PUTTING ON THE CRUSH ...

MARKET STRUCTURE, INFORMATION AND THE SOYBEAN COMPLEX

by

Dominic Rechner

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Name: Dominic Rechner

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Examining Committee:

Chairman: S. Easton

Michael Bowe
Assistant Professor
Senior Supervisor

Geoffrey Poitras
Assistant Professor

George Blazenko
Assistant Professor

Lindsay Meredith
Associate Professor
Business Administration
External Examiner

Date Approved: Nov 30/89

Title of Thesis/Project/Extended Essay

"Putting on the Crush" ... Market Structure, Information and the Soybean Complex.

~~Author:~~ ________________

(signature)

Dominic Rechner

(name)

6 December 1989

(date)

ABSTRACT

This study explores efficiency in a speculative competitive market. From a discussion of the theoretical aspects of the efficient market hypothesis and the structure of futures markets, "disequilibrium" pricing is rationalized on the basis of market imperfections in the informational aspect of markets. Spread strategies are used to test for dependency and weak form efficiency on the Chicago Board of Trade. They are applied to daily futures prices for the commodities of the soybean complex. The results are free of sampling bias and reasonable trading costs are considered. The empirical results show strong evidence of pricing inefficiency in the crushing margin of soybean processors.

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DEDICATION

To Donna and my parents

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I INTRODUCTION

Basically there are two interrelated aspects of a market: transactions and information. The efficiency of a market simply refers to the efficiency with which a market performs its related functions of facilitating transactions and improving information on the terms thereof. The informational role of prices refers to the quality of information revealed through the pricing mechanism and thus relates to the efficiency with which an asset is priced. (Burns, 1983)

Fama (1970, 1976) summarizes an efficient market as one in which prices always "fully reflect" available information. Although this definition stops short of defining the idea of what is meant by prices "fully reflecting" available information, Jensen (1978) clarifies this point in that "a market is efficient with respect to information set θ_t if it is impossible to make economic profits by trading on the basis of information set θ_t." (P. 96) The economic profits represent risk-adjusted returns, net of all costs.

There are various forms of the efficient market hypothesis which can be tested. The forms are distinguished by the class of information employed in empirical evaluations. The most commonly tested has been the "weak form" where efficiency implies that there are no economic profits offered by trading on the basis of the past history of prices. Rejection of the weak form of the Efficient Market Hypothesis requires the establishment of dependencies in the price history which can be profitably exploited. However, as Burns (1983) points out, efficiency is a variable to be explained (as a characteristic of the equilibrium or structure of the market), not an (implicit/explicit) exogenous parameter. This means that one cannot study the efficiency of a market in the framework of a specific industry structure where the development of many aspects of market efficiency are assumed away. This implies that any theoretical proposals must be based on an adequate organization of the market whose properties it is seeking to explain. It is only then that empirical studies may yield both meaningful conclusions and implications for policy purposes.

Danthine (1977) and Lucas (1978) note that the many tests reported in the literature are simultaneous tests of market efficiency, perfect competition, risk neutrality, constant returns to scale and the impossibility of corner optima.

The present study presents theoretical and empirical insights to the market organization of futures markets and develops an alternative to the two mainstream views of perfectly competitive markets and competitive markets with costly information.

The Efficient Market Hypothesis is introduced in Section II, followed by a critique of past weak form tests of speculative competitive markets in Section III. The structure of the markets is discussed in Section IV where it is proposed that these markets, due to search costs and the absence of enforceable property rights with respect to informational technologies, are inherently diffuse information markets.

Section V reviews recent models incorporating diffuse information and proposes that, due to the absence of enforceable property rights with respect to informational technologies, speculative capital markets will be characterized by disequilibrium pricing.

The performance of opening-gap based spread strategies in the Chicago Board of Trade soybean complex are tested in Section VI. It is found that significant profit potential exists and the hypotheses of a random walk and a weak form of the Efficient Market Hypothesis are rejected. The implications are discussed in Section VII.

