make profits only at one another's expense.

Neutralization of Risks

An explanation of potential speculative risks is illustrated in Figure 2-1. Given that Circle A represents total risks in the cash market and Circle B denotes total risks in the futures market, Position I shows the ideal situation in which all traders wishing to hedge can find insurance available from speculators. These hedging traders can offset or neutralize their risk in the cash

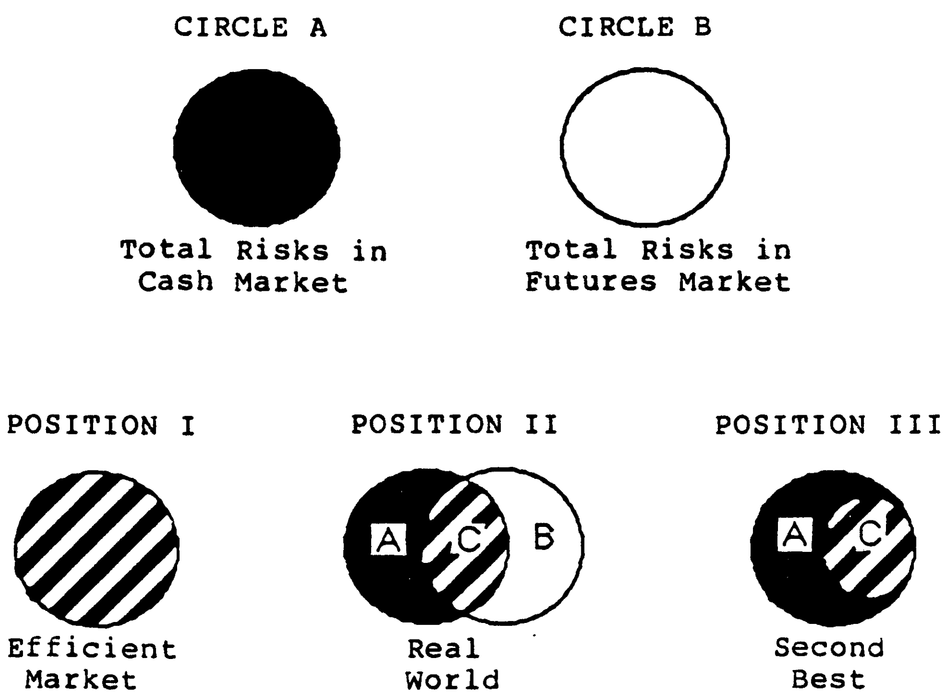

Figure 2-1

Neutralization of Risks

Source: Adapted from Blau, Gerda, 1944, "Some Aspects of the Theory of Futures Trading," The Review of Economic Studies, Vol. 12 (1), No. 31, p. 3.

market by making a transaction in the futures market. This implies that speculators are available for each hedging transaction who expect to make a profit on the transaction itself or on their total portfolio of commodity holdings. Therefore, if speculators are buyers of insurance, they should make money over the long-run: the essence of the Keynes-Hicks hypothesis.

Position II in the diagram depicts a more real world circumstance in which only a portion (Area C) of total risks are offset. Area A represents non-hedgeable risks in the cash market, and Area B represents all additional risks in the futures market which have no opposite in the cash market. This example assumes there are some traders who wish to hedge (or speculate) but can find no speculators (or hedgers) willing to offset the risk inherent to the trade.

Position III represents a second best situation compared with the efficient market. While some risks in the cash market are not being offset, no speculation is taking place without an opposite hedge. Such non-neutralized speculation can impair the effectiveness of hedging because speculators would be trading for the intent of making profits, not of providing insurance (Blau 1944).

Gambling Theory

Another interpretation of speculative risk is based upon the motivation of speculators in the commodity market and asserts that for many speculators, a futures market is a gambling casino (Hardy 1940). Instead of providing insurance and earning a fee, speculators as a class are willing to pay for the privilege of socially acceptable gambling. Empirical research by Katherine Dusak (1973) tests this hypothesis for wheat, corn, and soybean futures, and the results indicate average returns very close to zero if not actually negative. Dusak argues that the risk premium depends upon the extent to which variations in commodity prices are systematically related to variations in the return on total wealth. This approach categorizes commodities as assets which earn a return to the investor. For Dusak, a return to the spot commodity holder can be decomposed into three elements: a pure time return to capital, a risk premium, and storage costs, such that

$$FP_{t,t+n} = SP_t + Rc_t + RP_t + Ps_t \qquad (2\text{-}3)$$

where Rc_t = return to capital.

Her work approximated the risk premium, RP_t, as the percentage change in the futures price over the time interval, minus storage costs, minus the riskless rate of interest over the same period. Her concept in equation form for period t is

$$RP_t = (\%\Delta\ FP_{t,t+n}) = (\%\Delta\ SP_t) - Ps_t - Ir_t \qquad (2\text{-}4)$$

where $\%\Delta$ = percentage change and Ir_t = riskless interest rate at time t. After defining the risk premium in this manner, her empirical tests calculate the risk premium to be not statistically different from zero or slightly negative. While this conclusion in itself does not directly verify the idea that speculators are net gamblers, it does differ sharply from the insurance interpretation offered by Keynes and Hicks.

Convenience Yield Explanation

Yet another explanation centers on a trader's utility function. The holding of commodity contracts may provide extra utility to a trader by increasing convenience, economy, or security over leaving the contracts to be carried by someone else in the market. This convenience yield is the sum of extra advantages other than appreciation or monetary gain which a trader receives from carrying inventory instead of holding the equivalent value in cash and trading at a later date (Blau 1944). Using this idea, the futures price for copper in time period t could be described as a function of the spot price and the convenience yield, such that:

$$FP_{t,t+n} = SP_t + CY_t \quad (2\text{-}5)$$

where CY_t = convenience yield.

Although the above theories discussing the relationship between spot and futures prices are sometimes complementary and sometimes divergent, most theorists writing on the subject profess some relationship does exist. Moreover, the theories previously outlined imply that decisions to participate in copper commodity trading influence the allocation of copper through the market over time.

The Predictive Function

Along with an allocative function, copper futures have also been described as serving a predictive function. This function is based on the premise that the futures price quoted today is an unbiased predictor for the subsequent spot price (Goss 1981). If the futures price is totally accurate in predicting the future spot price, then the basis is equal to zero and the following relationship is implied for a three-month contract:

$$FP_{t,t+3} = SP_{t+3} \quad (2\text{-}6)$$

where $FP_{t,t+3}$ = futures price today (period t), SP_{t+3} =

subsequent spot price three months from today. This equation is equivalent to

$$\frac{SP_{t+3}}{FP_{t,t+3}} = 1 \tag{2-7}$$

which the author refers to as the basis ratio.

For the general case, these equations become

$$FP_{t,t+n} = SP_{t+n} \tag{2-8}$$

$$\frac{SP_{t+n}}{FP_{t,t+n}} = 1 \tag{2-9}$$

where n = number of months covered in the futures contract (usually ranging in copper trading from one to twelve months).

In testing this hypothesis for copper, zinc, tin, and lead from 1971 to 1978 on the London Metal Exchange, Goss (1981) concluded that futures prices for tin and possibly for copper and zinc were unbiased predictors of subsequent spot prices and performed a forward pricing role. He expressed this relationship in linear form as

$$A_t = \alpha + \beta P_{t-i} + \xi_t \tag{2-10}$$

where A_t = spot (cash) price, P_t = three months futures price, i = 1, 2, or 3 months lag, ξ_t = random disturbance, and t = time in months. His general hypothesis was that $\alpha = 0$ and $\beta = 1$. The equation was estimated using two regression methods: Ordinary Least Squares (OLS) and General Instrumental Variable Estimation (GIVES). T-tests for the hypotheses H_1: $\alpha = 0$ and H_2: $\beta = 1$ for i = 1, 2, and 3, were supportive of his general hypothesis for tin using both regression techniques. For copper and zinc, the OLS estimates indicated the general hypothesis should be rejected, while the GIVES estimates suggested acceptance. In the case of lead, both sets of regression estimates suggested rejection of his general hypothesis.

Goss (1981) summarizes the economic implications of his results as follows:

> It would seem that the copper and zinc futures markets are performing their forward pricing function quite well, the tin market is performing somewhat better in this role, and the lead futures market is performing less well against the criteria for unbiased prediction. That is economic agents using copper, zinc and tin futures prices as a basis for forward contract pricing or for tendering for such contracts will have found themselves as well off on average as if they had known the spot price in advance, during the sample period. Users of lead futures prices for such purposes however, will have found themselves taking unexpected profits or losses.

Results such as these can be utilized to comment upon the performance of a futures market (Kofi 1973). Performance in terms of contributing to more orderly production and marketing of the commodity being traded can be judged by how well it predicts prices (Larson 1967).

Furthermore, such a prediction is useful to producers in guiding production levels and to merchants in inventory management.

The Role of Information

Commodity future exchanges have been described as clearing centers for information (Powers 1970). Information is essential to competition and, as markets become more decentralized, information concerning demand and supply conditions must be carefully collected and interpreted--an often costly process.

The notion that the futures price is an unbiased predictor of the future spot price is based on several assumptions concerning information flows in the market. These assumptions are extensions of Eugene F. Fama's market efficiency hypothesis (1976) which asserts that securities prices fully reflect all available information relevant to determining value. Hence, for futures prices to serve as predictors, the necessary condition that both copper spot and futures prices must fully reflect all available information must be met (Goss 1981).

Fama's market efficiency hypothesis takes three forms. First, weak form efficiency implies price formation is based upon only past market behavior or on observed price changes. Second, semistrong efficiency asserts prices are determined also by all publicly available information such as that concerning copper production and inventories, general economic conditions, and technology. Furthermore, semistrong form efficiency assumes no inside or private information is available. And third, strong form efficiency describes a situation in which all information, public and private, is fully reflected in prices (Neave and Wiginton 1981).

Although Fama's work deals with the securities market, his conclusions can be applied to the commodity market in general and the copper market in particular. The predictive capacity of futures prices has been tested for commodities with both continuous and discontinuous inventories as well as those with no inventories. According to Goss, previous studies indicate futures prices are unbiased predictors for continuous inventory commodities like corn, soybeans, and coffee, but not for discontinuous inventory items such as potatoes or non-inventory goods such as finished live beef cattle (Goss 1981). Because copper is held in continuous inventory and spot prices do not exhibit extreme seasonal trends as exhibited by some agricultural commodities, the literature concerning other commodities and securities becomes logically applicable.

Implications for the Efficient Market Hypothesis

Studies concerning the ability of prices to convey information have been developed from different views of Fama's market efficiency hypothesis. If the copper futures market is weak form efficient and price formation is based only upon past market behavior, then chartists would essentially set prices. Most articles in the Wall Street Journal would be of little interest. More important, the proving of weak form efficiency by the scientific method would fail to have significant meaning in the Information Age in which we are now living.

More compelling studies test the semistrong and strong forms of market efficiency. If the copper futures market is semistrong form efficient, there should be no manner in which a trader could use publicly available information to make above average profits (Cornell 1977). This conclusion or "zero profit rule" has led to investigations which consider the ability of traders to make profits on the average (Cootner 1960a, 1960b; Dusak 1973; Telser 1960). If traders are not able to make profits on the average, then the futures price must be an unbiased predictor of the spot price. Otherwise speculators could always profit from this bias by taking one position in the spot market and the opposite position in the futures market (Cornell 1977).

This result further implies that if traders can make profits on the average (Grossman 1977), then the futures price cannot be defined as an unbiased predictor of spot prices (Hansen and Hodrick 1979). Such a conclusion is supported by Working's argument that the futures market cannot act both as a forecasting agency and a medium for rational price formation (Working 1948: Leuthold 1974). Hence, if profits are being made, the market for information is not semistrong form efficient.

Examination of strong form market efficiency is more complicated because the possibility exists for insider knowledge and trading based on private information. The existence of private information is not the complicating factor, but instead the issue of how private information is ultimately reflected in prices. One explanation by Richard E. Kihlstrom and Leonard J. Mirman (1975) is based upon trader's expectations. After traders acquire inside information, the expectations held by these insiders are on the average more accurate than expectations which are not revised on the basis of privileged information. Therefore, insiders can profit by adjusting trading plans to reflect their revised expectations. If the induced demand is significant, market prices will be forced to adjust and the privileged information is reflected in market prices (Kihlstrom and Mirman 1975).

In this manner, private information becomes public information when it is ultimately reflected in prices. Private information is a source of inefficiency only when it leads to speculative profits as illustrated above in the discussion of semistrong form efficiency.

Equilibrium in the Market for Information

The tradeoff between speculative profit and predictive futures prices and observations about market efficiency arise from the general assumption of equilibrium in the market for information. The nature of equilibrium in the market for information is described below by a paradox developed by Grossman and Stiglitz (1980).

Assume at any time there exists a finite set of copper traders, and profits are possible on the average. Some are more informed than others about factors determining price formation. These informed individuals will profit from their information if, and only if, some of the information is not immediately transmitted to uninformed individuals by copper spot prices (Grossman 1977). When some information remains untransmitted, informed and uninformed traders have different expectations about future copper spot prices. In equilibrium, traders decide whether or not to become informed based upon the value of information or its profit-making potential (Green 1977). (Realize that if no profits were possible, all traders would consider the futures price an unbiased predictor of future spot prices and would act accordingly). Because information has value, acquiring it involves a cost in real resources (Green 1977).

However, if traders find they can learn nothing from information which is not apparent in prices, (i.e., information has no profit making potential) there is no equilibrium in which costly information will be collected. This occurs because when information has no value, traders have no incentive to collect it. Yet no equilibrium exists in which information will be collected. Ceasing to collect information will cause the price to be uninformative, and there is again incentive for traders to collect costly information (Bray 1981; Grossman and Stiglitz 1980).

While the Grossman and Stiglitz paradox pushes the role of information to one theoretical horizon, the presentation does enforce the poignance of the predictive function of copper futures prices.

The Stabilizing Function

Besides assuming an allocative and predictive function, copper futures prices are theorized as fulfilling a stabilizing function as well. This function is based on the premise that an active futures market reduces the variation in spot prices.

This stabilization can come about from two different directions. First, because the copper futures market allocates risks between hedgers and speculators, sellers may reduce the variability of their income when the possibility of trading futures exists (Danthine 1978). Sellers are willing to compensate speculators for such activity because they are more risk averse or because the nature of their activity requires them inherently to assume more risks.

Second, trading in copper futures may take place because of different expectations about the future. The futures price provides a summary of the information held by market participants which is of particular importance to otherwise uninformed traders who base their supply decisions on these prices. Since these supply decisions have direct impact on spot prices, the future prices have an important stabilizing influence on spot prices (Danthine 1978).

The Influence of Information in the Market

The direct impact supply decisions have on spot prices can be attributed to the way the presence of a futures market for copper helps to convey information to market participants. According to Mark J. Powers (1978):

> the existence of futures trading should increase the speed with which information is disseminated, the area over which it is disseminated, and the degree of saturation within the area. It should tend to equalize the flows of information to current and potential futures and cash market participants. The result should be more informed decision making and prices that are more closely representative of basic supply and demand conditions; prices whose random element is less than it would be without futures trading; price messages that are more sharply defined and less distorted by noise or the random element.

Hence, the more informed market participants are, the greater the likelihood market prices will be representative of inventory and demand situations. Furthermore, active futures markets may tend to be associated with spot prices which reflect more informationally efficient equilibria (Friedman, Harrison, and Salmon 1982).

Speculative activity in general in copper futures also theoretically should dampen price fluctuations. If speculators possess a better than average forecasting skill, they should moderate price fluctuations by buying and selling such that rising prices would be compressed and falling prices be cushioned (Taylor and Leuthold 1974). In addition, speculators may be more willing to assume risks in inventory ownership so they may buy at higher prices and sell at lower ones than copper producers, thereby creating a smaller range of cash price variations than would otherwise occur.

Buffer Stock Schemes

The conclusion that the presence of a futures market for a commodity reduces fluctuations in the spot market leads to discussion of two strategies--a buffer stock and price forecast announcements--which could be employed by governments or other organizations to reduce variation in the copper spot price. The first, a buffer stock strategy, is executed when the controlling agency buys copper during periods of low price in the hope of creating a shortage which would raise prices, and sells copper during periods of high prices to facilitate a price drop in light of excess supplies. S. Ghosh, G. L. Gilbert, and A. J. Hughes Hallett (Ghosh, Gilbert, and Hallett 1982) studied several stabilization models from 1971 to 1980. Their results suggest:

> a buffer stock can successfully be used to stabilize copper price movements even when subject to the very large random shocks which have been observed in the recent past.

While their research indicated significant reduction in price variability is certainly possible, it may not be profitable in a net present value sense. Their study shows low and negative net present values for money invested into such a scheme compared with returns (Ghosh, Gilbert, and Hallett 1982).

Welfare Gains from Price Stabilization

Other authors have concluded that significant welfare gains are possible from price stabilization. One such explanation by Sarris and Taylor (1978), is illustrated in Figure 2-2.

Sarris and Taylor first assume supply does not respond to price but fluctuates randomly between Q_1 and Q_3. The controlling agency buys at price P_1 and sells at price P_3 to stabilize prices at P_2. When the controlling agency buys at P_1, producers receive a windfall gain of P_1AFP_2 on the amount they already have for sale in the market. When stocks are later sold to drive the price down from P_3 to P_2, producers would lose P_2ECP_3. Due to the linearity of the demand curve, the benefit area exceeds the loss area, and producers have a net benefit from price stabilization.

Consumers gain P_2ECP_3 when supply is low and the controlling agency sells. This gain is from the price

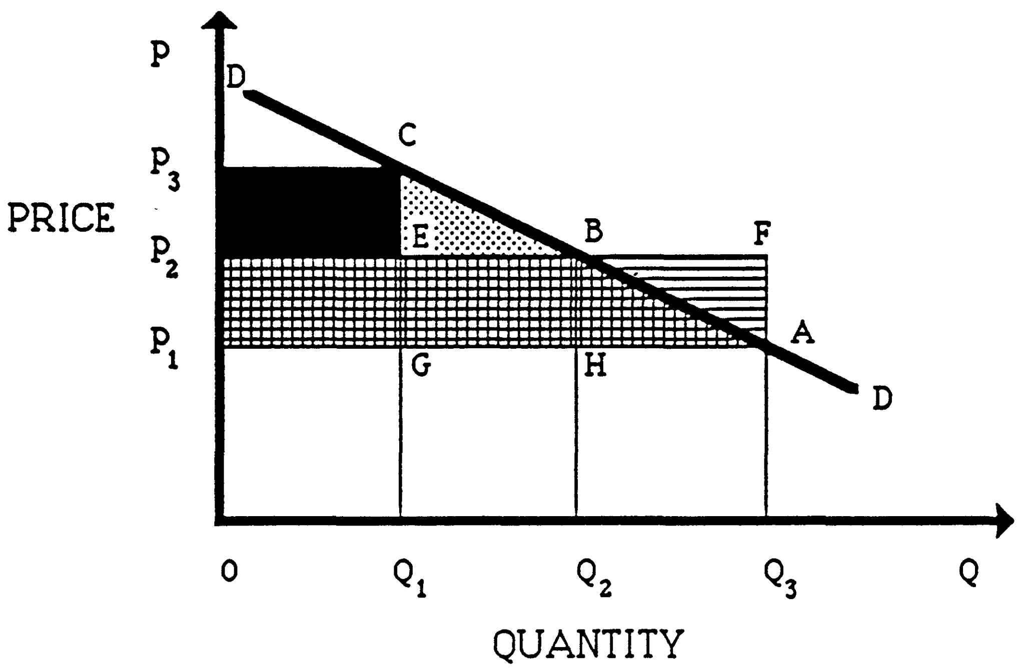

Figure 2-2

Welfare Gains from Price Stabilization

Source: Adapted from Sarris, Alexander H., and Lance Taylor, 1978, "Buffer Stock Analysis for Agricultural Products: Theoretical Murk or Empirical Resolution?," Stabilizing World Commodity Markets, Lexington, Mass.: D. C. Heath and Co., pp. 149-159.

reduction on the amount they would be consuming at P_3. In addition, consumers purchase the stocks the controlling agency places on the market and gains triangle EBC in benefits. Total benefits now equal P_2BCP_3. When the controlling agency purchases, it drives prices up on a larger volume, and consumers lose P_1ABP_2. This loss exceeds the gains accruing from the price reduction, and consumers have a net loss from price stabilization. This model does produce a welfare gain equal to GHBC - HAB, but producers receive this gain at the expense of consumers (Adams and Klein 1978).

All buffer stock schemes face initial difficulties in selecting the appropriate level about which prices would best be stabilized. (Ghosh, Gilbert, and Hallett 1982). Such a selection again requires collecting and analyzing information about copper markets and prices. If costs of acquiring this information are significant, the low and negative net present value results obtained by Ghosh, Gilbert, and Hallett might be realized.

One possible explanation of the difficulties currently facing the International Tin Council (ITC) may be the high cost of information. Keeping track of international trading in tin must be a monstrous task in itself for the ITC, let alone the task of anticipating price changes.

Stabilizing a perceived short-run fluctuation could be extremely costly if the change became a long-run trend. Furthermore, the Sarris-Taylor model discussed above assumes supply fluctuates at random. If this is not indeed the case, welfare gains may not be possible by such stabilization schemes.

Understanding of the market is vital to the success of a controlling agency and requires significant processing of economic information on a daily basis.

Another explanation of the ITC's dilemna could come from the notion that the market for information may be in equilibrium. The tendency toward disequilibrium in the information market (as presented previously by the Grossman-Stiglitz paradox) could of course impact the copper market in general. Such a development would only complicate the mission of the ITC.

Price Forecast Announcements

Instead of the controlling agency intervening in the market directly, the agency could announce forecasts which in turn influence the behavior of private producers.

The effects of these forecasts were considered by Smyth (1973), who showed the publication of rational forecasts by a controlling agency will reduce the variance of the cash prices. The welfare benefits or losses of such a scheme are divided among three separate groups: the producers who follow the public forecasts, producers who ignore the public forecasts, and consumers (Turnovsky 1978). If the variance in spot prices is actually decreased, both sets of producers gain a welfare benefit for reasons similar to those given in Figure 2-2. Those producers who followed the published forecast will receive proportionately more of the welfare benefit. So as in the buffer stock model, the reduction in price fluctuation resulting from the improved information leads to a loss in consumer welfare (Turnovsky 1978).

In both the buffer stock case and the price forecast announcement example, flows of information in the market determine the degree of success of price stabilization schemes.

Summary

In light of the three roles of copper futures prices discussed in this chapter, the question of how information is handled in the market seems to be an inherent issue for evaluating performance. Information available to market participants influences copper production rates, inventory levels, and the amount of money being invested in the industry. These types of decisions dictate the allocation of copper resources and the amount of capital going to the copper industry over time. Information also serves to reduce uncertainty, so it helps to determine the ability of copper futures prices to predict future spot prices. Finally, information impacts copper supply, demand, and price formation in the short run. Because controlling agencies sometimes desire to reduce cash price fluctuations, such stabilizing schemes depend on this information for their success.

The role of information will be examined by an empirical hypothesis test outlined in Chapter 3. The research explores the predictive function of copper futures prices by focusing upon the forward pricing performance of the futures market in copper.

Chapter 3

STATEMENT OF HYPOTHESIS

One approach to studying the role of information in the copper market is to focus upon the predictive function of futures prices. By evaluating the forward pricing performance of the futures market, the nature of information flows in the system can be identified (Smith 1978). This paper seeks to examine the forward pricing performance of the copper futures market from 1980 to 1985 with the following hypothesis.

Copper futures prices can be described as being unbiased predictors of the future spot price. This statement implies that the basis ratio (the spot price divided by the associated futures price) is not statistically different from one. In mathematical notation, this is the relationship given in Chapter 2 as Equation (2-8):

$$FP_{t,t+n} = SP_{t+n}$$

and as Equation (2-9):

$$\frac{SP_{t+n}}{FP_{n,t+n}} = 1$$

where $FP_{t,t+n}$ = futures price today (period t) with a duration of n months, and SP_{t+n} = subsequent spot price n months from now (period t+n).

Failing to reject the hypothesis that the basis ratio is statistically different from one suggests the following inferences can be made about the forward pricing performance of the copper futures market and the role of information in the market.

Inferences

I. The copper futures market from 1980 to 1985 has been performing a statistically significant forward pricing function.

A. This forward pricing function provides valuable information to the market (Blau 1944; Keynes 1930; Hicks 1946; Hardy 1940; Dusak 1973).

B. The forward pricing function also helps to acheive an optimal allocation of copper resources (Larson 1967).

II. A necessary condition for copper futures prices to serve as predictors is that both spot and futures prices must fully reflect all available information. Therefore, if the basis ratio is not statistically different from one over the period studied, then copper spot and futures prices fully reflect all available information (Goss 1981: Fama 1976).

A. If prices fully reflect all available information, then the market for information in copper from 1980 to 1985 may be described as being weak-form, semistrong-form, or strong-form efficient (Neave and Wiginton 1981).

B. If the market is semistrong-form (or strong-form) efficient, then by definition there should be no manner in which a trader could use public (or public and private) information to make above average profits (Cornell 1977: Grossman 1977: Hansen and Hodrick 1979: Working 1948: Leuthold 1974).

C. The Grossman-Stiglitz paradox suggests significant forces exist in this situation to draw the system away from a general equilibrium. When traders find they can learn nothing from information which is not apparent in prices, there is no equilibrium in which information will be collected (Grossman and Stiglitz 1980; Green 1977).

D. Ceasing to collect information will cause prices to become uninformative, and the market for information will no longer be efficient. Hence, the Grossman-Stiglitz paradox could support the notion that the market for information cannot simultaneously be efficient and in equilibrium (Bray 1981: Grossman and Stiglitz 1980).

E. This trade-off between efficiency and equilibrium in the market supports the argument that stabilization schemes can be utilized to reduce cash price fluctuations in the copper market but perhaps only in the short run. In the long run, tendencies toward disequilibrium in the market for information may render such policies ineffective (Ghosh, Gilbert, and Hallett 1982: Turnovsky 1978).

These inferences considered together point toward two general conclusions should the hypothesis not be disproven.

First, a basis ratio not statistically different from one implies the copper futures market has performed its forward pricing function quite well, and market participants will be at least as well off as if they had known subsequent spot prices in advance (Goss 1981). Traders will be signaled when it is necessary for them to hedge, and speculators will earn a fee for that service in the Keynes-Hicks sense.

Second, such a statistical result would make a strong statement on market efficiency because the futures market would be a nearly perfect predictor of subsequent spot prices. This predictive ability would in turn make the need for collecting other information obsolete. In light of the Grossman-Stiglitz paradox, the market for information would move away from equilibrium. A disequilibrium situation would not allow for much effectiveness of stabilization schemes to reduce fluctuations in the copper market.

The methods for testing the thesis hypothesis are discussed in the next chapter. The results of the hypothesis test follow in Chapter 5.

Chapter 4

HYPOTHESIS TEST AND METHODOLOGY

The empirical hypothesis test that the basis ratio is statistically different from one was composed of two stages. The first stage, calculation, involved computing the basis ratio and determining if the ratio was statistically different from one. The second stage, verification, attempted to comment on the power of the basis ratio calculation as a reliable hypothesis test. Two alternative methods of predicting the future spot price were undertaken for comparison: a moving average model and a regression model. The ensuing comparison of these models helped to clarify the nature of copper futures prices over the period studied.

Calculation

Data on copper spot prices and three futures contracts were collected from January, 1980 through February, 1985. Average monthly spot prices were taken from the Statistical Supplement to the Survey of Current Business published by the U. S. Department of Commerce. Average monthly spot prices for one-month, three-month and twelve-month contracts traded on the COMEX were provided by the AMAX

Metals Group, Greenwich, Connecticut. The data were input into the statistical package, ABSTAT, Release 3.0, published by Anderson-Bell, 1982. A list of variable names and the computer output may be found in the appendixes.

To calculate the basis ratio, the spot price series was lagged the appropriate number of periods to compare with the futures price, and then used in the numerator of the equation:

$$\frac{SP_{t+n}}{FP_{t,t+n}} \qquad (4\text{-}1)$$

This process is more easily described by referring to Table 4-1.

The table shows that the lagging of the spot price series, by one month in this case, allowed the observed futures price to be tested as a predictor of the subsequent spot price. The basis ratio was calculated by dividing column 3 in Table 4-1 by column 2. This procedure was followed for each month from January 1980 to February 1985 (or a total of 62 periods) for the data on one-month futures contract closings. Similar calculations were made for the copper futures contract data with three-month and twelve-month closings. The general equations for the three basis ratios are given below.

Table 4-1

Calculation of the Basis Ratio

Date	(1) Observed Spot Price	(2) Observed Futures Price (1 Mo. Closing)	(3) Spot Price Series Lagged 1 Mo.	(4) Basis Ratio (3÷2)
Jan. 1980	119.39	117.002	113.81	1.14366
Feb. 1980	133.81	128.640	106.04	0.82431
Mar. 1980	106.04	97.255	94.85	0.97527
Apr. 1980	94.85	88.876	93.48	1.05180
May. 1980	93.48	89.336	92.71	1.03777
Jun. 1980	92.71	87.167	103.56	1.18806

For contracts of one-month duration:

$$\frac{SP_{t+1}}{FP_{t,t+1}} \quad (4\text{-}2)$$

For contracts of three-month duration:

$$\frac{SP_{t+3}}{FP_{t,t+3}} \quad (4\text{-}3)$$

For contracts of twelve-month duration:

$$\frac{SP_{t+12}}{FP_{t,t+12}} \quad (4\text{-}4)$$

The variable names given to each copper futures contract data set reference the duration of the contract as shown in Table 4-2. The spot price variable name is SPOT.

Table 4-2

Variable Names for Contract Duration

Duration	Position	Variable Name
1 month	1	FIRST
3 months	2	SECOND
12 months	3	THIRD

These variable names were utilized to develop the variable names for the three basis ratios. The basis ratio name for a one-month contract refers to Equation (4-2) and is expressed as LAG1FIR. Table 4-3 gives the basis ratio variable names.

Table 4-3

Variable Names for Basis Ratios

Equation Number	Duration	Position	Variable Name
(4-2)	1 month	1	LAG1FIR
(4-3)	3 months	2	LAG3SEC
(4-4)	12 months	3	LAG12TH

To determine whether the basis ratios were statistically different from one, the mean was calculated and tested using a two-tailed T-test at the 5% significance level. The mean was calculated yearly for each basis ratio data set, LAG1FIR, LAG3SEC, and LAG12TH, as well as for the study period of 62 months. Testing the mean for each year of the data set would identify years in which the copper futures price has been an unbiased predictor of the subsequent spot price. The standard deviations were also calculated to help describe each data set.

The general five-step hypothesis test used for the T-tests is outlined in Table 4-4. Results of the T-tests may be found in Chapter 5.

Table 4-4

Five-Step Hypothesis Test:

Testing the Significance of the Mean

STEP 1: Statement of Hypothesis

$H_0 : \mu = \mu_0 \qquad (\mu_0 = 1)$

$H_1 : \mu \neq \mu_0$

STEP 2: Significance Level

$\alpha = .05 \qquad \alpha/2 = .025$

Type of Test = T-Distribution (Equivalent to Z-Distribution since N is large)

STEP 3: Critical Region

Reject H_0 if $T_{calc} > t_{\alpha/2}$

if $T_{calc} < -t_{\alpha/2}$

STEP 4: Calculation

$$T_{calc} = \frac{\bar{X} - \mu_0}{s/\sqrt{n}}$$

STEP 5: Acceptance or Rejection of Hypothesis

The evidence suggests failure to reject $\mu = \mu_0$ at $\alpha = .05$.

The evidence suggests rejection of $\mu = \mu_0$ $(\mu \neq \mu_0)$ at $\alpha = .05$.

Because trends in the data might be identified visually when graphed, graphs were constructed for each of the seven variables (SPOT, FIRST, SECOND, THIRD, LAG1FIR, LAG3SEC, and LAG12TH). These graphs are included in the next chapter.

Verification

The hypothesis that copper futures prices are unbiased predictors of subsequent spot prices can be tested by calculating the basis ratio in a manner similar to the one described above. Two other relatively simple predictive models have also been developed to forecast subsequent copper spot prices. These alternative methods of predicting the subsequent spot price will help to determine the nature of the predictive role of copper futures prices over the period studied.

Because data for copper futures prices were available through February of 1985 (period 62), the two alternative models were calculated using data from periods 1 to 55 so that periods 56 to 62 could be used to check the accuracy of the models.

The Moving Average Model

Four versions of the moving average model were calculated: a single-moving average (SMA) of order one, a single-moving average of order four, a single-moving average of order twelve, and a linear-moving average of order four. The formulas for the one-period ahead forecasts at time t and (t+1) of the three single-moving averages are given below:

First Forecast:

$$F_{t+1}^{(t)} = \frac{X_1 + X_2 + \ . \ . \ . \ X_T}{T} = \frac{1}{T} \sum_{i=1}^{T} X_i \qquad (4-5)$$

Second Forecast:

$$F_{t+2}^{(t+1)} = \frac{X_2 + \ . \ . \ . \ X_T + X_{T+1}}{T} = \frac{1}{T} \sum_{i=1}^{T} X_i \qquad (4-6)$$

where MA = moving average and T = order. Hence, T would equal 1, 4, and 12 for a first-order, fourth-order, and twelfth-order moving average, respectively.

One disadvantage of a single-moving average model is that when the time series has a trend, the SMA model forecast will show a type of systematic error. This systematic error can be mitigated by using the difference between a double-moving average value and the single-moving average value (Makridakis, Wheelwright, and McGee 1983, p. 79). Such a model is called a linear-moving average model.

The foundation of this method is the concept of a double moving average (DMA) or a moving average of a moving average. In symbols, DMA (M X N) represents an M-period MA of an N-period MA. The double-moving average then is used as one of two adjustments to the SMA. The other adjustment helps to account for the trend present as shown in Equation 4-7.

$$SMA(T) + E(SMA-DMA) + Trend \quad (4-7)$$

where SMA(T) = single-moving average of order T, E(SMA-DMA) = the error difference between the SMA and a DMA of order T, and Trend = the absolute trend from the previous data point from period t to period t + 1.

For the copper spot price data the time series was used to calculate a linear moving average with SMA(4) and DMA(4X4). Selection of this type of moving average model is justified because the time series is decreasing over the period studied (Makridakis, Wheelwright, and McGee 1983).

The four moving average models just described were used to forecast the copper spot price. Graphs showing each moving average versus the actual spot price were constructed and are displayed in Chapter 5. Computer calculations of the moving averages are in Appendix C. The performance of the moving average models was evaluated by using the last seven periods of the data set as test periods. The difference between the actual spot price and the price forecast by the moving average models, or the error difference, was determined. The mean and standard deviation of each set of error differences were calculated for comparison of the accuracy of the models. Chapter 5 also contains these statistics.

The Regression Model

As an alternative to the moving average models, three regression equations were developed using the ordinary least squares method to predict copper spot prices. Along with the variables, FIRST, SECOND, and THIRD, discussed previously, four additional data sets were developed as independent variables for the regression equation. The spot price variable, SPOT, was the dependent variable. The four new independent variables were USGOVT, the average rate on new-issue government securities; GOLD, the average monthly spot price for gold; CPI, the consumer price index; and INTRST, the average monthly prime interest rate. The source of data for USGOVT and GOLD was Business Statistics: A Supplement to the Survey of Current Business. Data for CPI came from the U. S. Department of Labor, Bureau of Labor Statistics, and the information for INTRST was published in Economic Indicators, prepared for the Joint Economic Committee by the Council of Economic Advisors.

Using the ABSTAT computer program, a correlation matrix of the variables was calculated. With the matrix as a guide, a list of twenty-three independent variable combinations was selected. A variable to account for time, PERIOD, was included in several combinations.

The regressions were then run on ABSTAT and plots made of the residuals. The resulting equations were tested for significance using the overall F-test. All equations were significant except when USGOVT was the only independent variable. The equations were then compared by R values which ranged between .320967 and .994897. The equations with the highest R values all contained the variable FIRST, so FIRST was selected as a variable in the final equation.

The other variables were evaluated to determine whether their inclusion could improve the regression equation using FIRST as the independent variable. The criteria used for selection included plots of the residuals, the Durbin-Watson statistic, economic meaning of signs of the coefficients, and evidence of multicollinearity. The presence of pattern in the plots of the residuals and autocorrelation by the Durbin-Watson statistic eliminated PERIOD and GOLD from the model. The variable INTRST was not selected because the Durbin-Watson statistic indicated autocorrelation, although a pattern was not obvious in the plot of the residuals.

The two remaining variables, USGOVT and CPI were selected for the final model. USGOVT showed no autocorrelation by the Durbin-Watson statistic. Although the Durbin-Watson statistic for the regression equation with FIRST and CPI did show autocorrelation present, the statistic did not show autocorrelation for the equation with FIRST, CPI, and USGOVT. For this reason, CPI was chosen as a variable to be included. The three final regression equations are given below where ξ = error term.

Regression #1: $$\text{Spot} = \beta_0 + \beta_1 \text{FIRST} + \xi \qquad (4\text{-}8)$$

Regression #2: $$\text{Spot} = \beta_0 + \beta_1 \text{FIRST} + \beta_2 \text{USGOVT} + \xi \qquad (4\text{-}9)$$

Regression #3: $$\text{Spot} = \beta_0 + \beta_1 \text{FIRST} + \beta_3 \text{CPI} + \xi \qquad (4\text{-}10)$$

The significance of adding USGOVT in (4-9) and CPI in (4-10) to the regression equation using FIRST as the sole independent variable was tested using partial F-test analysis. This analysis indicated neither USGOVT or CPI contributed significantly to the regression with FIRST alone. Even in light of this result, Regression #2 and Regression #3 were maintained for further analysis because they represent the second and third best regression equations developed from the chosen variables.

A chart showing the regression equations and related statistics may be found in Appendix D as well as complete computer output for the three regression equations selected. Graphs illustrating each regression equation versus the actual spot price may be found in Chapter 5.

The performance of the regression equations in predicting spot prices was evaluated using the same method as for the moving average models. The error difference between the actual spot price and the price forecast by the regression equations was calculated for periods 56 to 62. The means and standard deviations of the error differences were also determined. These results are given in detail in Chapter 5.

Comparison of the Models

The forecasts from all three basic models were compared by evaluating the actual errors and the means and variances associated with each group of forecasts. These three models, discussed above, are summarized below.

1. Futures Price Model (used the futures price to forecast subsequent spot prices).

2. <u>Moving Average Model</u> (used four different moving averages on the spot price series to predict future spot prices).

3. <u>Regression Model</u> (used combinations of seven variables to forecast future spot prices).

The forecasts from each model were compared with the actual spot prices observed in Periods 56 to 62. The differences between the forecasts and the observed spot prices were calculated and termed error differences. The means of the error differences were tested using the T-distribution to find any statistically different means. The variances of the error differences were tested in a similar manner using the F-distribution. The general five-step hypothesis tests developed to compare the means and variances may be found in Tables 4-5 and 4-6.

The three models were compared to shed more light on the predictive capacity of copper futures prices to predict subsequent spot prices. If tests on the means of the error differences find the means to be statistically equal, this result infers futures prices may have predictive potential. If the mean error difference associated with the futures price model is statistically different but greater in magnitude than the other models, the result would be negative evidence of its predictive powers. Results of

Table 4-5

Five-Step Hypothesis Test:

Testing the Difference Between the Means

STEP 1: Statement of Hypothesis

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

STEP 2: Significance Level

$\alpha = .05$ $\alpha/2 = .025$

Type of Test = T-Distribution (Equivalent to Z-Distribution since N is large)

STEP 3: Critical Region

Reject H_0 if $T_{calc} > t_{\alpha/2}$

if $T_{calc} < -t_{\alpha/2}$

STEP 4: Calculation

$$T_{calc} = \frac{\bar{X}_1 - \bar{X}_2}{\sigma \sqrt{1/n_1 + 1/n_2}} \qquad \sigma = \sqrt{\frac{n_1 S^2_1 + n_2 S^2_2}{n_1 + n_2 - 2}}$$

STEP 5: Acceptance or Rejection of Hypothesis

The evidence suggests failure to reject $\mu_1 = \mu_2$ at $\alpha = .05$.

The evidence suggests rejection of $\mu_1 = \mu_2$ ($\mu_1 \neq \mu_2$) at $\alpha = .05$.

Table 4-6

Five-Step Hypothesis Test:

Testing the Difference Between Variances

STEP 1: Statement of Hypothesis

$H_0 : \sigma^2_1 = \sigma^2_2$

$H_1 : \sigma^2_1 \neq \sigma^2_2$

STEP 2: Significance Level

$\alpha = .05$ $\alpha/2 = .025$

Type of Test = T-Distribution (Equivalent to Z-Distribution since N is large)

STEP 3: Critical Region

Reject H_0 if $F_{calc} > f_{\alpha/2}(v_1,v_2)$

if $F_{calc} < f_{1 - \alpha/2}(v_1,v_2)$

STEP 4: Calculation

$$F_{calc} = \frac{S^2_1}{S^2_2}$$

STEP 5: Acceptance or Rejection of Hypothesis

The evidence suggests failure to reject $\sigma^2_1 = \sigma^2_2$ at $\alpha = .05$.