II EFFICIENT MARKETS

The ability of a futures market to process information has traditionally been explored from the perspective of two hypotheses: the Random Walk Hypothesis and Jensen's (1978) Efficient Market Hypothesis. In its simple form, the Random Walk Hypothesis (RWH) states that there is no useful information in past prices which would be helpful for forecasting future prices. Jensen (1978) eases the conditions for efficiency as defined by the RWH so that efficiency corresponds to the absence of exploitable opportunities. Jensen makes the point that forecasts of a futures' price tomorrow can never be significantly more accurate than the random walk forecast which is today's price. He allows for adjustment costs in that prices may not fully and immediately adjust when new information becomes available. However, costs will exceed potential profits of trading based on forecasted futures' prices.

Stephen Taylor (1985) explains this notion by making the point that the EMH, referring to the weak form, can be true even when the RWH is false, in that trading costs prevent exploitation. "Efficiency ensures that a trader paying commissions should consider the present price to be the only relevant information in a price series' history." (P. 714) Thus, market efficiency, in the presence of transaction costs, will not imply Martingale pricing.

LeRoy (1982) raises similar points in his discussion of what it means for markets to both "fully reflect" available information and be "efficient". He explains that there is no intrinsic relation between any definition of efficiency and Martingale pricing. The connection between the two can only exist under restricted conditions and without these, there will be some predictability to prices. However, the predictability of the prices of financial instruments will be confined to the interest rate and risk premium components of the rate of return. This decomposition, since these two factors are merely two elements of the opportunity cost of trading, is consistent with Jensen's (1978) EMH.

The weak form of the EMH states that basically there is no useful, exploitable information in the past price history of a market at any given time. This means that there is no exploitable serial dependence in prices. Therefore, since the profitability of a mechanical (reactive) rule relies on serial dependence, evidence of systematic economic profits from trading a "system" constitutes evidence of serial dependence. As such, the net profitability of a trading rule constitutes evidence of a market inefficiency. (Smidt, 1965.)

III WEAK FORM TESTS

There have been many studies published in the literature which attempt to test the weak form of the EMH. (Houthakker, 1961; Stevenson and Bear, 1970; Leuthold, 1972; Rausser and Carter, 1983; Helms et al, 1984; and Bird, 1985.) While most of these studies have been based on Alexander's Filter, it is argued here that none of the results imply anything about the efficiency of the market. The only conclusions that can be drawn from these studies pertain to the usefulness of the technical indicators employed in trading the particular financial instruments on which they were tested. The basic problem with past attempts to test the weak form of the EMH has been a methodological one.

It was noted above that a profitable trading system is evidence of serial dependence. However, an unprofitable trading system is not evidence of the absence of serial dependence. Thus, it is inappropriate to make broad generalizations or suggestions from such a narrow approach. One cannot reject the hypothesis that there is (neglected) important information in past prices without first establishing that the information used is in fact relevant.

In order to be able to draw any evidence pertaining to the EMH from a weak form test, one would first need to consider the establishment of the suitability of the technical indicator used for the markets which are to be tested. A brief glance of the literature which encompasses technical trading systems and methods would reveal at least fifty accepted indicators. (Kaufman, 1987; Schwager, 1984.) If one were to include parameter variations and indicator combinations, the number of potential methods increases dramatically. If one were to further introduce money management rules such as stop strategies and entry and exit rules, one quickly recognizes the complexity of this field. Bearing this in mind, past studies, for reasons outlined above, do not present any significant evidence pertaining to the weak form of the hypothesis and yield very limited insight to the stochastic processes of the price series tested.

The limited usefulness of the published weak form tests is recognized in Martin *et al.* (1988) who note that the tests are not exhaustive and do not preclude the existence of more sophisticated viable strategies. In spite of this, they state that: "The fact that no such evidence has been published is consistent with the hypothesis that none exists or that such a scheme, if known, is being used by an ever wealthier trader who is concealing his or her secret." (P. 269) In this statement, they, as Fama (1976) and Sharp (1978), make the error of treating the two ideas under one Efficient Market hypothesis. However, the hypothesis that no trading mechanism exists which yields statistically significant abnormal returns and the hypothesis which allows for the possibility of *concealed* profitable trading systems are two distinctly different hypotheses since they are derived from two separate market models each having different underlying structures and properties.