The evidence suggests rejection of $\sigma^2_1 = \sigma^2_2$ ($\sigma^2_1 \neq \sigma^2_2$) at $\alpha = .05$.

analysis of the variances of the error differences will yield similar conclusions.

The methodology discussed in this chapter was developed to test and comment upon the predictive function of copper futures prices. The results of the hypothesis test will be presented in detail in Chapter 5.

Chapter 5

RESULTS

The predictive function of copper futures prices over the period studied was analyzed using the hypothesis test and methodology discussed in earlier chapters. The results will be discussed below and presented in graphic and tabular form. Supporting calculations may be found in the appendixes.

Copper Spot and Futures Price Data

A graph of copper spot prices from January 1980 to July 1985 is shown in Figure 5-1. The spot price ranged from a high of $1.34 per pound in February 1980 to a low of $0.62 in October 1984. Prices over the period studied showed a gradual decline, and the average price was toward the low end: $0.80 per pound with a standard deviation of $0.1357.

The same downward trend is evident in the graphs of the three copper futures price data sets given in Figures 5-2, 5-3, and 5-4. The first position copper futures prices, shown in Figure 5-2, had a high price also in February 1980 of $1.29 per pound and a low of $0.56 in October 1984. The average price for the one-month contracts was $0.74 with a

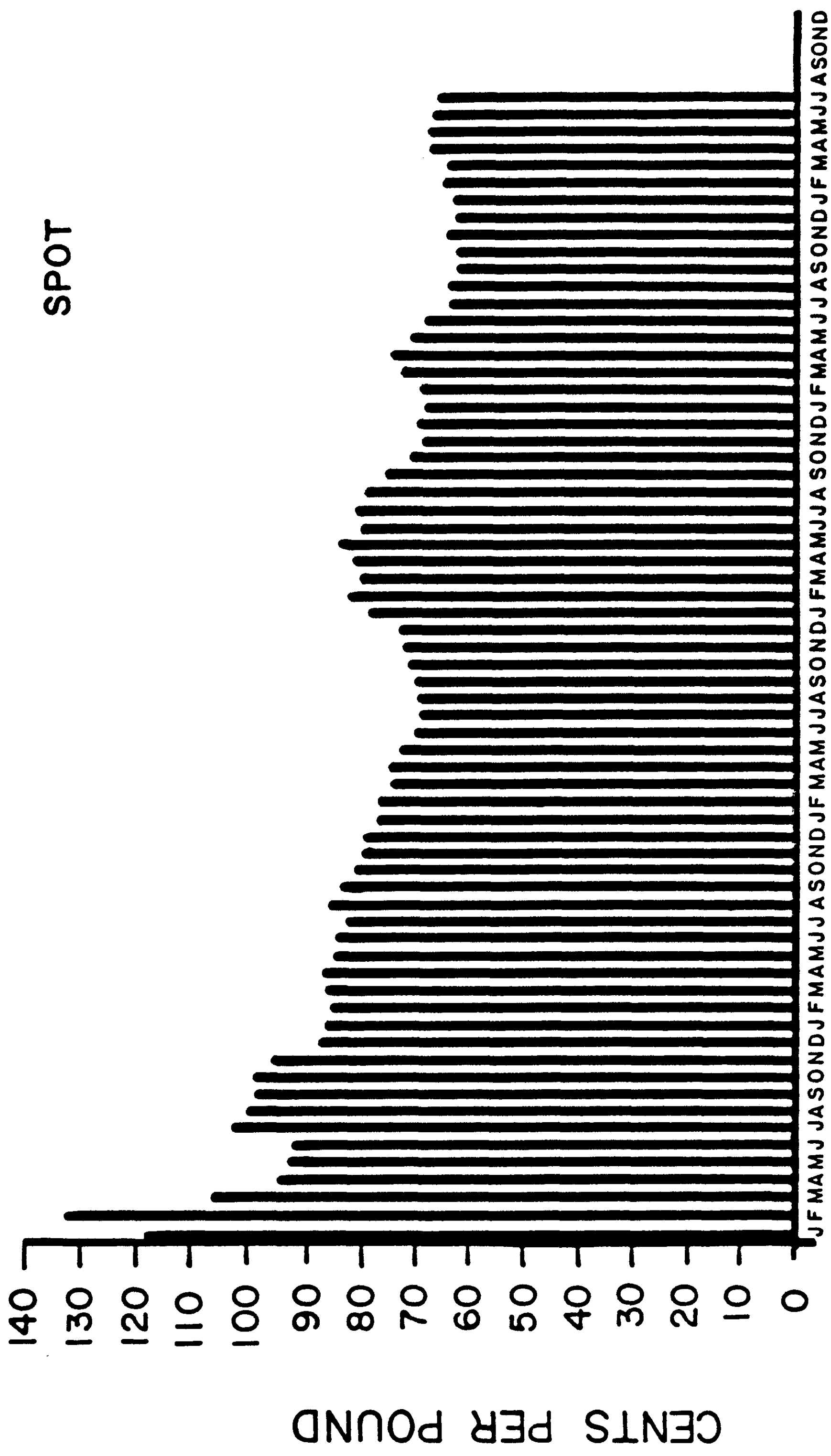

Figure 5-1

Copper Spot Price

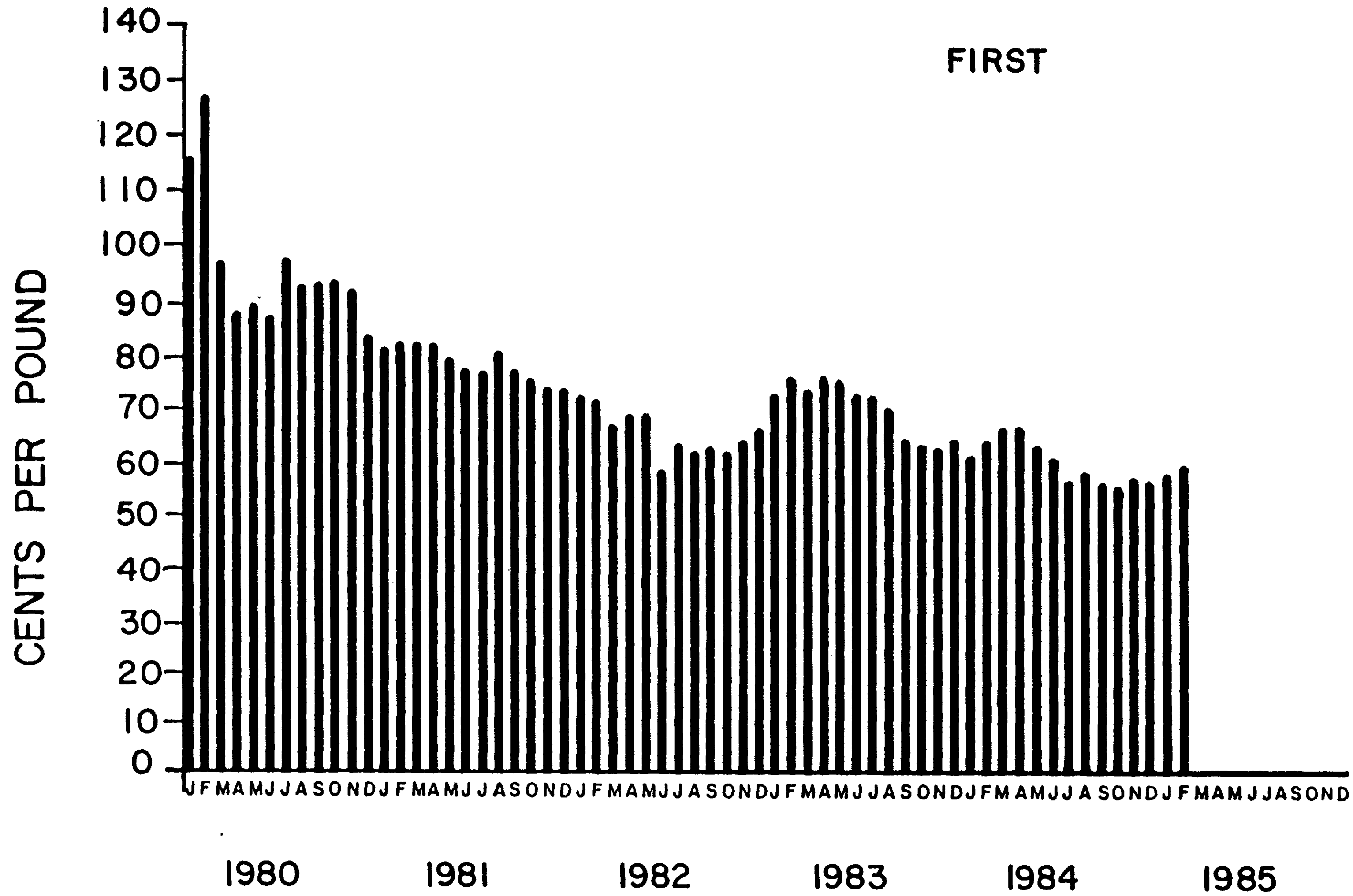

Figure 5-2

Copper Futures Price--First Position

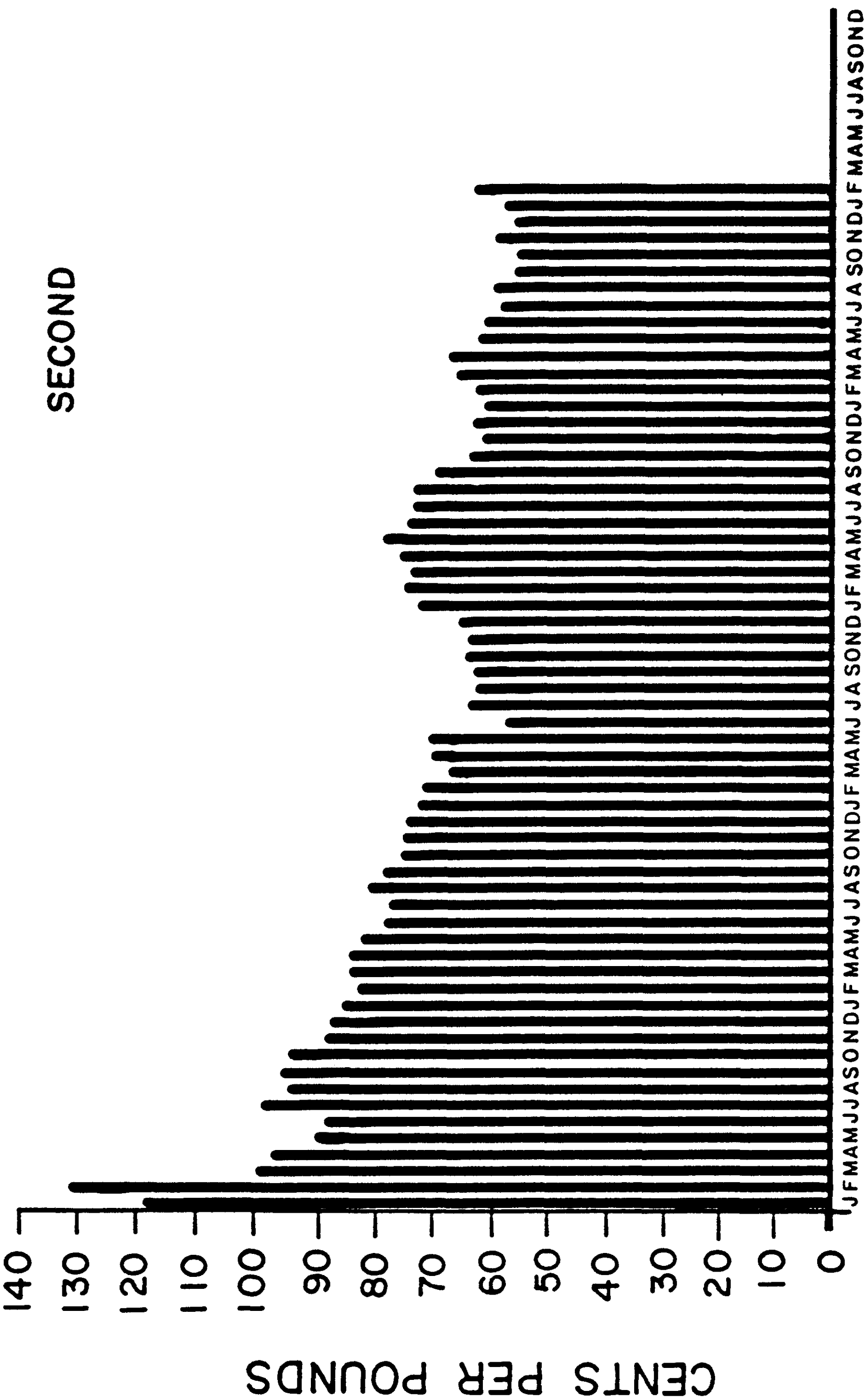

Figure 5-3

Copper Futures Price--Second Position

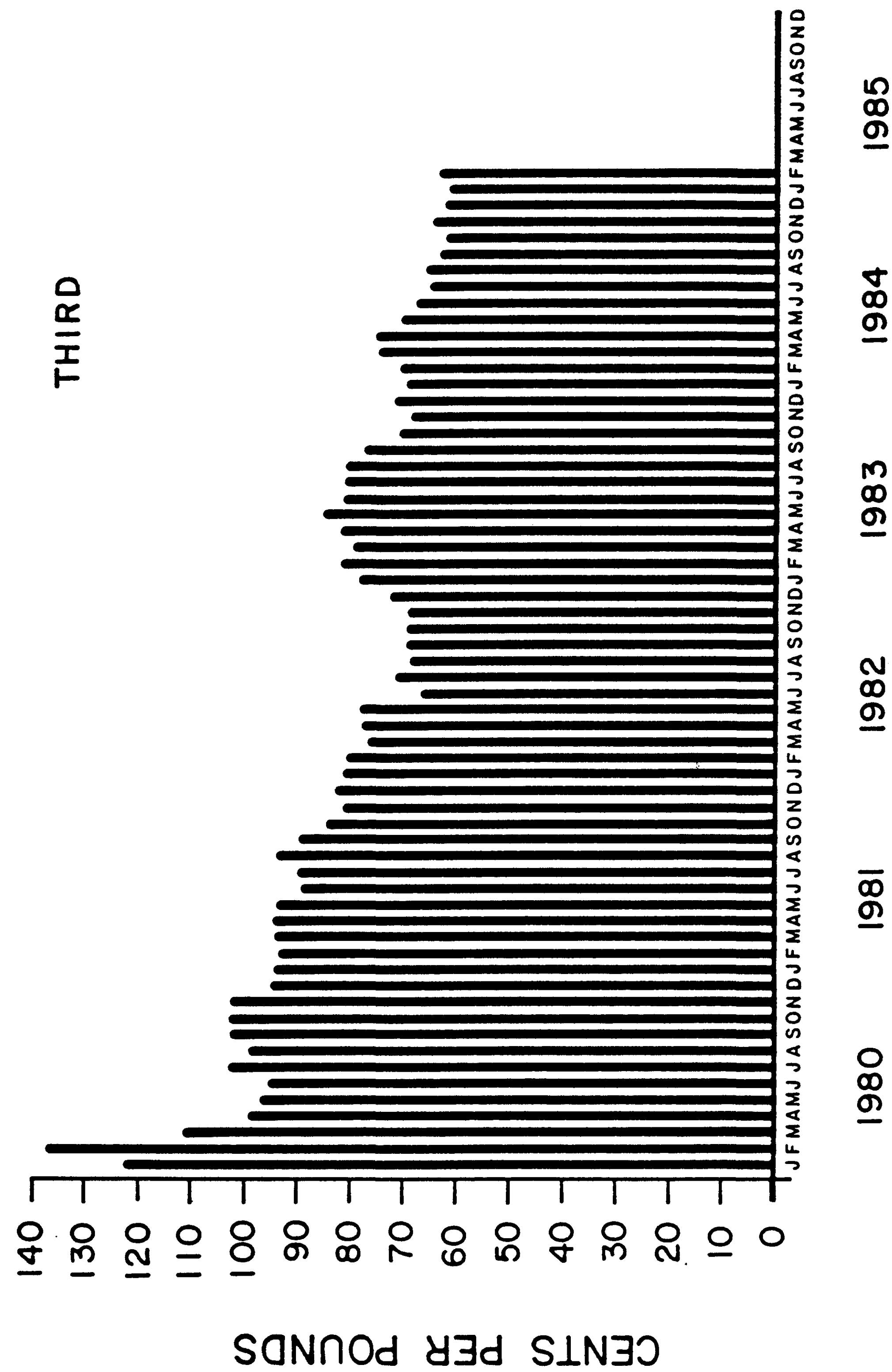

Figure 5-4

Copper Futures Price--Third Position

standard deviation of $0.1423 per pound. Figure 5-3 illustrates the three-month futures contract prices. The price range of the second position prices is from $1.31 to $0.57 in the same two months mentioned above. The mean for the data set was $0.76 per pound, and the standard deviation was $0.1470. The third position copper price data set, illustrated in Figure 5-4, shows a high in February 1980 of $1.38 and a low of $0.62 in December 1984. The mean price for the twelve-month contract was $0.83 with a standard deviation of $0.1537 per pound.

Comparing the standard deviations of the four data sets, the variability of the price seems to increase as the contract duration increases. The spot price sequence had the smallest standard deviation, and the twelve-month contract had the largest. When the variances were tested using the F-distribution, however, the evidence suggested the variances were all equal at $\alpha = .02$.

Basis Ratio Results

The basis ratio was determined for all three copper futures data sets and graphed for Figures 5-5, 5-6, and 5-7. The value of the ratio, which according to the hypothesis is equal to one, ranges from 1.27 to 0.64. Both the high and low basis ratio values are from LAG12TH, the

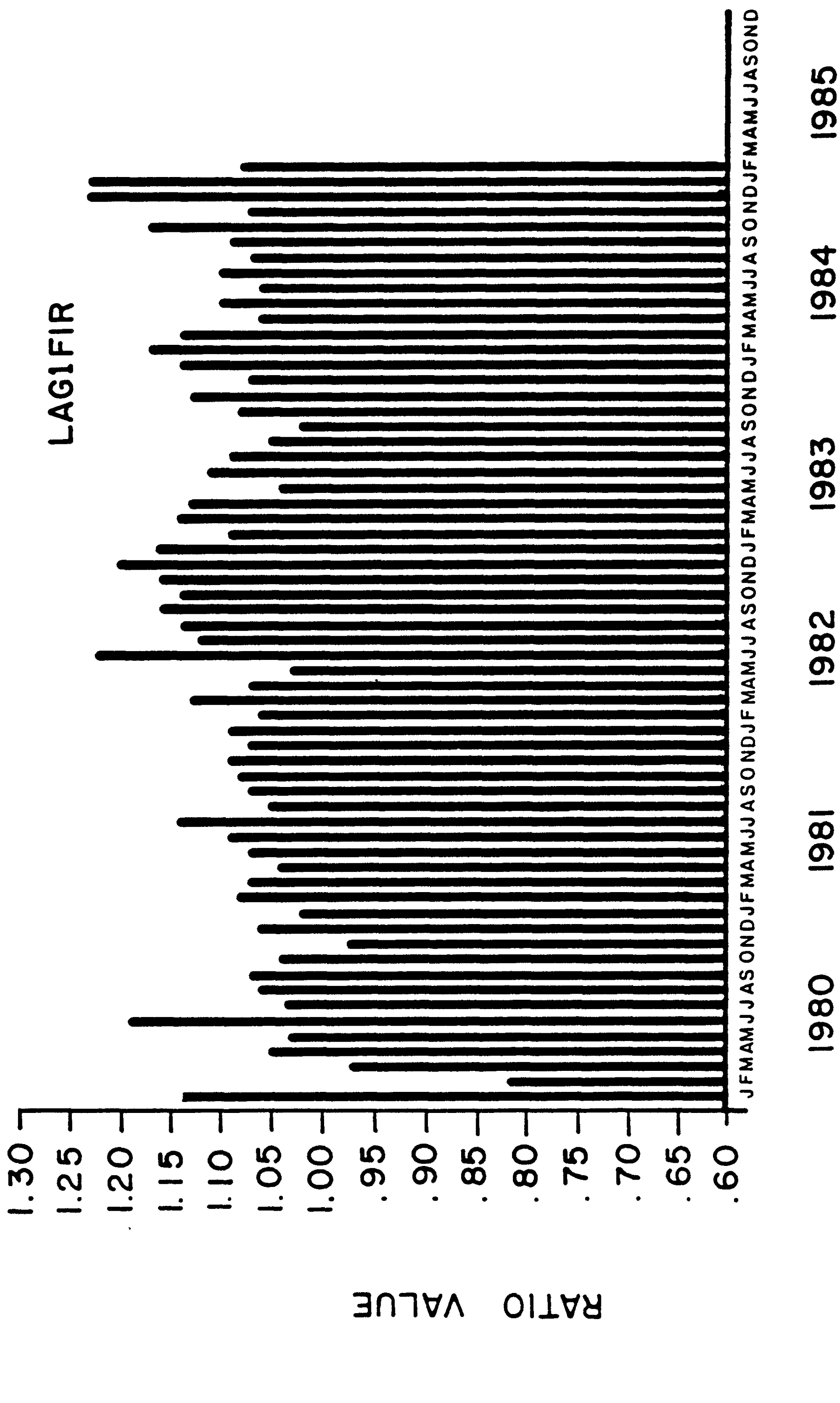

Figure 5-5

Basis Ratio--First Position

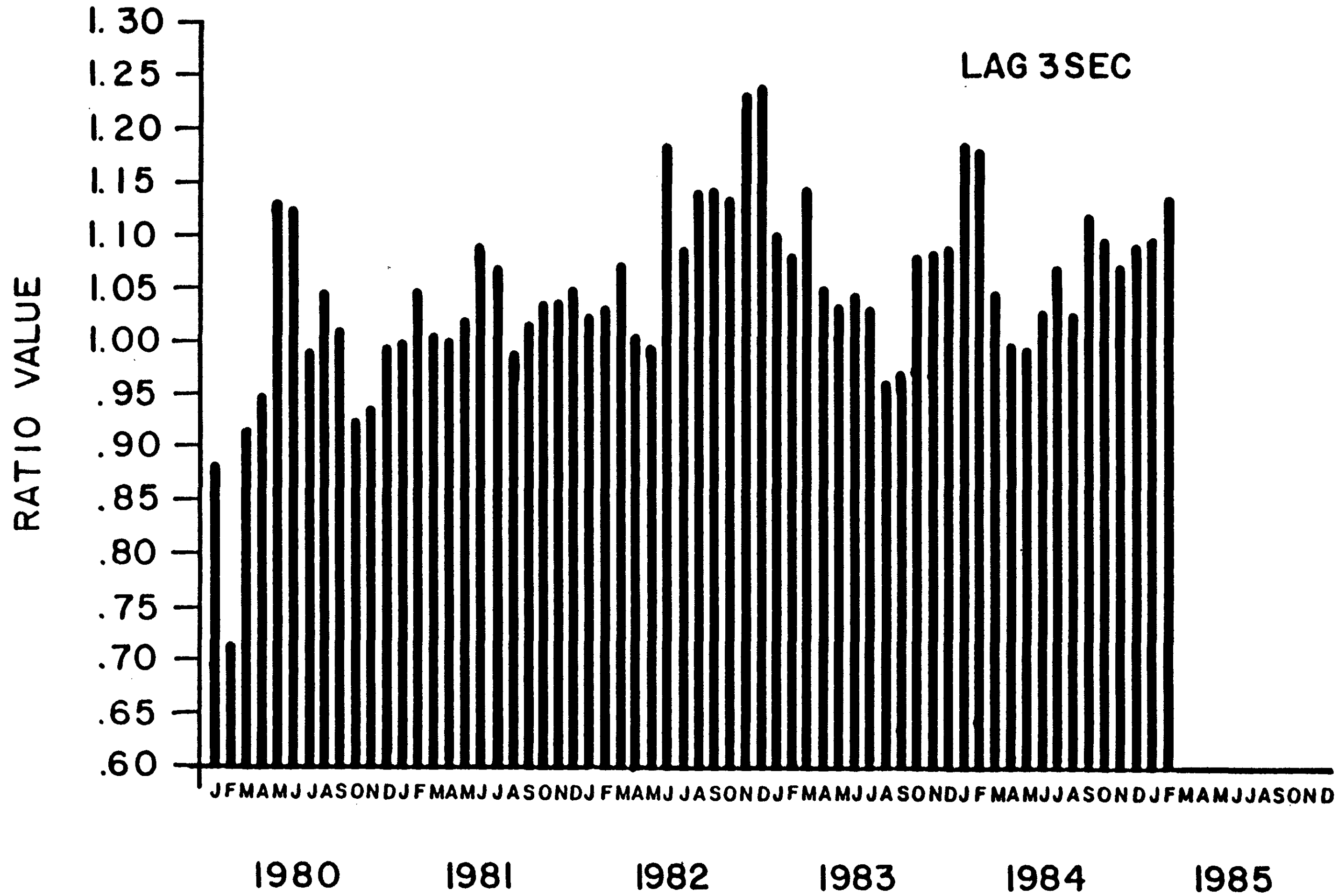

Figure 5-6

Basis Ratio--Second Position

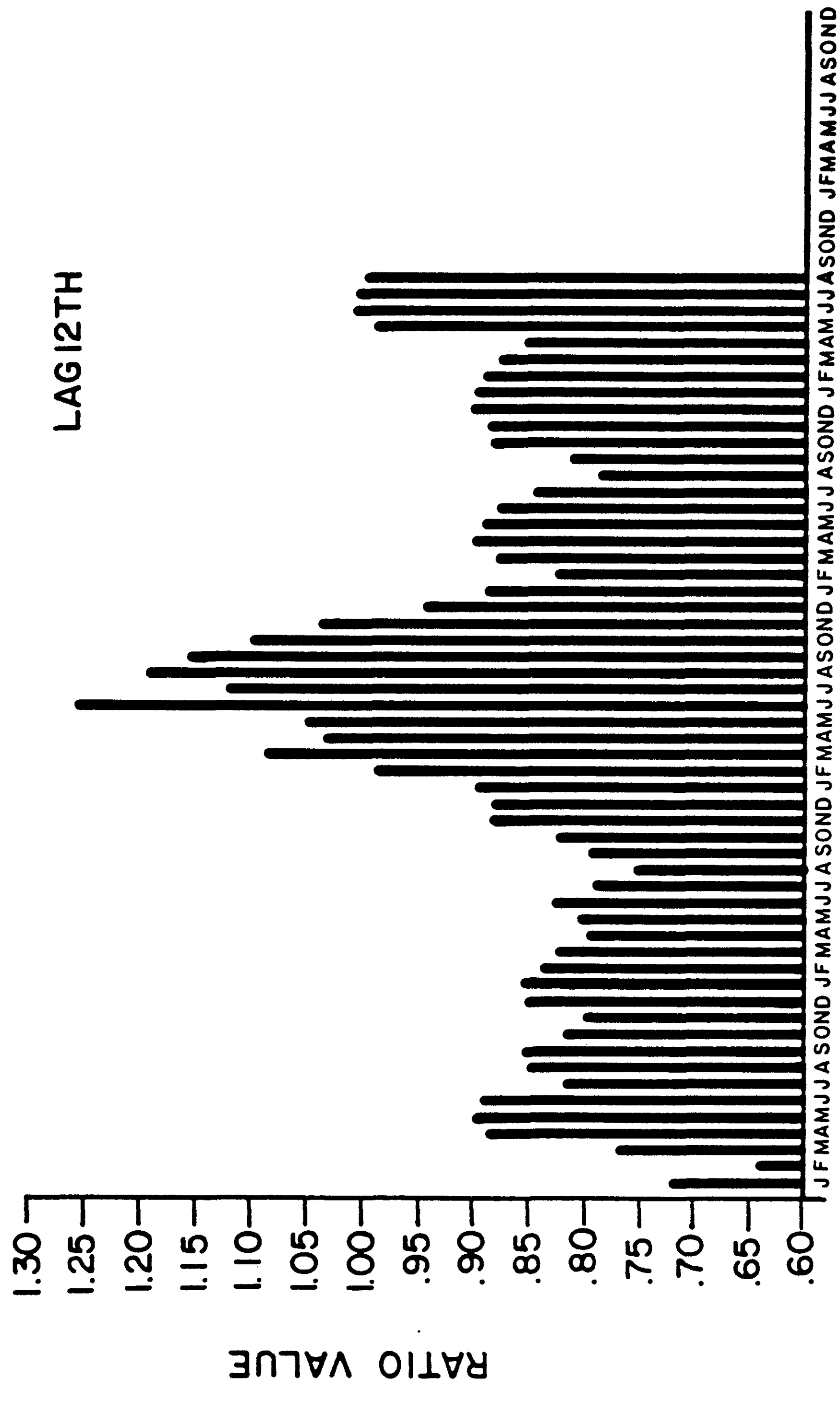

Figure 5-7

Basis Ratio--Third Position

twelve-month contract ratio. This result may be due to the large variance in the third position data set.

While the graphs of the raw data follow a similar pattern from 1980 to 1985, the same is not true for the basis ratio graphs. Most of the values in LAG1FIR are greater than one. In contrast, most of the basis ratio values calculated in LAG12TH are less than one.

Statistics describing the basis ratio results are presented in Table 5-1 by year and for the 62 month period. A two-tailed T-test found four instances in which the basis ratio was not statistically different from one. At $\alpha = .05$ LAG1FIR and LAG3SEC were found not to be statistically different from one. The same was true for LAG12TH in 1982 and 1984 at $\alpha = .02$. Over the entire 62 month period, the basis ratio was found to be statistically different from one in all three cases.

Out of 18 cases, only four basis ratios supported the hypothesis. In an absolute sense, the general hypothesis test was inconclusive. The ability of copper futures prices to predict subsequent spot prices will be examined in the rest of this chapter through two verification models. These two models were based upon a series of moving averages and three regression equations.

As discussed in Chapter 4, the verification models will

Table 5-1

Statistics on Basis Ratios

YEAR	1980	1981	1982	1983	1984	1980-1985
LAG1FIR						
Mean	1.037	1.072	1.130	1.092	1.115	1.092
S.D.	.091	.029	.056	.041	.056	.066
T-calc	1.408*	8.600	8.041	7.773	7.114	10.841
LAG3SEC						
Mean	.979	1.041	1.116	1.061	1.081	1.058
S.D.	.113	.030	.083	.053	.064	.085
T-calc	- .643*	4.734	4.841	3.986	4.384	5.367
LAG12TH						
Mean	.820	.826	1.082	.873	.951	.907
S.D.	.075	.037	.106	.039	.067	.122
T-calc	-8.314	-16.290	2.679**	-11.280	-2.533**	-5.984

* At α =.05, accept hypothesis that basis ratio is not statistically different from one.

** At α =.02, accept hypothesis that basis ratio is not statistically different from one.

help to determine the nature of the predictive role of copper futures prices. This will be accomplished by re-expressing the basis ratio equation in a form which is more easily comparable.

The Base Case Equation

The relationship used to derive the basis ratio was given in Equation (2-8):

$$FP_{t,t+n} = SP_{t+n}$$

Instead of using this relationship to calculate a basis ratio, the futures price, $FP_{t,t+n}$, was used directly to forecast the subsequent spot price, SP_{t+n}. Over the test period from August 1984 to February 1985, copper futures contracts of one-, three-, and twelve-month durations were utilized as forecasts. The results are shown in Table 5-2.

The means of the error terms were negative for FIRST and SECOND but positive for the THIRD forecast. At α = .01, the evidence suggested the mean errors were equal for FIRST and SECOND, SECOND and THIRD, but not equal for FIRST and THIRD. The same was true of the equality of the error variances at $\alpha = .05$.

Table 5-2

Forecasts From Futures Price Models

1 PERIOD	2 ACTUAL	3 FIRST	4 ERROR (3-2)	5 SECOND	6 ERROR (5-2)	7 THIRD	8 ERROR (8-2)
56	64.54	58.598	-5.94	64.425	- .12	81.620	17.08
57	63.41	59.348	-4.06	62.069	-1.34	78.329	14.92
58	62.04	57.055	-4.99	59.448	-2.59	71.512	9.47
59	65.65	56.339	-9.31	60.337	-5.31	69.007	3.36
60	63.54	59.626	-3.91	57.989	-5.55	71.919	8.38
61	64.49	57.542	-6.95	57.263	-7.25	69.831	5.34
62	66.45	59.150	-7.30	60.374	-6.08	71.345	4.90
MEAN	64.30	58.24	-6.07	60.27	-4.03	73.37	9.06
S.D.	1.47	1.27	1.94	2.43	2.68	4.72	5.21

The Moving Average Forecasts

The moving averages described in Chapter 4 were constructed for the entire study period. The actual data may be found in Appendix C, and graphs of the data in relation to the actual spot price are illustrated in Figures 5-8, 5-9, 5-10, and 5-11.

The single moving average of order 1 is shown in Figure 5-8. The solid line represents the actual spot price, and the dashed line represents the forecast. The mean error of SMA(1) is the lowest of all the models at -0.29 as shown in Table 5-3.

SMA(4), illustrated in Figure 5-9, has a slightly higher mean error, 1.32. The highest mean error out of all the models is SMA(12) with a value of 5.32 per Table 5-3. A graph of SMA(12) versus the actual price is in Figure 5-10.

The linear moving average model, DMA forecast, had a mean error only slightly lower than SMA(4) with a lower standard deviation. Using a T-test at =.01, the evidence suggested the mean errors were equal for all combinations of the errors for the moving average models except for SMA(1) and SMA(12). The same was true for the F-test on the error variances.

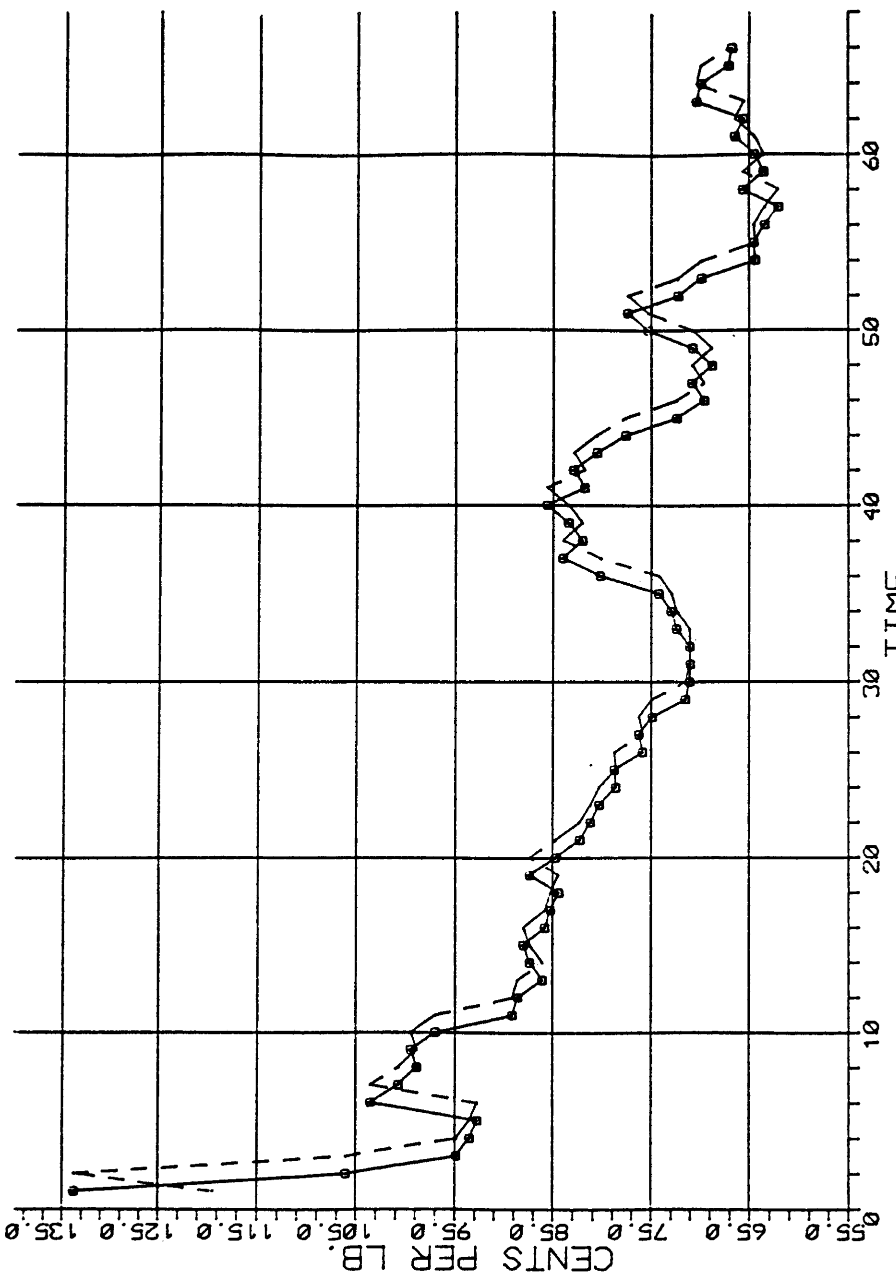

Figure 5-8

SPOT vs. SMA(1)

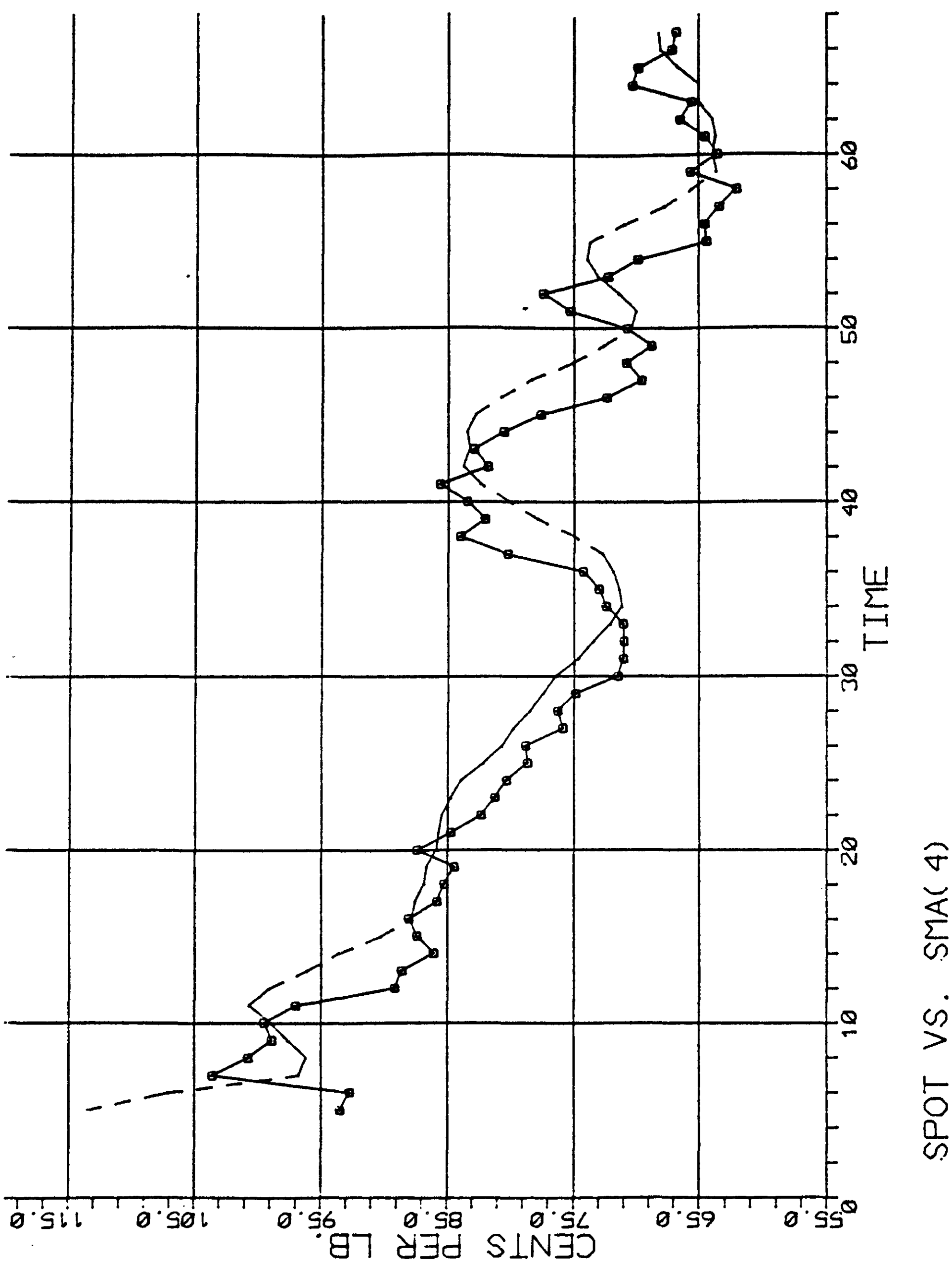

Figure 5-9

SPOT vs. SMA(4)