To show this distinction, one should recall that it is the assumption of a competitive organization of the markets for information which *denies* the existence of concealed trading rules. This assumption is also the foundation of the EMH.

If a trading rule is being used by an ever-wealthier trader who is concealing his secret, then the implication is that there is a monopolistic aspect to the market for information. Furthermore, as the information is the foundation of pricing, this would in turn mean that, a past history of prices is, in fact, quite useful for forecasting future prices and that the data series is not (for practical purposes) merely a bank of noise.

IV MARKET EQUILIBRIUM

Equilibrium in any market is derived from the collective interaction of market participants. A futures price reflects the opinions of producers, consumers and speculators about the price of a financial instrument based on a commodity for future delivery. Efficiency theorists are concerned whether, at any given time, there is an efficient equilibium. They claim that, at any given time, a futures market is either at or sufficiently close to an efficient equilibrium to prevent profitable exploitation of the difference.

Jensen (1978) explains that "the EMH is in essence an extension of the zero profit condition from the certainty world of price theory to the dynamic behavior of prices in speculative markets under conditions of uncertainty." (P. 96.)

In a competitive goods market, the existence of excess profits acts as an incentive to change the market structure, either firms enter or exit. In a state of general equilibrium every firm is maximizing profits subject to given constraints even though the maximum happens to be zero economic profits. Thus, to make greater profits, at least one given constraint must change. With respect to a new technology, given no artificial constraints, the existence of excess profits acts as an incentive for others to imitate the new technology until any excess profits disappear. This is the essence of the market structure assumed in the derivation of the Efficient Markets Hypothesis.

There is, however, a basic difference between financial and goods markets - namely, the ability to imitate. In a goods market, one can purchase the innovative good, inspect it and reproduce it. If costs or regulatory constraints prohibit replication of the technology, then we say the firm holds monopoly power and can earn economic rents. With respect to financial markets, the asset is an instrument with certain attributes such as risk and return. If we assume that returns are intemporally stochastic, one can produce financial instruments through purchase and sale to yield some expected return based on one's objectives. In this way, financial instruments are in a sense "experience goods"; the goods of the classical goods market are "search goods" where the critical attributes are discernable from the direct examination of the good.

Therefore, in a futures market we are looking at the market for a commodity-based instrument (which is a promise of making/taking delivery) where an individual's transactions involve the opening and closing of positions and the second party to a transaction can be either producing an instrument or realizing a return - closing out an open position. With regard to common stocks, the market is for a corporation-based instrument; however the size of the market, through settlement practices, is limited to twice the capitalization of the corporation in any one particular equity issue. Furthermore, common equity, in contrast to a futures contract, may be considered to be a perpetual instrument whereas contracts of a particular delivery month are cleared (all open positions are closed and settled) in the delivery month. Additionally, through daily resettlement practices, under arbitrage free pricing, all open positions may be considered to be settled daily.

The technology of this market is the technology applied to the information set - the past history of prices. However, there is a basic difference between this market and the abstract of a competitive goods market as envisioned by many theorists. Unlike a goods market, in financial markets, the specification of a technology, due to the absence of enforceable property rights, cannot readily be known and thus imitated. (Here, the technology refers to either technical indicators or forecasting models.) Furthermore, even if a technology were being imitated, due to the anonymity of the market in transactions, the imitator has no idea that he is imitating the specific technology of another market participant.

Liquidity and anonymity are two characteristics which lie at the heart of futures markets and are the foundation of Telser's (1981) liquidity theory of the existence of futures markets. According to Telser, the futures market is a market organization designed to facilitate trade among strangers. In this way, anonymity, through the reduction of transaction costs, acts to promote liquidity. Telser states that,

> "it is the demand for a fungible financial instrument traded in a liquid market that is necessary for the creation of an organized futures market." (P. 8)

However, the importance of anonymity to the existence and liquidity of futures markets is much deeper than this statement implies. Without anonymous trading, one would expect fewer participants - not due to increased transaction costs (although this may also be a factor) - but from the fact that anonymity is a substitute for the enforceable property rights of technological specifications as discussed above. Anonymous trading permits the concealment of technologies. On the other hand, if well-defined property rights were available, the markets would need to be non-anonymous in transactions in order for those property rights to be enforceable. **Anonymity is sufficient to prevent both the mimicking of trades and deducing technological specifications from another's trading data.**

Kyle (1984) uses liquidity and anonymity to explain squeezes as futures market phenomena. While liquidity facilitates the execution of large orders, "anonymity tends to dramatically change the nature of the market because knowledge of who is trading what is in many cases a valuable commodity itself." (P. 143) In the context of market manipulations, knowing the actions of a manipulator would result in the adjustment of prices to levels where the expected profit of the price setting behavior would be extracted.