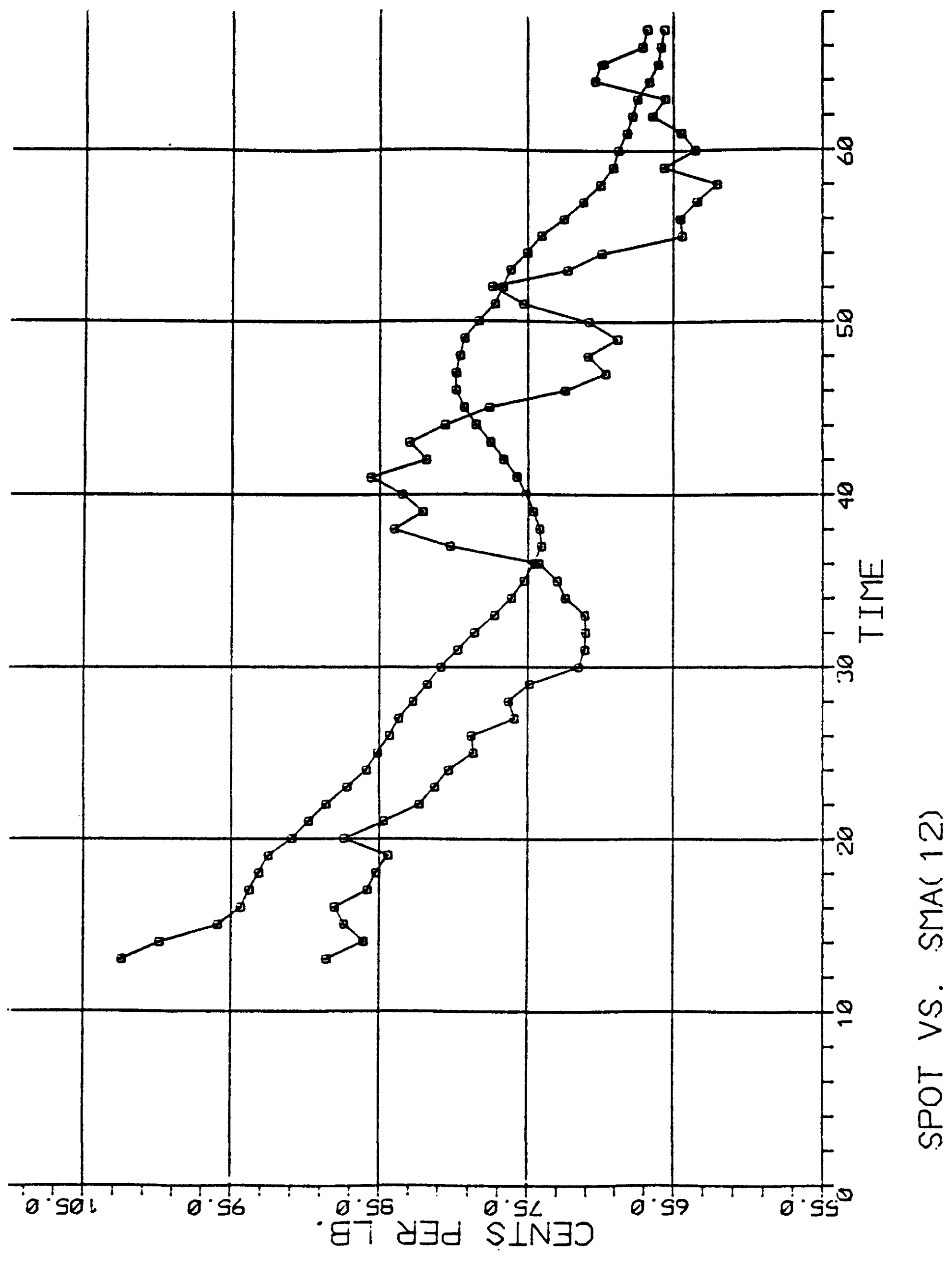

Figure 5-10

SPOT vs. SMA(12)

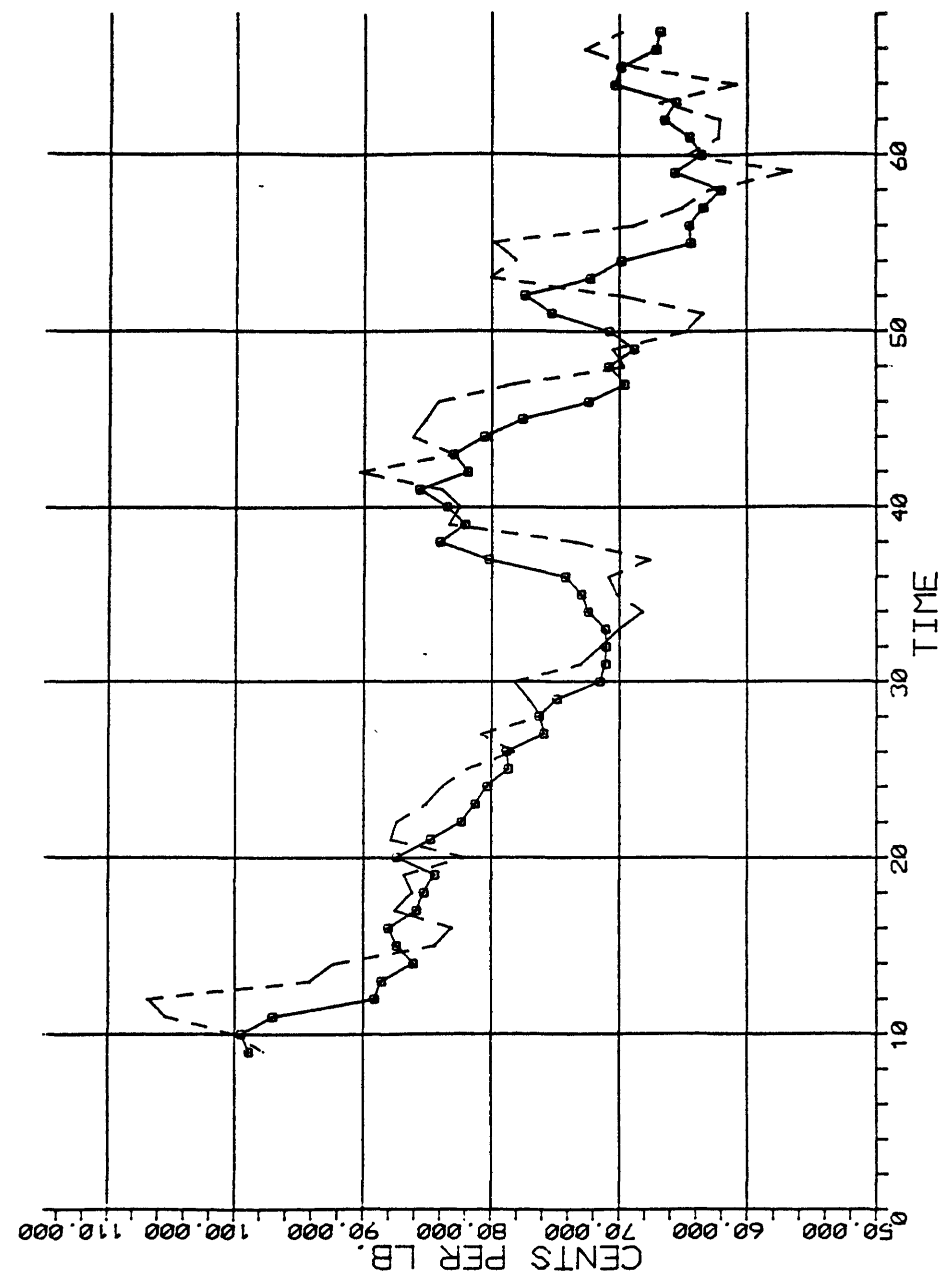

Figure 5-11

SPOT vs. DMA Forecast

Table 5-3

Forecasts From Moving Average Models

1 PERIOD	2 ACTUAL	3 SMA(1)	4 ERROR (3-2)	5 SMA(4)	6 ERROR (5-2)	7 SMA(12)
56	64.54	64.40	-.14	70.97	6.43	72.47
57	63.41	64.54	1.13	67.76	4.35	71.14
58	62.04	63.41	1.37	65.50	3.46	69.95
59	65.65	62.04	-3.61	63.60	-2.05	69.09
60	63.54	65.65	2.11	63.91	.37	68.76
61	64.49	63.54	-.95	63.66	-.83	68.16
62	66.45	64.49	-1.96	63.93	-2.52	67.80
MEAN	64.30	64.01	-.29	65.62	1.32	69.62
S.D.	1.47	1.14	2.03	2.80	3.45	1.68

8 ERROR (7-2)	9 DMA(4)	10 ERROR (9-2)	11 E. DIF. (6-10)	12 TREND	13 FORECAST (5+11+12)	14 ERROR (13-2)
7.93	73.02	8.48	-2.05	.14	69.06	4.52
7.73	72.91	9.50	-5.15	-1.13	61.48	-1.93
7.91	71.59	9.55	-6.09	-1.37	58.04	-4.00
3.44	69.48	3.83	-5.88	3.61	65.43	- .22
5.22	66.96	3.42	-3.05	-2.11	58.75	-4.79
3.67	64.17	-.32	-.51	.95	64.10	-.39
1.35	63.78	-2.67	-.15	1.96	65.74	-.71
5.32					63.23	-1.07
2.63					4.00	3.05

The Regression Equation Forecasts

Similar results came from the three regression equations. The mean errors from Regressions 1, 2, and 3 were 2.55, 2.58, and 2.63, respectively. The standard deviations were respectively 0.39, 0.39, and 0.38 as shown in Table 5-4.

This outcome from the regression equations is not surprising in consideration of the partial F-tests on Regressions 2 and 3. The partial F-tests concluded the addition of USGOVT and CPI respectively to the regression with FIRST as the sole independent variable did not contribute significantly to forecasting SPOT.

The graphs of the regression equations against the actual spot price are displayed in Figures 5-12, 5-13, and 5-14. As might be expected, the graphs appear to be nearly identical.

Both the T-tests on the error means and the F-test on the error variances suggested the means and the variances respectively were indeed equal.

Analysis of Forecasts

Over the seven-month test period, both verification models (the moving average models and the regression equations) outperformed the base case equations as

Table 5-4

Forecasts From Regression Equations

1 PERIOD	2 ACTUAL	3 REGR. #1	4 ERROR (3-2)	5 REGR. #2	6 ERROR (7-2)	7 REGR. #3	8 ERROR
56	64.54	67.6224	3.08	67.6003	3.06	67.6927	3.15
57	63.41	65.4941	2.08	65.4694	2.06	65.5502	2.14
58	62.04	64.8296	2.79	64.8207	2.78	64.8840	2.84
59	65.65	67.8804	2.23	67.9271	2.28	67.9732	2.32
60	63.54	65.9461	2.41	66.0128	2.47	66.0162	2.48
61	64.49	67.4386	2.95	67.5253	3.04	67.5325	3.04
62	66.45	68.7575	2.31	68.8294	2.38	68.8788	2.43
MEAN	64.30	66.85	2.55	66.88	2.58	66.93	2.63
S.D.	1.47	1.44	.39	1.46	.39	1.46	.38

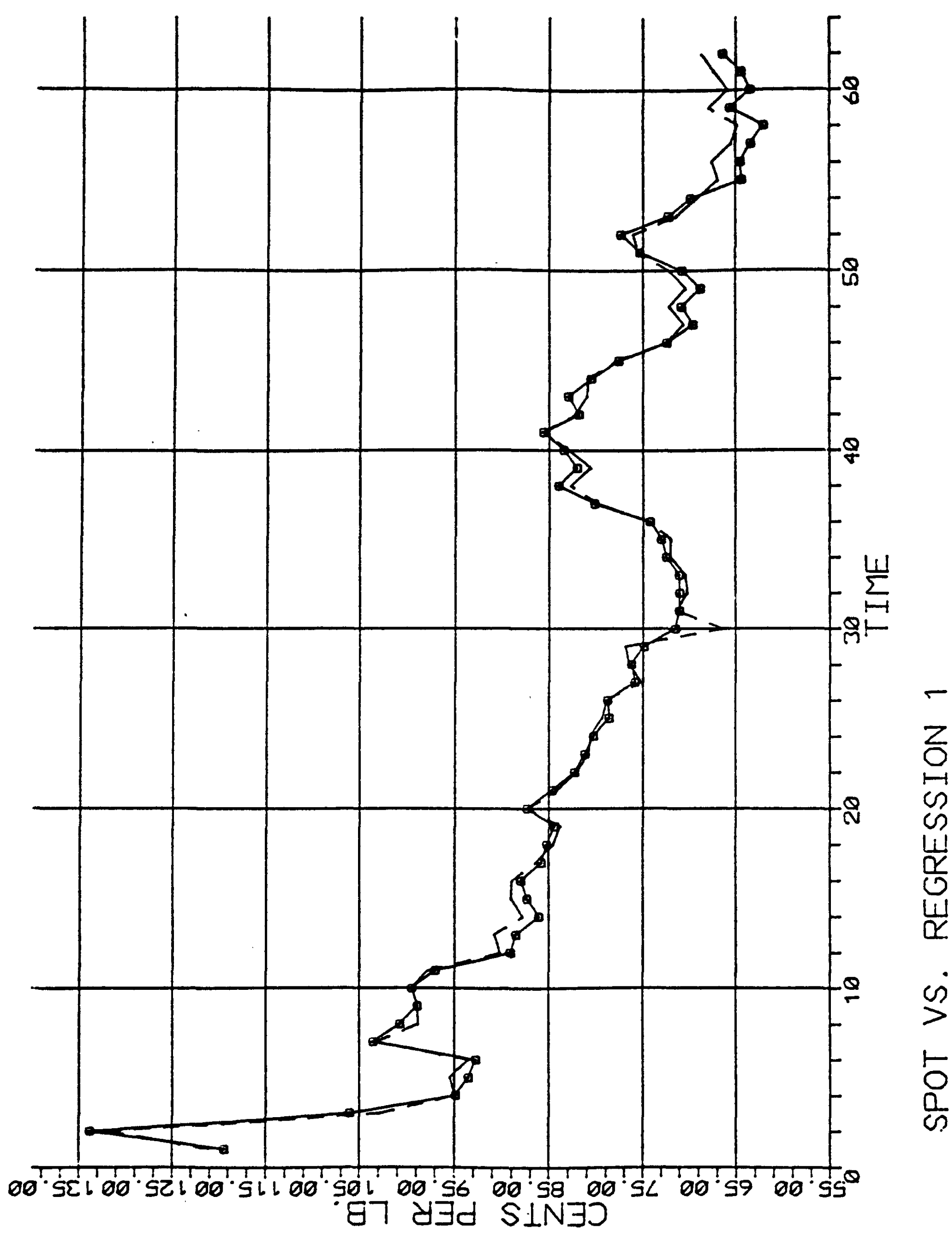

Figure 5-12

SPOT vs. Regression 1

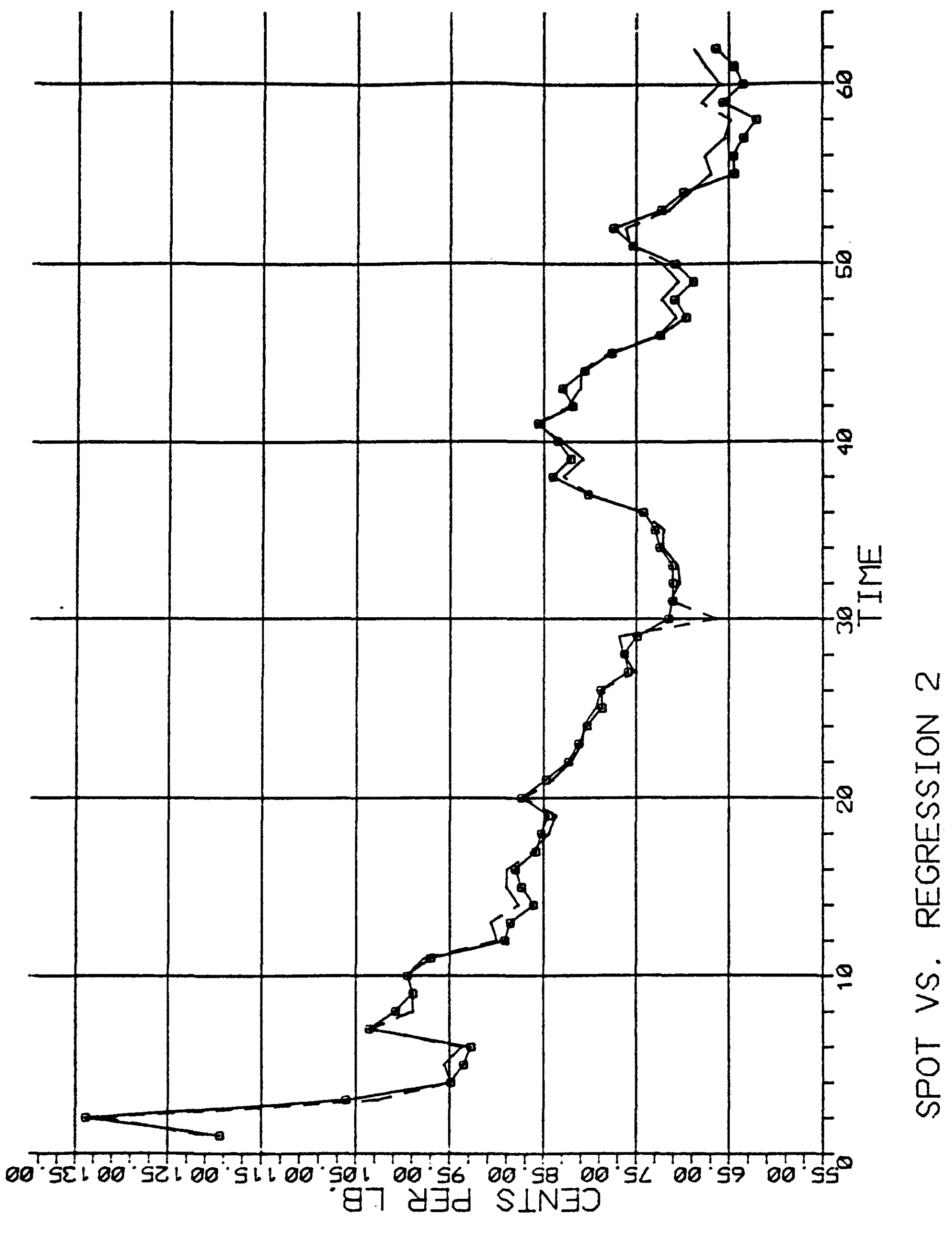

Figure 5-13

SPOT vs. Regression 2

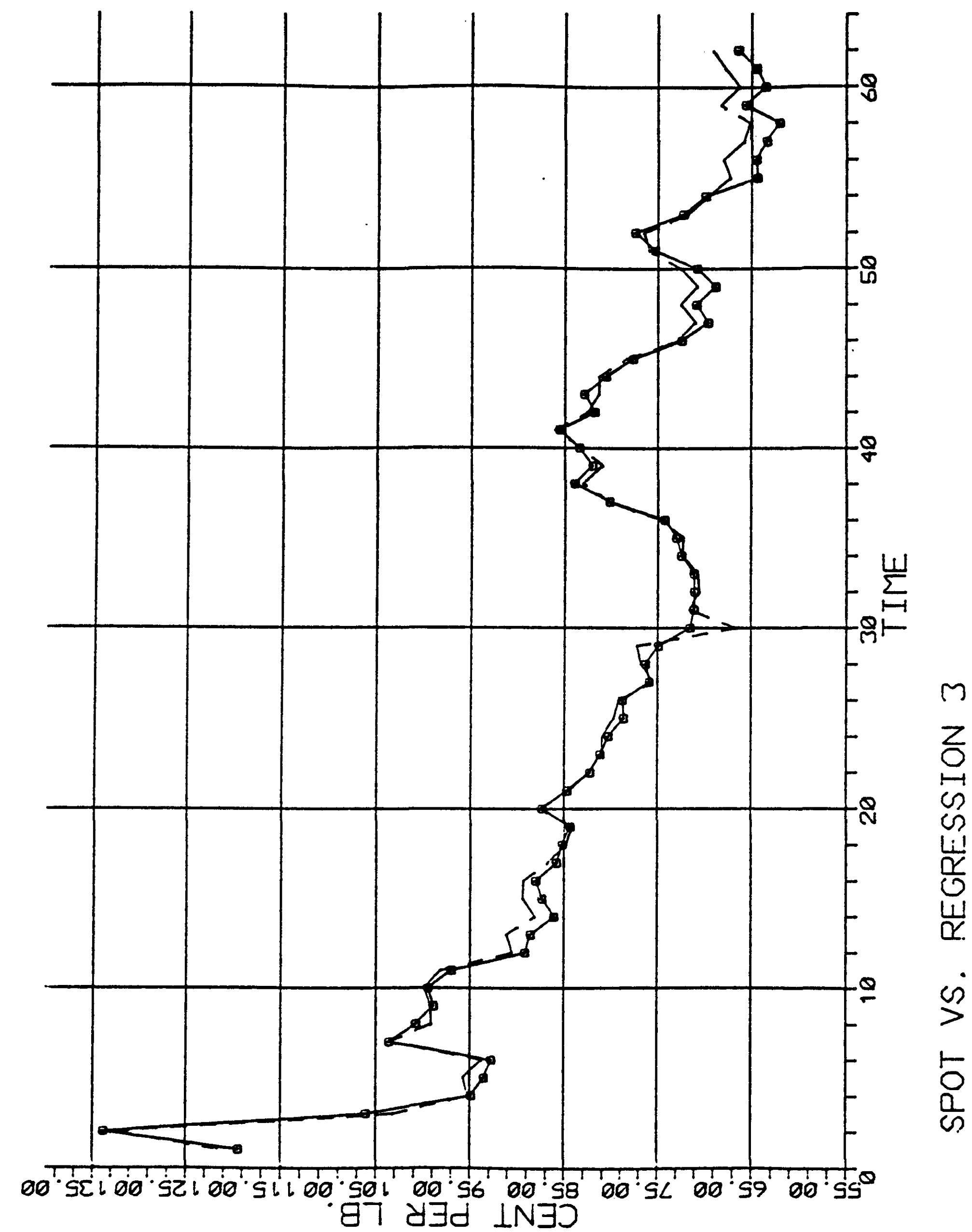

Figure 5-14

SPOT vs. Regression 3

predictors of the spot price. This conclusion is based on the observation that the absolute values of the mean errors were greatest for the base case equations.

Using this criterion, the moving average models, except for SMA(12), possessed the lowest set of mean errors and could be identified as being the best predictors of SPOT. The variances associated with the errors, however, were significantly greater than those associated with the regression equations using an F-test at α = .05. Therefore, a more general conclusion might be that both verification models appeared to outperform the base case equations as predictors.

This conclusion has at least two implications. First, it suggests that the futures price data in the form of a regression equation may be a better model choice to predict the spot price than a base case equation. This in turn infers the basis ratio may not be the optimal model to measure the predictive function of copper futures prices. Second, the superior performance of the moving average model could point toward more accurate forecasts of SPOT using spot price data instead of futures price data. The moving average models were all constructed using the spot price series, while the base case and regression equations were developed from the series of copper futures prices.

While the empirical results presented in this chapter do not lend much support to the hypothesis given in Chapter 3, they can be used to make several inferences about the relationship between spot and futures prices. These inferences as well as comments upon other theoretical issues raised in Chapter 2 will be discussed in Chapter 6.

Chapter 6

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

Copper futures prices may be said to perform at least three general functions in the commodity market: an allocative function, a predictive function, and a stabilizing function. One's viewpoint as to which function is the primary one depends on one's concept of the role of information in the market and the relationship between copper spot and futures prices. These theoretical perspectives were discussed at length in Chapter 2 to lay the foundation for the empirical hypothesis test.

The predictive function of copper futures prices was selected for further empirical study because the performance of this function influences the theories behind the other two. The hypothesis test that the basis ratio was not statistically different from one produced supportive results in 4 out of 18 time periods. To comment upon the appropriateness of the basis ratio as a performance measure of the forward pricing function of copper futures prices, two sets of verification models were developed: four moving average models and three regression equations. After the basis ratio was transformed into a linear equation and compared for accuracy over a seven-month test period with the two verification models, both verification models showed superior predictive ability in forecasting subsequent copper spot prices. This result suggested either the basis ratio concept was not the best model for analyzing the predictive function of copper futures prices or the copper futures prices over the period studied had not performed their forward pricing function very well.

Explanations for Basis Ratio Divergence

The basis ratio defined by Equation (2-9):

$$\frac{SP_{t+n}}{FP_{n,t+n}} = 1$$

can also be expressed linearly as Equation (2-8):

$$FP_{t,t+n} = SP_{t+n}$$

This relationship between copper futures prices and spot prices was not conclusively supported by the empirical hypothesis test. Possible reasons for divergence can come from the literature review in Chapter 2.

In contrast to Equation (2-8), the relationship between $FP_{t,t+n}$ and SP_{t+n} has been expressed in at least four different ways. Per Working (1953), Equation (2-1):

$$FP_{t,t+n} = SP_t + Ps_t$$

Per Keynes-Hicks (Keynes 1930: Hicks 1936), Equation (2-2):

$$FP_{t,t+n} = SP_t + RP_t$$

Per Dusak (1973), Equation (2-3):

$$FP_{t,t+n} = SP_t + Rc_t + Rp_t + Ps_t$$

Per Blau (1944), Equation (2-5):

$$FP_{t,t+n} = SP_t + CY_t$$

These four alternative methods of defining the relationship between $FP_{t,t+n}$ and SP_t contain variables which may cause the basis ratio to diverge from one: the price of storage (Ps_t), the risk premium (RP_t), the return to capital (Rc_t), and the convenience yield (CY_t). The results of the empirical test suggest one of these variables or a combination of them is significantly influencing the price formation process in the very short run. Because there is a divergence from one in the basis ratio LAG1FIR in four out of five time periods, the influences of the variables above would be occuring in less than 30 days time in order to impact the spot price.

Another explanation of the basis ratio's divergence from one might be copper supply shocks during the study period. These shocks, which would most likely be sudden quantities of physical copper put on the market, might be unanticipated by traders and not reflected in copper prices until after the fact. Supply shocks as well as general increased supplies could also have altered traders expectations thus changing RP_t, Rc_t, and CY_t over time.

Divergence also might be attributed to fluctuations in exchange rates. Pricing of copper and copper futures might be based upon expectations about exchange rates which occur (or do not occur) days later.

Discussion of Hypothesis Inferences

The divergence in the basis ratio from one can also be analyzed from within the framework of the hypothesis inferences presented in Chapter 3. Even though the thesis hypothesis was not conclusively proven by the empirical results, it does not necessarily follow that the converses of the inferences are valid. Such a line of reasoning is, however, another explanation of the divergence from one of the basis ratios.

The main premise of this approach is that copper futures prices are not fully reflecting all available information. Hence, the necessary condition for futures prices to serve as predictors of subsequent spot prices has not been met. If prices then were not fully reflecting all available information, the basis ratio would not be expected to equal one. The copper spot price would be random in its relationship to futures prices and/or information not reflected by prices, if obtained by traders, could be utilized by them to make above average profits. This approach is essentially the converse of inferences IA, IB, IIA, and IIB outlined in Chapter 3.

Inferences IIC, IID, and IIE also offer a reason for the results of the hypothesis test: the copper market may be in a disequilibrium situation. The Grossman-Stiglitz paradox suggests the market for information cannot simultaneously be efficient and in equilibrium. Therefore, although prices may reflect all available information and are thus efficient, copper futures prices may fail as predictors of subsequent spot prices because no incentives exist to gather new information in later periods. In other words, once prices reflect all information, no new information will be sought, and prices will then be uninformative. Such oscillations in the market for information could classify it as being in a state of disequilibrium.

Suggestions for Further Research

In light of the fact that the empirical evidence did not conclusively support nor refute the thesis hypothesis, further research in this area would be enlightening. One avenue to explore would be the lengthening of the study period several years. Because two of the four basis ratios which supported the hypothesis occurred in 1980, examining futures prices in the 1970s could identify a trend in the predictive nature of futures prices.

Another possibility would be consideration of other metals or agricultural commodities. Two potential candidates would be tin and zinc for which Goss (1981) found supportive evidence for a similar hypothesis. Tin might be an especially good choice because a more thorough understanding of price formation in the tin market could be beneficial to a healthy reorganization of trading on the London Metal Exchange. Emphasis on the impact of exchange rates would add depth to the analysis of commodities with international markets.

Additional refining of a regression equation which utilizes a futures price series as one independent variable supported by the inclusion of measures of the price of storage, convenience yield, risk premium, and return to capital as other independent variables is also compelling. Research which seeks to define and clarify variables that influence price formation helps analysts and traders alike utilize the market more efficiently.

Overall, increased efficiency allows market participants to recover more quickly from poor decisions and gain more rapidly from insightful ones.

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Appendix A

KEY TO VARIABLE NAMES

KEY TO VARIABLE NAMES

VARIABLE NUMBER	VARIABLE NAME	DESCRIPTION
1	YEAR	*Year by number
2	MONTH	*Month by number
3	PERIOD	*Period 1 = January, 1980 Period 67 = July, 1985
4	SPOT	*Average monthly copper spot price
5	FIRST	*Average monthly copper futures price closing in one month
6	SECOND	*Average monthly copper futures price closing in three months
7	THIRD	*Average monthly copper futures price closing in twelve months
8	LAG3	*SECOND lagged three periods
9	LAG12	*THIRD lagged twelve periods
10	LAG1	*FIRST lagged one period
11	LAG3SEC	*LAG3 / SECOND
12	LAG12TH	*LAG12 / THIRD
13	LAG1FIR	*LAG1 / FIRST
14	USGOVT	*Average monthly rate on new-issue government securities
15	L3-SEC	*LAG3 - SECOND
16	L12-THI	*LAG12 - THIRD
17	L1-FIR	*LAG1 - FIRST
18	GOLD	*Average monthly spot price for gold
19	CPI	*Consumer Price Index
20	INTRST	*Average monthly prime interest rate

Appendix B

RAW DATA AND DESCRIPTIVE STATISTICS

ABSTAT 3.01 FILE: THESIS REV#65

COMMAND: PRINT DATA

MISSING VALUE TREATMENT: INCLUDE

VARIABLES:

CASE	1 YEAR	2 MONTH	3 PERIOD	4 SPOT	5 FIRST	6 SECOND	7 THIRD	8 LAG3	9 LAG12
1	80.0000	1.00000	1.00000	119.390	117.002	119.184	122.698	106.040	89.1300
2	80.0000	2.00000	2.00000	133.810	128.640	131.570	137.565	94.8500	88.5700
3	80.0000	3.00000	3.00000	106.040	97.2550	99.9810	111.131	93.4800	86.0700
4	80.0000	4.00000	4.00000	94.8500	88.8760	97.2240	99.2290	92.7100	87.3800
5	80.0000	5.00000	5.00000	93.4800	89.3360	98.7360	97.1860	103.560	88.0300
6	80.0000	6.00000	6.00000	92.7100	87.1670	88.4190	95.4070	100.710	85.8000
7	80.0000	7.00000	7.00000	103.560	97.7110	98.9430	103.264	98.8600	85.2300
8	80.0000	8.00000	8.00000	100.710	92.8900	93.9330	99.3360	99.4700	84.4100
9	80.0000	9.00000	9.00000	98.8600	93.0260	94.6330	102.476	96.9300	87.3900
10	80.0000	10.0000	10.0000	99.4700	93.6830	95.2890	102.676	89.1300	84.7200
11	80.0000	11.0000	11.0000	96.9800	91.8080	93.5060	102.722	88.5700	82.3100
12	80.0000	12.0000	12.0000	89.1300	83.7070	85.8930	95.4100	86.0700	81.2200
13	81.0000	1.00000	13.0000	88.5700	84.3360	86.3740	94.2210	87.3800	80.2900
14	81.0000	2.00000	14.0000	86.0700	81.1420	83.2030	93.5970	88.0300	78.6300
15	81.0000	3.00000	15.0000	87.3800	82.4860	84.1930	94.5340	85.8000	79.7800
16	81.0000	4.00000	16.0000	88.0300	82.3640	84.2710	94.7980	85.2300	75.8600
17	81.0000	5.00000	17.0000	85.8000	79.6080	81.6930	93.0480	84.4100	76.2700
18	81.0000	6.00000	18.0000	85.2300	77.5360	79.4550	89.5930	87.3900	74.8700
19	81.0000	7.00000	19.0000	84.4100	76.7930	78.7020	90.0480	84.7200	71.4900
20	81.0000	8.00000	20.0000	87.3900	80.5260	82.5640	93.8310	82.3100	71.0500
21	81.0000	9.00000	21.0000	84.7200	77.1690	79.0480	89.8450	81.2200	71.0000
22	81.0000	10.0000	22.0000	82.3100	74.9700	76.6300	85.2340	80.2900	71.0600
23	81.0000	11.0000	23.0000	81.2200	73.5430	74.8750	81.9100	78.6300	72.4100
24	81.0000	12.0000	24.0000	80.2900	73.3910	74.7300	82.8550	78.7800	72.9700
25	82.0000	1.00000	25.0000	78.6300	72.0030	73.3650	82.0930	75.8600	74.2300
26	82.0000	2.00000	26.0000	78.7800	71.4470	73.0870	81.6260	76.2700	80.2200
27	82.0000	3.00000	27.0000	75.8600	67.5460	69.0110	77.3650	74.8700	84.0200
28	82.0000	4.00000	28.0000	76.2700	68.9170	70.4430	78.1930	71.4900	82.0700
29	82.0000	5.00000	29.0000	74.8700	69.3680	70.8750	78.7300	71.0500	83.4900
30	82.0000	6.00000	30.0000	71.4900	58.0840	59.4340	67.0480	71.0000	85.6300
31	82.0000	7.00000	31.0000	71.0500	63.3070	64.5050	71.9480	71.0600	81.8400
32	82.0000	8.00000	32.0000	71.0000	62.1360	63.1570	68.8430	72.4100	82.9500
33	82.0000	9.00000	33.0000	71.0600	62.3740	63.4480	69.2400	72.9700	80.5400
34	82.0000	10.0000	34.0000	72.4100	64.0690	65.1050	69.5830	74.2300	77.5900
35	82.0000	11.0000	35.0000	72.9700	63.9750	64.9150	69.3300	80.2200	72.3900
36	82.0000	12.0000	36.0000	74.2300	66.6140	67.6550	72.7240	84.0200	69.5800
37	83.0000	1.00000	37.0000	80.2200	72.6240	73.6500	78.8070	82.0700	70.8000
38	83.0000	2.00000	38.0000	84.0200	75.6260	76.8790	82.3890	83.4900	68.7900
39	83.0000	3.00000	39.0000	82.0700	73.3070	74.3540	80.1520	85.6320	70.7500
40	83.0000	4.00000	40.0000	83.4900	75.8730	77.0300	82.6900	81.8400	75.3100
41	83.0000	5.00000	41.0000	85.6300	78.8070	79.9000	85.7430	82.9500	77.3900
42	83.0000	6.00000	42.0000	81.8400	75.0320	76.1840	82.0410	80.5400	72.2300
43	83.0000	7.00000	43.0000	82.9500	73.6740	74.8570	81.6200	77.5900	69.8500
44	83.0000	8.00000	44.0000	80.5400	73.6740	74.8570	81.6200	72.3900	64.4000
45	83.0000	9.00000	45.0000	77.5900	70.3950	71.4500	78.3290	69.5800	64.5400
46	83.0000	10.0000	46.0000	72.3900	64.5710	65.5360	71.5120	70.8000	63.4100
47	83.0000	11.0000	47.0000	69.5800	62.5520	63.5380	69.0070	68.7900	62.0400
48	83.0000	12.0000	48.0000	70.8000	64.2380	65.2330	71.9190	70.7500	65.6500
49	84.0000	1.00000	49.0000	68.7900	62.2950	63.1830	69.8310	75.3100	63.5400
50	84.0000	2.00000	50.0000	70.7500	64.2180	65.2130	71.3450	77.3900	64.4900
51	84.0000	3.00000	51.0000	75.3100	67.9140	68.7960	75.2610	72.2300	66.4500
52	84.0000	4.00000	52.0000	77.3900	68.4600	69.5100	75.6630	69.8500	65.5500
53	84.0000	5.00000	53.0000	72.2300	63.4020	64.4250	71.1340	64.4000	70.3200

DATA SET 1/4

ABSTAT 3.01   FILE: THESIS   REV865

COMMAND: PRINT DATA

VARIABLES:

CASE	1 YEAR	2 MONTH	3 PERIOD	4 SPOT	5 FIRST	6 SECOND	7 THIRD	8 LAG3	9 LAG12
54	84.0000	6.00000	54.0000	69.8500	61.0300	62.0690	68.3120	64.5400	69.8600
55	84.0000	7.00000	55.0000	64.4000	58.5900	59.4400	65.6400	63.4100	67.0900
56	84.0000	8.00000	56.0000	64.5400	59.3400	60.3370	65.9570	62.0400	66.7700
57	84.0000	9.00000	57.0000	63.4100	57.0550	57.9890	63.7710	65.6500	MISSING
58	84.0000	10.0000	58.0000	62.0400	56.3390	57.2630	62.4280	63.5400	MISSING
59	84.0000	11.0000	59.0000	65.6500	59.6260	60.3740	64.6330	64.4900	MISSING
60	84.0000	12.0000	60.0000	63.5400	57.5420	58.1660	61.9160	65.5500	MISSING
61	85.0000	1.00000	61.0000	64.4900	59.1500	59.7250	61.9300	65.5500	MISSING
62	85.0000	2.00000	62.0000	66.4500	60.5710	64.2390	63.9630	70.3200	MISSING
63	85.0000	3.00000	63.0000	65.5500	MISSING	MISSING	MISSING	69.8600	MISSING
64	85.0000	4.00000	64.0000	70.3200	MISSING	MISSING	MISSING	67.0900	MISSING
65	85.0000	5.00000	65.0000	69.8600	MISSING	MISSING	MISSING	66.7700	MISSING
66	85.0000	6.00000	66.0000	67.0900	MISSING	MISSING	MISSING	MISSING	MISSING
67	85.0000	7.00000	67.0000	66.7700	MISSING	MISSING	MISSING	MISSING	MISSING

VARIABLES:

CASE	10 LAG1	11 LAG3SEC	12 LAG12TH	13 LAG1FIR	14 USGOV	15 L3-SEC	16 L12-THI	17 L1-FIR	18 GOLD
1	133.810	0.889717	0.726418	1.14366	12.0360	-13.1440	-33.5680	16.8080	675.377
2	106.040	0.720909	0.643841	0.824316	12.8140	-36.7200	-48.9950	-22.6000	665.513
3	94.8500	0.934978	0.774491	0.975271	15.5260	-6.50101	-25.0610	-2.40500	553.629
4	93.4800	0.953571	0.880590	1.05180	14.0030	-4.51400	-11.8490	4.60399	516.771
5	92.7100	1.14133	0.905789	1.03777	9.15000	12.8240	-9.15601	3.37400	513.912
6	103.560	1.13921	0.899305	1.18806	6.99500	12.2910	-9.60700	16.3930	600.717
7	100.710	0.999161	0.825360	1.03069	8.12600	-8.30078E-02	-18.0340	2.99900	643.273
8	98.8600	1.05895	0.849742	1.06427	9.25900	5.53699	-14.9260	5.96999	627.510
9	99.4700	1.02480	0.852785	1.06927	10.3210	2.34698	-15.0860	6.44398	675.774
10	96.9800	0.935365	0.825120	1.03519	11.5800	-6.15901	-17.9560	3.29698	660.343
11	89.1300	0.947212	0.801289	0.970831	13.8880	-4.93600	-20.4120	-2.67801	622.476
12	88.5700	1.00206	0.851274	1.05810	15.6610	0.176994	-14.1900	4.86298	594.814
13	86.0700	1.01165	0.852146	1.02056	14.7240	1.00599	-13.9310	1.73400	557.388
14	87.3800	1.05802	0.840091	1.07688	14.9050	4.82700	-14.9670	6.23799	500.263
15	88.0300	1.01909	0.833351	1.06721	13.4780	1.60699	-15.7540	5.54400	498.761
16	85.8030	1.01138	0.800228	1.04172	13.6350	0.958992	-18.9380	3.43600	454.905
17	85.2300	1.03326	0.812698	1.07062	16.2950	2.71699	-17.5780	5.62198	479.788
18	84.4100	1.09987	0.835669	1.08866	14.5570	7.93499	-14.7230	6.87400	460.761
19	87.3900	1.07647	0.793910	1.13799	14.6990	6.01798	-18.5580	10.5970	408.839
20	84.7200	0.996924	0.757213	1.05208	15.6120	-0.253998	-22.7810	4.19399	410.960
21	82.3100	1.02748	0.790250	1.06662	14.9510	2.17199	-18.8450	5.14101	444.095
22	81.2200	1.04776	0.833705	1.08337	13.8730	3.66300	-14.1740	6.24999	437.195
23	80.2900	1.05015	0.884019	1.09174	11.2690	3.75500	-9.50002	6.74699	413.671
24	78.6300	1.05420	0.880695	1.07138	10.9260	4.05000	-9.88501	5.23899	408.743
25	78.7800	1.03401	0.904219	1.09412	12.4120	2.49499	-7.86301	6.77699	384.125
26	75.8600	1.04355	0.982775	1.06177	13.7800	3.18299	-1.40601	4.41299	374.071
27	76.2700	1.08490	1.08602	1.12916	12.4930	5.85899	6.65500	8.72399	330.218
28	74.8700	1.01486	1.04958	1.08638	12.8210	1.04699	3.87700	5.95300	350.488
29	71.4900	1.00247	1.06046	1.03059	12.1480	0.175003	4.75999	2.12199	334.403
30	71.0500	1.19460	1.27714	1.22323	12.1080	11.5660	18.5820	12.9660	314.982
31	71.0300	1.10162	1.13749	1.12152	11.9140	6.55500	9.89200	7.69299	340.102
32	71.0600	1.14651	1.20492	1.14362	9.00600	9.25300	14.1070	8.92400	365.952
33	72.4100	1.15008	1.16320	1.16090	8.19600	9.52200	11.3000	10.0360	435.564
34	72.9700	1.14016	1.11507	1.13893	7.75000	9.12499	8.00700	8.93099	421.755
35	74.2300	1.23577	1.04414	1.16030	8.34200	15.3050	3.06000	10.2550	414.993
36	80.2200	1.24189	0.956769	1.20425	8.01300	16.3650	-3.14400	13.6060	445.431
37	84.0200	1.11432	0.898398	1.15692	7.81000	8.41999	-8.00700	11.3960	479.893
38	82.0700	1.08599	0.834942	1.08521	8.13000	6.61099	-13.5990	6.44400	490.408