In Kyle's framework, the manipulator trades in such a way that his motives may be concealed through anonymous trading. In this way, anonymity allows for non-competitive price setting by the manipulator. **However, in the spirit of the present study, anonymity allows traders to act on private information which is the product of an informational technology as described above. Furthermore, anonymity helps ensure that the technological specifications also remain private information.** It should be emphasized, at this point, that the market imperfection portrayed gives speculative markets a monopolistic aspect to the market for information, not the markets for the actual instruments or commodities. Throughout the above discussion it was implicitly assumed that the markets are competitive in transactions. For discussions of monopoly in the transactions market see Eastbrook (1986), Newberry (1984) and Kyle (1984).

Therefore, the market is characterized by search costs with respect to technologies which are exacerbated by the absence of enforceable property rights with respect to technology. Thus, the information set of the market and of individual market participants will differ in that the latter will be a subset of the former. This contrasts the traditional view that the two coincide since the information set was assumed to include all technologies. The absence of property rights with respect to technology implies a completely different market structure and the only way that Jensen's (1978) EMH can be derived is by assuming either non-anonymity (a personalized market) or by assuming that all feasible technology is known - thus making it infeasible at the margin.

In aggregate, prices will reflect all employed technologies. However, there is no *a priori* reason to assume that this exhausts the set of all possible technologies. Even if a competitive speculative market made optimal use of available information including technology, no upper bound to the information set would be implied.

Therefore, competitive speculative markets, due to the absence of enforceable property rights with respect to technology are inherently markets with diffuse information. **Different forecasting abilities will be reflected in different technology sets and thus constitute the source of diffuse information.**

V MODELS INCORPORATING DIFFUSE INFORMATION

Grossman and Stiglitz (1976) and Grossman (1976) present a model of a market where information is costly. In the price system which they develop, information is conveyed from the informed individuals to the uninformed. While prices never fully adjust to reflect all information, the difference is just enough to provide a normal return to the informed participants for purchasing the information. Thus, the only equilibrium is an informational equilibrium. The market price must reveal just enough of the costly information so that participants have no incentive to acquire such information. This structure unilaterally suggests that participants know the aspects of the information and that, if motivated to purchase the information, the individual can readily obtain the specifications. This competitive nature of the informational aspect of the market yields similar implications to those of Jensen (1978).

However, without access to technology-related information, there is an imperfection in the market for information and informational equilibrium, in the sense that the returns to acquiring information are just normal risk-adjusted returns, can never be achieved. We therefore require a model of speculative capital markets with stronger informational constraints to properly characterize the informational aspect of the market.

Stephen Figlewski (1978) develops a model where the assymetry is not in "information" but in forecasting ability. He takes this position on the basis of the idea that "it is not possible to separate the impact of elementary information such as news releases etc. from the subjective evaluation of this information by participants in the market." (P. 585) While this notion may seem non-scientific, in the spirit of the present study, we may consider the "elementary" information to include the price history and imagine that the technology set, (as developed in Section IV) constitutes the basis of the set of "subjective evaluations". The model has an added dimension in that the market weighs trader information by "dollar votes" rather than quality. However, this is not a necessary condition for disequilibrium pricing in the absence of enforceable property rights with respect to technologies.

The operational definition of an efficient market is now "one in which the market price at any time (plus normal profits) is the best, that is minimum variance estimate of the futures price given the individual forecasts of all the market participants." (Figlewski, 1978; P. 585) With the absence of enforceable property rights, disequilibrium, in the sense that the market price is not the minimum variance estimate of the future price, only requires heterogeneous expectations.