DATA SET   2/4

COMMAND: PRINT DATA

VARIABLES:

CASE	10 LAG1	11 LAG3SEC	12 LAG12TH	13 LAG1FIR	14 USGOV	15 L3-SEC	16 L12-THI	17 L1-FIR	18 GOLD
39	83.4900	1.15165	0.882698	1.13891	8.30400	11.2760	-9.40202	10.1830	419.696
40	85.6300	1.06244	0.910751	1.12860	8.25200	4.00998	-7.30000	9.75699	432.180
41	81.8400	1.03017	0.902582	1.03849	8.10900	3.04998	-8.35300	3.03300	437.555
42	82.9500	1.05718	0.880414	1.10553	8.02000	4.35599	-9.01100	7.91799	412.841
43	80.5400	1.03651	0.855796	1.09319	9.12000	2.73299	-11.7700	6.86599	423.053
44	77.5900	0.967044	0.789023	1.05315	9.30000	-2.46700	-17.2200	3.91599	416.240
45	72.3900	0.973828	0.823961	1.02834	9.35000	-1.07000	-13.7890	1.99499	411.455
46	69.5800	1.00032	0.886704	1.07757	8.71000	5.26400	-8.10200	5.00899	393.200
47	70.8000	1.08266	0.899039	1.13186	8.71000	5.25198	-6.96701	8.24000	382.245
48	68.7900	1.08457	0.912833	1.07086	8.96000	5.51690	-6.26900	4.55198	387.140
49	70.7500	1.19193	0.909911	1.13573	8.93000	12.1270	-6.29102	8.45499	370.888
50	75.3100	1.18673	0.903918	1.17272	9.03000	12.1770	-6.05501	11.0920	385.955
51	77.3900	1.04992	0.882928	1.13953	9.44000	3.43399	-8.81100	9.47599	394.264
52	72.2300	1.00489	0.866342	1.05507	9.69000	0.339996	-10.1130	3.76999	381.650
53	69.8500	0.999612	0.938557	1.10178	9.90000	-2.50167E-02	-0.814018	6.44790	377.261
54	64.4000	1.03981	1.02266	1.05508	8.82000	2.47099	1.54800	3.36198	377.655
55	64.5400	1.06665	1.02197	1.10140	10.1300	3.96200	1.44199	5.94199	346.443
56	63.4100	1.02822	1.01233	1.06844	10.4900	1.70299	0.812981	4.06199	347.693
57	62.0400	1.13211	MISSING	1.08737	10.4100	7.66101	MISSING	4.98499	340.913
58	65.6500	1.10962	MISSING	1.16527	9.97000	6.27699	MISSING	9.31100	340.109
59	63.5400	1.06818	MISSING	1.06564	8.79000	4.11598	MISSING	3.91400	340.861
60	66.4500	1.09753	MISSING	1.23420	8.16000	7.38399	MISSING	8.90800	319.739
61	66.4500	1.09753	MISSING	1.23420	7.76000	5.82500	MISSING	MISSING	302.791
62	65.5500	1.14829	MISSING	1.00220	8.22000	6.08100	MISSING	MISSING	[illegible]
63	70.3200	MISSING	MISSING	MISSING	8.57000	MISSING	MISSING	MISSING	303.943
64	69.8600	MISSING	MISSING	MISSING	8.00000	MISSING	MISSING	MISSING	324.932
65	67.0900	MISSING	MISSING	MISSING	7.56000	MISSING	MISSING	MISSING	316.073
66	66.7700	MISSING	MISSING	MISSING	7.01000	MISSING	MISSING	MISSING	[illegible]
67	MISSING	MISSING	MISSING	MISSING	7.05000	MISSING	MISSING	MISSING	317.802

VARIABLES:

CASE	19 CPI	20 INTRST
1	233.200	15.2500
2	236.400	16.0000
3	239.800	18.1300
4	242.500	19.5000
5	244.900	16.2500
6	247.600	13.0000
7	247.800	11.5000
8	249.400	11.2500
9	251.700	12.2500
10	253.900	14.0000
11	256.200	16.1300
12	258.400	19.6300
13	260.500	20.7500
14	263.200	19.5000
15	265.100	18.2500
16	266.800	17.7500
17	269.000	19.2500
18	271.300	20.5000
19	274.400	14.0000
20	276.500	14.0000
21	279.300	14.0300
22	279.900	14.0000
23	280.700	13.5000

DATA SET 3/4

ABSTAT 3.01 FILE: THESIS

COMMAND: PRINT DATA

VARIABLES:

CASE	19 CPI	20 INTRST
24	281.500	12.5000
25	282.500	12.0000
26	283.400	12.0000
27	283.100	12.0000
28	284.300	12.0000
29	287.100	12.0000
30	290.600	12.0000
31	292.200	11.7500
32	292.800	14.5000
33	293.300	13.5000
34	294.100	12.7500
35	293.600	11.7500
36	292.400	11.5000
37	293.100	11.2500
38	293.200	10.7500
39	293.400	10.5000
40	295.500	10.5000
41	297.100	10.5000
42	298.100	10.5000
43	299.300	10.5000
44	300.300	10.7500
45	301.800	11.0000
46	302.600	11.0000
47	303.100	11.0000
48	303.500	11.0000
49	305.200	11.0000
50	306.600	11.0000
51	307.300	11.2500
52	308.800	11.7500
53	309.700	12.2500
54	310.700	12.7500
55	311.700	13.0000
56	313.000	13.0000
57	314.500	13.0000
58	315.300	12.3000
59	315.300	11.6300
60	315.500	11.0000
61	316.100	10.6300
62	317.400	10.5000
63	318.500	10.5000
64	320.100	10.5000
65	321.300	10.2500
66	322.300	9.75000
67	322.800	9.50000

DATA SET 4/4

ABSTAT 3.01 FILE: THESIS REV#65

COMMAND: DESC

MISSING VALUE TREATMENT: VARWISE

THERE ARE 20 VARIABLES AND 67 CASES

VARIABLE	VALID CASES	NUMBER MISSING	% MISSING
1 YEAR	67	0	0.0
2 MONTH	67	0	0.0
3 PERIOD	67	0	0.0
4 SPOT	67	0	0.0
5 FIRST	62	5	7.5
6 SECOND	62	5	7.5
7 THIRD	62	5	7.5
8 LAG3	65	2	3.0
9 LAG12	56	11	16.4
10 LAG1	66	1	1.5
11 LAG3SEC	62	5	7.5
12 LAG12TH	56	11	16.4
13 LAG1FIR	62	5	7.5
14 USGOV	67	0	0.0
15 L3-SEC	62	5	7.5
16 L12-THI	56	11	16.4
17 L1-FIR	60	7	10.4
18 GOLD	67	0	0.0
19 CPI	67	0	0.0
20 INTRST	67	0	0.0

VARIABLE	MEAN	STD.DEV.	VARIANCE	STD ERROR OF MEAN	COEFF OF VARIATION
1 YEAR	82.3134	1.63493	2.67299	0.199738	1.98622
2 MONTH	6.23881	3.44255	11.8512	0.420575	55.1797
3 PERIOD	34.0000	19.4850	379.666	2.38048	57.3089
4 SPOT	80.2772	13.5666	184.053	1.65743	16.8997
5 FIRST	74.3666	14.2291	202.466	1.80709	19.1337
6 SECOND	75.8750	14.6973	216.011	1.86656	19.3704
7 THIRD	82.7057	15.3719	236.296	1.95224	18.5863
8 LAG3	78.8380	10.9281	119.422	1.35546	13.8614
9 LAG12	75.6913	7.88218	62.1287	1.05330	10.4136
10 LAG1	79.7143	12.7332	162.135	1.56735	15.9736
11 LAG3SEC	1.05773	8.47160E-02	7.17680E-03	1.07589E-02	8.00922
12 LAG12TH	0.937455	0.121781	1.48306E-02	1.62737E-02	13.4201
13 LAG1FIR	1.09161	6.65452E-02	4.42826E-03	8.45125E-03	6.09605
14 USGOV	10.5722	2.65249	7.03569	0.324053	25.0893
15 L3-SEC	3.49202	7.44743	55.4642	0.945825	213.270
16 L12-THI	-9.11425	11.5223	132.763	1.53973	-126.421
17 L1-FIR	6.06827	5.27380	27.8130	0.680846	86.9079
18 GOLD	432.354	103.300	10671.0	12.6202	23.8926
19 CPI	287.350	24.6001	605.166	3.00538	8.56102
20 INTRST	13.0378	2.89880	8.40306	0.354145	22.2339

DATA SET DESCRIPTIVE STATISTICS

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COMMAND: CORR

                  *** CORRELATION MATRIX ***

VARIABLES:
 1 YEAR          1.00000
 2 MONTH        -0.152535   1.000000
 3 PERIOD        0.977256 6.05226E-02   1.00000
 4 SPOT         -0.740153  -0.199655  -0.790386   1.000000
 5 FIRST        -0.743862  -0.206477  -0.795595   0.994466   1.000000
 6 SECOND       -0.753664  -0.212334  -0.806752   0.992310   0.997823   1.00000
 7 THIRD        -0.782087  -0.210891  -0.835149   0.981373   0.987545   0.989099   1.000000
 8 LAG3         -0.795123  -0.158886  -0.837156   0.840390   0.848545   0.847244   0.834550   1.00000
 9 LAG12        -0.763406  -0.162028  -0.805796   0.623134   0.614019   0.623304   0.615958   0.627958   1.000000
10 LAG1         -0.737543  -0.213158  -0.790646   0.911256   0.919670   0.915989   0.896098   0.919101   0.613408
                 1.000000
11 LAG3SEC       0.369407   0.165188   0.408542  -0.698303  -0.705528  -0.712531  -0.723085  -0.260364  -0.307959
                -0.481368   1.00000
12 LAG12TH       0.353219   0.120237   0.382547  -0.673018  -0.695286  -0.691006  -0.716298  -0.550294 8.66756E-02
                -0.697154   0.605627   1.000000
13 LAG1FIR       0.370452 6.48678E-02   0.388071  -0.604519  -0.613308  -0.616435  -0.640156  -0.259188  -0.257506
                -0.272618   0.815858   0.560834   1.00000
14 USGOVT       -0.524698  -0.137120  -0.559360   0.320967   0.330170   0.355941   0.459953   0.195579   0.318403
                 0.230683  -0.451849  -0.313467  -0.400559   1.00000
15 L3-SEC        0.338743   0.180439   0.380844  -0.715538  -0.714963  -0.720638  -0.717297  -0.242262  -0.318833
                -0.473408   0.961569   0.543847   0.787592  -0.394841   1.000000
16 L12-THI       0.468453   0.156147   0.506637  -0.815694  -0.829695  -0.825339  -0.844110  -0.626923 -9.75493E-02
                -0.714582   0.703896   0.963916   0.633469  -0.364367   0.689182   1.000000
17 L1-FIR        0.239216 4.75800E-02   0.251814  -0.486627  -0.481880  -0.484576  -0.502914 -9.93607E-02  -0.187186
              -9.90742E-02   0.713692   0.407067   0.945801  -0.321911   0.755361   0.507947   1.00000
18 GOLD         -0.738045 -6.20861E-03  -0.746746   0.868726   0.879333   0.872120   0.852219   0.858033   0.562363
                 0.868041  -0.488791  -0.600312  -0.438077   0.159334  -0.472989  -0.693890  -0.291310   1.000000
19 CPI           0.942315   0.113511   0.976081  -0.868392  -0.876549  -0.886485  -0.898296  -0.889066  -0.794191
                -0.862129   0.480995   0.466690   0.443739  -0.482429   0.458719   0.594311   0.297448  -0.833124
                 1.00000
20 INTRST       -0.615480  -0.136952  -0.651012   0.415615   0.440268   0.467388   0.527161   0.430341   0.436208
                 0.373511  -0.326780  -0.298641  -0.370806   0.738605  -0.291984  -0.369094  -0.282198   0.428626
                -0.631610   1.000000
                  1 YEAR    2 MONTH   3 PERIOD     4 SPOT    5 FIRST   6 SECOND    7 THIRD     8 LAG3    9 LAG12
                 10 LAG1  11 LAG3SEC 12 LAG12TH 13 LAG1FIR 14 USGOVT  15 L3-SEC  16 L12-THI  17 L1-FIR   18 GOLD
                  19 CPI  20 INTRST
```

CORRELATION MATRIX

Appendix C

MOVING AVERAGE MODELS

PERIOD	SPOT	SMA(1)	ERR 2	SMA(4)	ERR 3	SMA(12)	ERR 4	DMA(4)	ERR 5	ERROR DIFFRNC	TREND	DMA FORECAST	ERR 6
1	119.39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	133.81	119.39	-14.42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	106.04	133.81	27.77	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	94.85	106.04	11.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	93.48	94.85	1.37	113.52	20.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	92.71	93.48	.77	107.05	14.34	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	103.56	92.71	-10.85	96.77	-6.79	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	100.71	103.56	2.85	96.15	-4.56	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	98.86	100.71	1.85	97.62	-1.25	N/A	N/A	99.40	.54	-1.78	1.85	97.69	-1.18
10	99.47	98.86	-.61	98.96	-.51	N/A	N/A	97.37	-2.10	1.59	-.61	99.94	.47
11	96.98	99.47	2.49	100.65	3.67	N/A	N/A	98.34	1.36	2.31	2.49	105.45	8.47
12	89.13	96.98	7.85	99.01	9.88	N/A	N/A	99.06	9.93	-.05	7.85	106.80	17.67
13	88.57	89.13	.56	96.11	7.54	102.42	13.85	98.68	10.11	-2.57	.56	94.10	5.53
14	86.07	88.57	2.50	93.54	7.47	99.85	13.78	97.33	11.26	-3.79	2.50	92.25	6.18
15	87.38	86.07	-1.31	90.19	2.81	95.87	8.49	94.71	7.33	-4.52	-1.31	84.36	-3.03
16	88.03	87.38	-.65	87.79	-.24	94.31	6.28	91.91	3.88	-4.12	-.65	83.02	-5.01
17	85.80	88.03	2.23	87.51	1.71	93.75	7.95	89.76	3.96	-2.24	2.23	87.50	1.70
18	85.23	85.80	.57	86.82	1.59	93.11	7.88	88.08	2.85	-1.26	.57	86.13	.90
19	84.41	85.23	.82	86.61	2.20	92.48	8.07	87.18	2.77	-.57	.82	86.86	2.45
20	87.39	84.41	-2.98	85.87	-1.52	90.89	3.50	86.70	-.69	-.84	-2.98	82.05	-5.34
21	84.72	87.39	2.67	85.71	.99	89.78	5.06	86.25	1.53	-.54	2.67	87.83	3.11
22	82.31	84.72	2.41	85.44	3.13	88.60	6.29	85.91	3.60	-.47	2.41	87.38	5.07
23	81.22	82.31	1.09	84.71	3.49	87.17	5.95	85.43	4.21	-.72	1.09	85.08	3.86
24	80.29	81.22	.93	83.91	3.62	85.86	5.57	84.94	4.65	-1.03	.93	83.81	3.52
25	78.63	80.29	1.66	82.14	3.51	85.12	6.49	84.05	5.42	-1.91	1.66	81.88	3.25
26	78.78	78.63	-.15	80.61	1.83	84.29	5.51	82.84	4.06	-2.23	-.15	78.23	-.55
27	75.86	78.78	2.92	79.73	3.87	83.68	7.82	81.60	5.74	-1.87	2.92	80.78	4.92
28	76.27	75.86	-.41	78.39	2.12	82.72	6.45	80.22	3.95	-1.83	-.41	76.15	-.12
29	74.87	76.27	1.40	77.39	2.52	81.74	6.87	79.03	4.16	-1.64	1.40	77.14	2.27
30	71.49	74.87	3.38	76.45	4.96	80.83	9.34	77.99	6.50	-1.54	3.38	78.28	6.79
31	71.05	71.49	.44	74.62	3.57	79.69	8.64	76.71	5.66	-2.09	.44	72.97	1.92
32	71.00	71.05	.05	73.42	2.42	78.57	7.57	75.47	4.47	-2.05	.05	71.42	.42
33	71.06	71.00	-.06	72.10	1.04	77.21	6.15	74.15	3.09	-2.05	-.06	70.00	-1.06
34	72.41	71.06	-1.35	71.15	-1.26	76.07	3.66	72.82	.41	-1.67	-1.35	68.13	-4.28
35	72.97	72.41	-.56	71.38	-1.59	75.24	2.27	72.01	-.96	-.63	-.56	70.19	-2.78
36	74.23	72.97	-1.26	71.86	-2.37	74.56	.33	71.62	-2.61	.24	-1.26	70.84	-3.39
37	80.22	74.23	-5.99	72.67	-7.55	74.05	-6.17	71.76	-8.46	.90	-5.99	67.58	-12.64
38	84.02	80.22	-3.80	74.96	-9.06	74.18	-9.84	72.72	-11.30	2.24	-3.80	73.40	-10.62
39	82.07	84.02	1.95	77.86	-4.21	74.62	-7.45	74.34	-7.73	3.52	1.95	83.33	1.26
40	83.49	82.07	-1.42	80.14	-3.36	75.14	-8.35	76.41	-7.09	3.73	-1.42	82.45	-1.05
41	85.63	83.49	-2.14	82.45	-3.18	75.74	-9.89	78.85	-6.78	3.60	-2.14	83.91	-1.72
42	81.84	85.63	3.79	83.80	1.96	76.64	-5.20	81.06	-.78	2.74	3.79	90.33	8.49
43	82.95	81.84	-1.11	83.26	.31	77.50	-5.45	82.41	-.54	.85	-1.11	82.99	.04
44	80.54	82.95	2.41	83.48	2.94	78.49	-2.05	83.25	2.71	.23	2.41	86.12	5.58
45	77.59	80.54	2.95	82.74	5.15	79.29	1.70	83.32	5.73	-.58	2.95	85.11	7.52
46	72.39	77.59	5.20	80.73	8.34	79.83	7.44	82.55	10.16	-1.82	5.20	84.11	11.72
47	69.58	72.39	2.81	78.37	8.79	79.83	10.25	81.33	11.75	-2.96	2.81	78.22	8.64
48	70.80	69.58	-1.22	75.03	4.23	79.55	8.75	79.22	8.42	-4.19	-1.22	69.61	-1.19
49	68.79	70.80	2.01	72.59	3.80	79.26	10.47	76.68	7.89	-4.09	2.01	70.51	1.72
50	70.75	68.79	-1.96	70.39	-.36	78.31	7.56	74.09	3.34	-3.70	-1.96	64.73	-6.02
51	75.31	70.75	-4.56	69.98	-5.33	77.20	1.89	72.00	-3.31	-2.02	-4.56	63.40	-11.91
52	77.39	75.31	-2.08	71.41	-5.98	76.64	-.75	71.09	-6.30	.32	-2.08	69.65	-7.74
53	72.23	77.39	5.16	73.06	.83	76.13	3.90	71.21	-1.02	1.85	5.16	80.07	7.84
54	69.85	72.23	2.38	73.92	4.07	75.01	5.16	72.09	2.24	1.83	2.38	78.13	8.28
55	64.40	69.85	5.45	73.70	9.30	74.01	9.61	73.02	8.62	.67	5.45	79.82	15.42
56	64.54	64.40	-.14	70.97	6.43	72.47	7.93	72.91	8.37	-1.94	-.14	68.88	4.34
57	63.41	64.54	1.13	67.76	4.35	71.14	7.73	71.58	8.17	-3.83	1.13	65.06	1.65
58	62.04	63.41	1.37	65.55	3.51	69.95	7.91	69.49	7.45	-3.94	1.37	62.98	.94
59	65.65	62.04	-3.61	63.60	-2.05	69.09	3.44	66.97	1.32	-3.37	-3.61	56.62	-9.03
60	63.54	65.65	2.11	63.91	.37	68.76	5.22	65.20	1.66	-1.29	2.11	64.73	1.19
61	64.49	63.54	-.95	63.66	-.83	68.16	3.67	64.18	-.31	-.52	-.95	62.19	-2.30
62	66.45	64.49	-1.96	63.93	-2.52	67.80	1.35	63.77	-2.68	.16	-1.96	62.13	-4.32
63	65.55	66.45	.90	65.03	-.52	67.44	1.89	64.13	-1.42	.90	.90	66.83	1.28
64	70.32	65.55	-4.77	65.01	-5.31	66.63	-3.69	64.41	-5.91	.60	-4.77	60.84	-9.48
65	69.86	70.32	.46	66.70	-3.16	66.04	-3.82	65.17	-4.69	1.53	.46	68.70	-1.16
66	67.09	69.86	2.77	68.05	.96	65.84	-1.25	66.20	-.89	1.85	2.77	72.66	5.57
67	66.77	67.09	.32	68.21	1.44	65.61	-1.16	66.99	.22	1.22	.32	69.74	2.97

CALCULATION OF MOVING AVERAGE MODELS

Appendix D

REGRESSION EQUATIONS

INDEPENDENT VARIABLES	EQUATION	R^2	F-TEST SIGNIF.?	COEFFICIENTS SIGNIF.?	SIGNS OF COEFFICIENTS SIGNIF.?	PLOTS OF RESIDUALS SHOW PATTERN?	DURBIN-WATSON RESULTS	EVIDENCE OF MULTI-COLLINEARITY? (correlation between X's)	MODEL SELECTED?
FIRST	$12.5387 + .928148X_1$	.994467	yes		yes	no	1.614020 no autocorr.		yes
FIRST, INTRST	$13.2804 + .939472X_1 - .119274X_2$	.994774	yes			no	.170561 autocorr.		
PERIOD, FIRST	$12.3641 + .001775X_1 + .929783X_2$	.994469	yes			no	.168855 autocorr.		
PERIOD, FIRST, USGOVT	$13.3336 - .004958X_1 + .926727X_2 - .004994X_3$	.994504	yes			no	.007134 no autocorr.		
SECOND	$13.6845 + .895025X_1$	.992310	yes			maybe	.642216 autocorr.		
THIRD	$9.41189 + .746765X_1$	.981374	yes			yes	.746765 autocorr.		
FIRST, SECOND, THIRD	$12.7367 + .930579X_1 - .02712X_2 - .02932X_3$	.994390	yes			no	1.931740 no autocorr.	high correlation between SECOND & FIRST, FIRST & THIRD, SECOND & THIRD	
USGOVT	$66.3179 + 1.55255X_1$	.320967	no			yes	1.444400 autocorr.		
FIRST, USGOVT	$12.7852 + .9307X_1 - .04004X_2$	.994498	yes	USGOVT not signif.	yes	maybe	2.054860 no autocorr.		yes
GOLD	$31.4693 + .113878X_1$	.868727	yes			yes	1.684860 no autocorr.		
CPI	$225.979 - .507758X_1$	.868391	yes			yes	1.538410 no autocorr.		
INTRST	$59.2032 + .896211X_1$	.415615	yes			yes	.896211 autocorr.		
FIRST, CPI	$9.30331 + .939826X_1 + .008347X_2$	.994490	yes	CPI not signif.	yes	maybe	.065080 autocorr.		yes

REGRESSION EQUATION DETAIL

1/2

INDEPENDENT VARIABLES	EQUATION	R^2	F-TEST SIGNIF.?	COEFFICIENTS SIGNIF.?	SIGNS OF COEFFICIENTS SIGNIF.?	PLOTS OF RESIDUALS SHOW PATTERN?	DURBIN-WATSON RESULTS	EVIDENCE OF MULTI-COLLINEARITY? (correlation between X's)	MODEL SELECTED?
FIRST, CPI, INTRST	$18.4693 + .924164X_1 - .01292X_2 - .148418X_3$	.994815	yes			maybe	.177087 autocorr.		
FIRST, USGOVT, INTRST	$13.0833 + .939358X_1 + .0955X_2 - .182154X_3$	.974863	yes			maybe	.117491 autocorr.		
FIRST, GOLD	$12.4660 + .948923X_1 - .003318X_2$	.994539	yes			yes	.172393 autocorr.		
FIRST, USGOVT, CPI, INTRST	$17.9268 + .925088X_1 + 9.282X_2 - .01204X_3 - .207568X_4$	.994897	yes			maybe	.178872 autocorr.		
FIRST, USGOVT, GOLD, CPI, INTRST	$19.2927 + .934634X_1 + .06288X_2 - .00225X_3 - .01547X_4 - .191800X_5$	.994918	yes			maybe	.065590 autocorr.		
PERIOD, FIRST INTRST	$15.9030 - .02368X_1 + .922176X_2 - .166668X_3$	.994886	yes			maybe	.087690 autocorr.		
FIRST, GOLD, INTRST	$13.1933 + .955835X_1 - .02682X_2 - .114715X_3$	.994821	yes			maybe	.136180 autocorr.		
PERIOD, FIRST, GOLD	$12.5510 - .0008723X_1 + .948309X_2 - .003348X_3$	.994541	yes			maybe	.156204 autocorr.		
FIRST, GOLD, CPI	$10.6459 + .953698X_1 - .003028X_2 + .004712X_3$	.994547	yes			maybe	.057300 autocorr.		

REGRESSION EQUATION DETAIL 2/2