Grossman (1976) shows that without wealth effects on demand, even when traders have different information, in the long run, the market price will discount all of the information. While this view is drawn from the competitive organization of the market for information as discussed above, **the absence of enforceable property rights, assuming a decentralized market, creates an imperfection in the market for information.** Therefore, given that the information market is primary to transactions, the market failure in the market for information results in "...a wide range of forecasting ability or a diversity of expectations among the participants (and) the market may deviate relatively far from efficiency." (Figlewski, 1978, P.597)

Thus, the market price of an instrument will not be the minimum variance estimate of the future price unless all relevant technologies are employed and exploited to the margin. Furthermore, as there is no *a priori* reason to assume this to be the case, as different private technology sets will result in heterogenous expectations and in the light of the market structure developed above, the returns to the technologies may be abnormal, in the sense that they may be greater than the risk-adjusted normal economic returns predicted by the competitive structure assumed in the derivation of the EMH.

Therefore, traditional tests of weak form efficiency are more correctly viewed as empirical tests of the significance of the technology used. If the technology is useful, in that it yields economic profits through capitalizing on dependencies, then the magnitude of the profits generated provides a relative measure of the extent to which the market is inefficient with respect to this information or technology.

VI EMPIRICAL EVIDENCE

The Soybean Complex

Today, the soybean is the primary oilseed produced, accounting for half of the world's production of oilseeds. The great variety of end uses for the oil and meal derived from soybeans has fueled the growth of this crop since commercial development began in the 18th century.

The United States is by far the largest soybean-producing nation, claiming more than 50 percent of global output and is the leading processor of soybeans. The demand for U.S. soybeans (or disappearance) is divided into three categories: crushing, exports and a residual of stocks and small amounts used directly for feed and seed. These uses are listed in Table 1.

TABLE 1

U.S. Soybeans - production, supply and disappearance 1983-1987 **a**

Crop year	Production (Mil. bu.)	Farm Price ($/bu.)	Total Supply (Mil.bu)	Exports (Mil.bu.)	Total Domestic (Mil.bu.)	Stocks (Mil. bu.)
1983	1,636	7.81	1,981	743	1,805	176
1984	1,861	5.78	2,037	598	1,721	316
1985	2,099	5.05	2,415	740	1,879	536
1986	1,940	4.78	2,476	757	2,040	436
1987	1,905	5.43	2,341	800	2,066	275

Price support operations 1983-1987 ***b***

Crop Year	Nat'l Av. Loan Rate ($/bu.)	Quantity Under Support (Mil. bu.)	Percentage of Prod'n
1983	5.02	101	6
1984	5.02	278	15
1985	5.02	518	25
1986	4.77	327	17
1987	4.77	276	14

a. *Total supply includes production and beginning stocks. Total domestic disappearance includes feed, residual, and other domestic uses not shown separately.*
Source: Production: U.S. Department of Agriculture (U.S.D.A.) National Agricultural Statistics Service.
Supply and disappearance: U.S.D.A. Economic Research Service, Feed Situation.

b. *Source: U.S.D.A. Agricultural Stabilization and Conservation Service.*

As the crushing demand is the largest component of the demand for soybeans, the profitability of soybean processing is an important factor in the supply and demand situation in the soybean complex. Therefore, soybean processing is the focal point of the marketing chain of soybeans and the two products: soybean meal and soybean oil.

In the U.S. market, the government plays a role in the domestic market through price support loan operations. However, as the proportions of production under support have been low in recent years, the government's role has not been a dominant force in the soybean market. Price support operations are listed in Table 1.

Soybeans usually contain about 18 percent crude oil and 80 percent high protein meal. Therefore the value of soybeans is directly determined by the values of the meal and oil.

Soybean meal is the dominant high protein meal produced, (substitutes include cottonseed, rapeseed, sunflower seed and corn meal) accounting for roughly two thirds of total meal production. The versatile meal has many uses in foods as well as feed and industrial uses.

TABLE 2

U.S. Soybean meal and soybean oil - supply and distribution 1983 - 1987. ***a***

Soybean Meal
Quantities are in thousands of short tons

Year	Production	Domestic Feed	Exports	Total	Average Price ($/Ton)
1983	26,714	19,306	7,109	26,415	187.19
1984	22,756	17,615	5,360	22,975	188.20
1985	24,529	19,480	4,917	24,397	125.40
1986	24,951	19,090	6,036	25,126	154.90
1987	27,738	20,350	7,300	27,650	162.50

Soybean oil
Quantities are in millions of lbs.

Year	U.S. Production Crude oil	Domestic Consumption in end Products	Exports	Average Price ($/100lb.)
1983	12,040	9,418	1,732	20.6
1984	10,872	9,919	2,068	30.6
1985	11,470	10,481	923	29.5
1986	11,618	10,307	1,188	18.0
1987	12,785	10,564	962	15.4

a. Source: U.S. Department of Agriculture Economic Research Service

Soybean oil is the chief edible oil produced and has additional uses in the production of adhesives and plastics.

The crushing margin or gross processing margin (GPM) is a measure of the profitability of primary processing which involves separating the crude oil and meal from the soybeans. While there are different possible processing methods, most processing in the U.S. is by solvent extraction. The beans are put into a solvent which dissolves the oil component, enabling the separation of the beans into crude soybean oil and soybean cake. The cake is then cooked and ground into soybean meal. The entire process is very efficient as standard yields from a 60 lb. bushel of soybeans average some 11 pounds of oil and 48 pounds of meal. The GPM measures the extent to which the proceeds from the sale of the two products covers the cost of the beans.

The standard yields of production, together with the existence of large and liquid cash and futures markets for all three commodities make soybean processing a unique industry. The futures markets allow processors to hedge against unfavourable GPMs and provide speculators with unique spreading opportunities. (Rose and Sheldon, 1984)

Henry Arthur (1971) looks at the use of futures in the soybean complex as a business management tool. He writes,

> "Naturally, the most frequent use of these three futures contracts as a management tool has been made by handlers and crushers of soybeans since these are the primary coordinators of the through-put and inventories of the industry. Moreover, the crusher is in a position where he can choose between many alternative hedging methods and can thereby make additional uses of the futures market as an adjunct to commitments in the cash market for his sales of meal and oil as well as for protection of procurement or inventory exposure in the form of beans." (P.181)

In surveying various soybean crushers, with particular attention to their use of futures markets, Arthur finds that,

> "The common characteristics of the various firms in the soybean crushing industry, so far as hedging is concerned, are far more significant than their differences. Relying in part upon indirect information, it appears that all crushers of soybeans do use the futures market as an integral part of their commercial operations." (P. 196)

A crush spread is a three-way intercommodity spread entailing a long position in soybeans and short positions in the other two products: oil and meal. If this spread is balanced so as to conform to the standard yields, the crush spread is a duplication of a processor's transactions. In this way, an opening crush spread order is identical to a short position in the GPM. Similarily, a reverse crush is basically a long position in the GPM. Given the standard contract sizes for Chicago Board of Trade (CBOT) soybeans, meal and oil (see Table 3) the yield standards of 11 lbs. of oil and 48 lbs. of meal from a bushel of soybeans can be achieved if, for every 10 soybean futures contracts bought/sold, 12 meal and 9 oil contracts were to be sold/bought for a balanced crush/reverse crush.

Table 3

CBOT contract details - soybeans, meal and oil and GPM calculation

Commodity

Soybeans

Trading unit	5000 bu.
Price quote	cents and quarter-cents per bu.
Minimum change	0.25 cents = $12.50 per contract.
Delivery months	01, 03, 05, 07, 08, 09, 11.
Daily limits	30 cents per bu.
CFTC Speculative Limits	3,000,000 bu. in any one future or in all futures combined.