```
ABSTAT 3.01

COMMAND: REGR

                    *** MULTIPLE LINEAR REGRESSION ***

DEPENDENT VARIABLE:  4 SPOT                  55 VALID CASES

COEFF OF DETERMINATION:   0.988964    ESTIMATED CONSTANT TERM:        12.5387
MULTIPLE CORR COEFF:      0.994467    STANDARD ERROR OF ESTIMATE:     1.37046

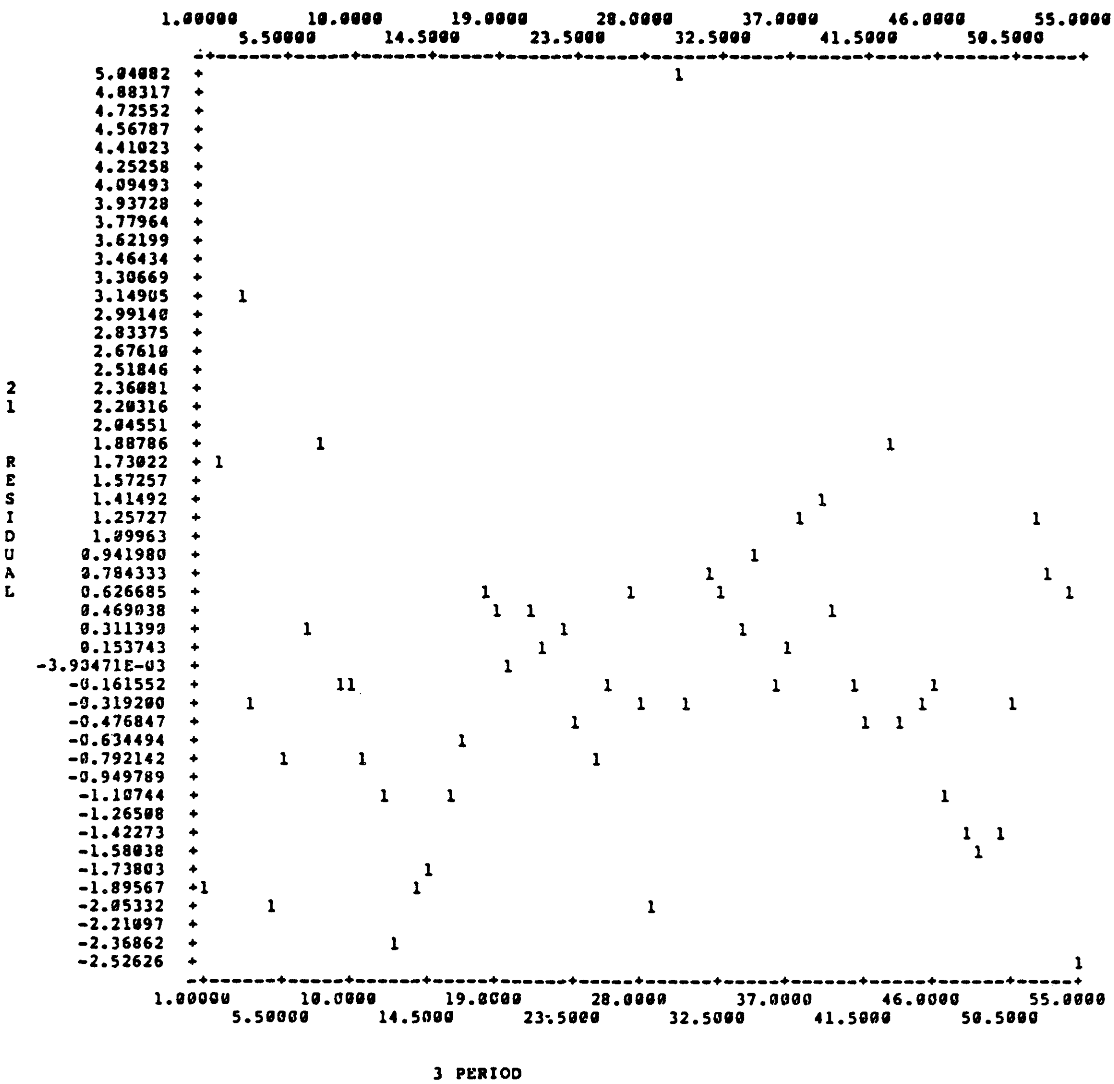
ANALYSIS OF VARIANCE FOR THE REGRESSION:
                      DEGREES OF    SUM OF      MEAN OF
SOURCE OF VARIANCE     FREEDOM      SQUARES     SQUARES      F TEST
      REGRESSION          1         8919.70     8919.70     4749.20
      RESIDUALS          53         99.5420     1.87815
      TOTAL              54         9019.25
                                             CORRELATION
                REGRESSION   STANDARDIZED       WITH
VARIABLE        COEFFICIENT   COEFFICIENT     DEPENDENT
 5 FIRST           0.928148      0.994466      0.994466

DURBIN-WATSON =     1.61402
```

REGRESSION #1

ABSTAT 3.01 FILE: COPPER

COMMAND: PLOT



PLOT OF RESIDUALS
REGRESSION #1

ABSTAT 3.01 FILE: COPPER

COMMAND: REGR

*** MULTIPLE LINEAR REGRESSION ***

DEPENDENT VARIABLE: 4 SPOT 55 VALID CASES

COEFF OF DETERMINATION:	0.989024	ESTIMATED CONSTANT TERM:	12.7853
MULTIPLE CORR COEFF:	0.994497	STANDARD ERROR OF ESTIMATE:	1.37979

ANALYSIS OF VARIANCE FOR THE REGRESSION:

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	F TEST
REGRESSION	2	8920.25	4460.12	2342.72
RESIDUALS	52	98.9990	1.90383	
TOTAL	54	9019.25		

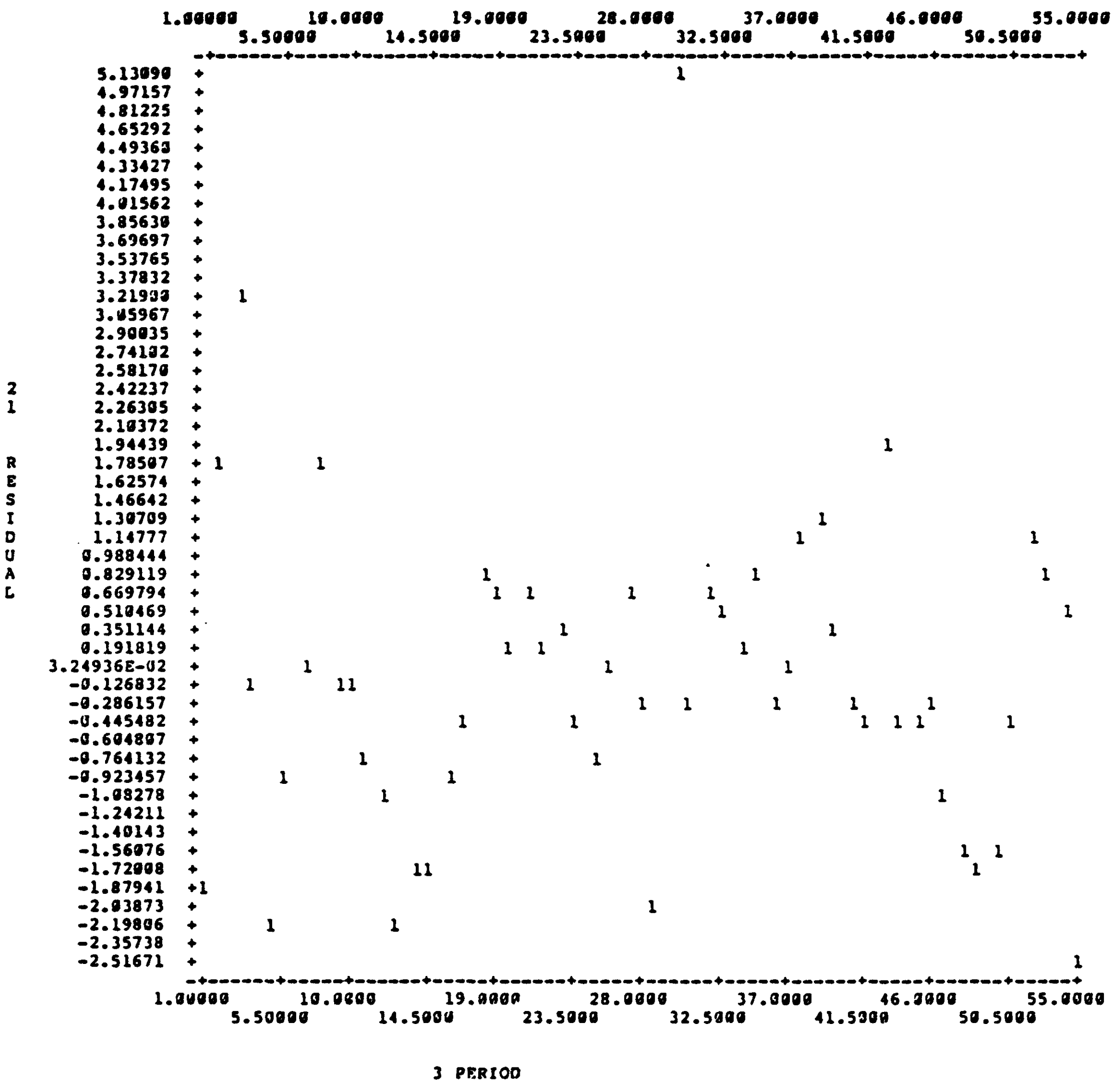
VARIABLE	REGRESSION COEFFICIENT	STANDARDIZED COEFFICIENT	CORRELATION WITH DEPENDENT
5 FIRST	0.930698	0.997199	0.994466
14 USGOVT	-4.004E-02	-8.279E-03	0.320967

DURBIN-WATSON = 1.63761

REGRESSION #2

ABSTAT 3.01 FILE: COPPER REV#60

COMMAND: PLOT



PLOT OF RESIDUALS
REGRESSION #2

COMMAND: REGR

*** MULTIPLE LINEAR REGRESSION ***

DEPENDENT VARIABLE: 4 SPOT　　55 VALID CASES

COEFF OF DETERMINATION: 0.989010　　ESTIMATED CONSTANT TERM: 9.30343
MULTIPLE CORR COEFF: 0.994490　　STANDARD ERROR OF ESTIMATE: 1.38070

ANALYSIS OF VARIANCE FOR THE REGRESSION:

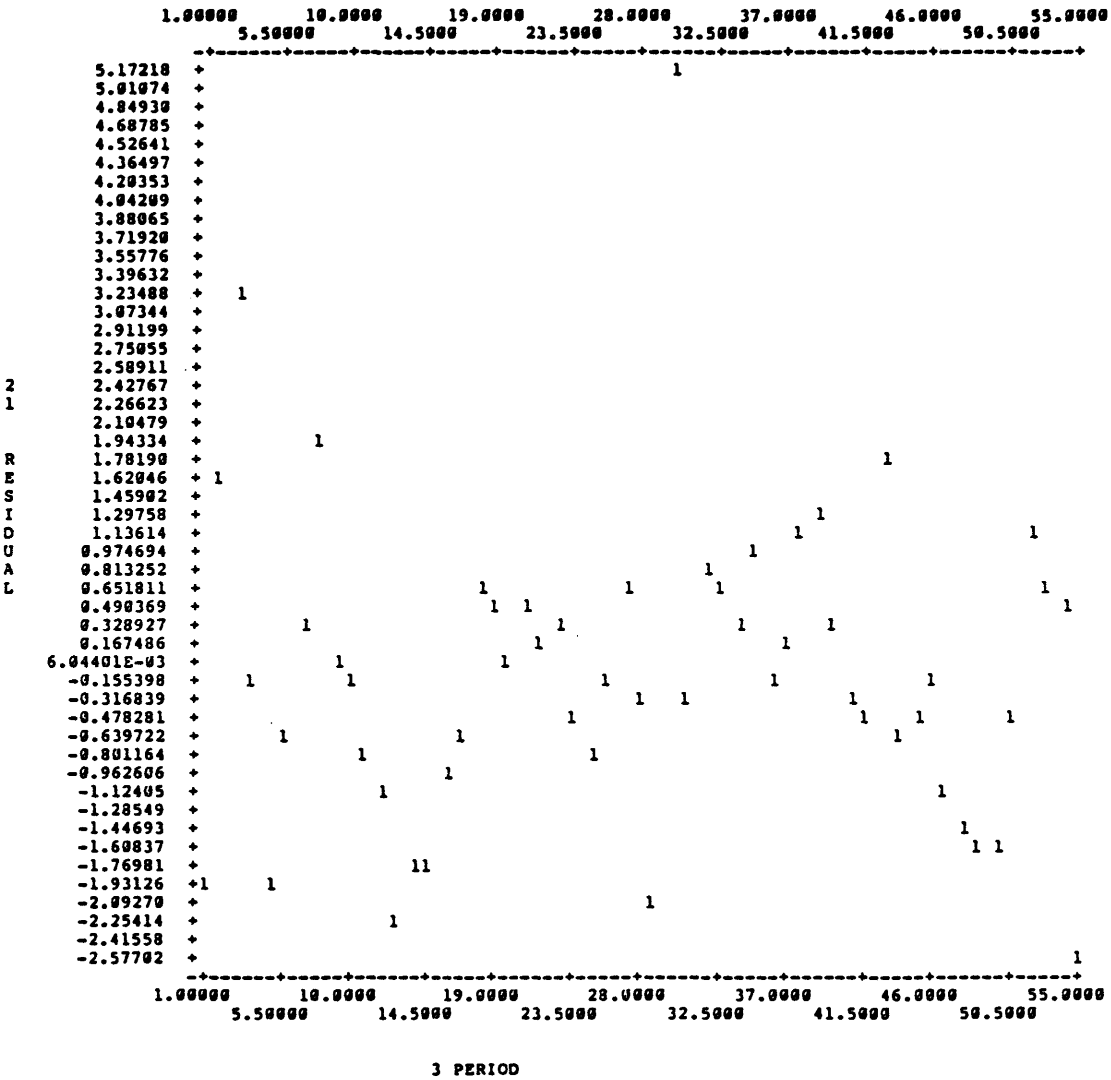
SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN OF SQUARES	F TEST
REGRESSION	2	8920.12	4460.06	2339.59
RESIDUALS	52	99.1299	1.90634	
TOTAL	54	9019.25		

VARIABLE	REGRESSION COEFFICIENT	STANDARDIZED COEFFICIENT	CORRELATION WITH DEPENDENT
5 FIRST	0.939825	1.00698	0.994467
19 CPI	8.346E-03	1.427E-02	-0.868392

DURBIN-WATSON = 7.291E-02

REGRESSION #3

COMMAND: PLOT



PLOT OF RESIDUALS
REGRESSION #3