Soybean Meal

Trading unit	100 short tons of 2000 lb. each.
Price quote	dollars and cents per short ton.
Minimum change	10 cents per short ton = $10 per cc.
Delivery months	01, 03, 05, 07, 08, 09, 10, 12.
Daily limits	$10 per short ton.
CFTC Speculative Limits	none

Soybean Oil

Trading unit	60,000 lb. (one standard tank car).
Price quote	dollars and cents per 100 lb.
Minimum change	1 cent per 100 lb. = $6 per contract.
Delivery months	01, 03, 05, 07, 08, 09, 10, 12.
Daily limits	$1 per 100lb. above or below the previous day's settlement price.
CFTC Speculative Limits	none

The GPM, based on average yields, is calculated as:

(soybean meal quote/2000)48 = $/bushel:value of meal
plus
(soybean oil quote/100)11 = $/bushel:value of oil
less
(soybean quote/100) = $/bushel:cost of beans

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crush margin/
gross processing margin = $/bushel

Therefore, in taking a linear combination of the three futures contracts, one may construct what would be the equivalent of a GPM futures contract which may be used by processors to hedge their operations. This collapsed series, then, provides a single series with which the soybean complex futures and/or cash markets can be tested against efficiency criteria.

Previous Studies Relevant to the Soybean Complex

In contrast to the present approach, past studies exploring the question of efficiency in the soybean complex proceed by examining the individual markets of soybeans, soybean oil and soybean meal.

Helms, Kaem and Rosenman (1984) used the commodities of the soybean complex to test the speculative efficiency hypothesis - that consecutive price changes, adjusted for trend, are independent of one another - by means of rescaled range analysis, a method of non-periodic dependence identification. Employing the proportionate daily change in prices for six contracts (January, 1977 and March, 1976 Chicago Board of Trade (CBOT) soybean, soybean oil and soybean meal futures) and proportionate intra-day (minute by minute) price changes for two separate days in each of the March and May, 1977 and January, 1978 CBOT soybeans, they "find that there are non-periodic cycles (persistent dependence) in both daily and intraday commodity futures prices." (P. 560.) On the basis of these results, they reject the speculative efficiency hypothesis.

Rausser and Carter (1983) employed data on monthly average soybean, soybean oil and soybean meal cash prices over the period 1966 to 1980 to test the relative forecast accuracy of multivariate and univariate ARIMA models to the futures markets and random walk forecasts of the individual commodities. Based on mean squared errors and inequality coefficients, their results "support the necessary relative accuracy condition for futures market inefficiency." (P. 477.) While Rausser and Carter were intending to extend the study to estimate the potential speculative profits from using the ARIMA models to trade the commodity futures and spot markets, these results have not been published to date.

Stevenson and Bear (1970) draw together several tests of the nature of July soybean and July corn futures over the years 1957 to 1968. On the basis of serial correlations, analysis of runs and various filter rule tests, their results indicate a tendency for negative dependence over short intervals and positive dependence over longer periods.

While these studies of efficiency in the soybean complex concentrated on the individual commodities, the present study is concerned only with the GPM. Furthermore, the current investigation deals solely with the profitability of the trading rules developed in this study. In simultaneously testing the efficiency of the three futures markets, this is the first genuine test of the efficiency of the "soybean complex" and it is believed that the study goes beyond the scope of Rausser and Carter, Stevenson and Bear and Helms et al.

Data

A daily GPM was calculated using open and close quotations for Chicago Board of Trade soybean, soybean meal and soybean oil futures. A continuous series was constructed using four month trading periods for each of March, August and December contracts over the period February 1, 1978 to May 31,

1987. Due to different trading cycles and available data, the March GPM was calculated using March contracts for each of the three commodities, the August GPM was calculated using July soybeans and August meal and oil and the December series calculated using November beans and December meal and oil. For the March GPM, the trading period runs from October 1 to January 31, February 1 to May 31 for the August series and June 1 to September 30 for the December contracts. In this way, about 85 observations from a given delivery month are used in constructing the annual and continuous series.

As the only previous information required to trade the system which is developed in the next section is the previous day's closing quotation, no adjustments were made to the data. Rollovers, which are days on which one ceases to trade the nearest delivery month and begins to trade the subsequent contract used, were ignored as it was felt that their influence on the results would be insignificant - of the 2351 trading days in the sample, only 27 are rollovers (changes to the next delivery month used) since only 28 "GPM contracts" are used.

The data was obtained from Commodity Systems Inc. Boca Raton, Florida.

The GPM, together with the soybean, soybean meal and soybean oil prices are plotted in figures 1 through 4.

FIGURE 1

GPM - CLOSE FEBRUARY 1, 1978 TO MAY 31,1987

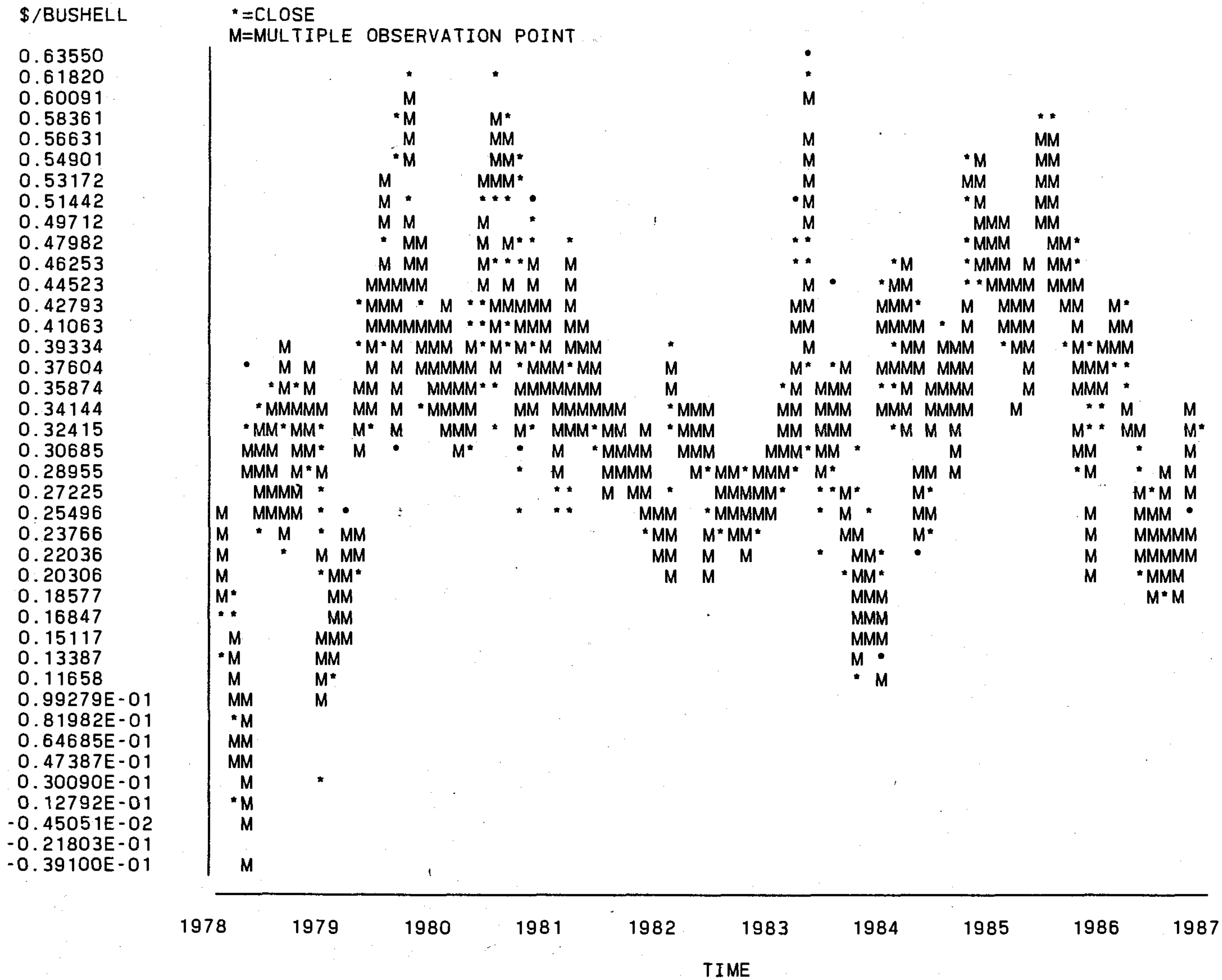


FIGURE 2

SOYBEANS - CLOSING PRICES FEBRUARY 1, 1978 TO MAY 31, 1987

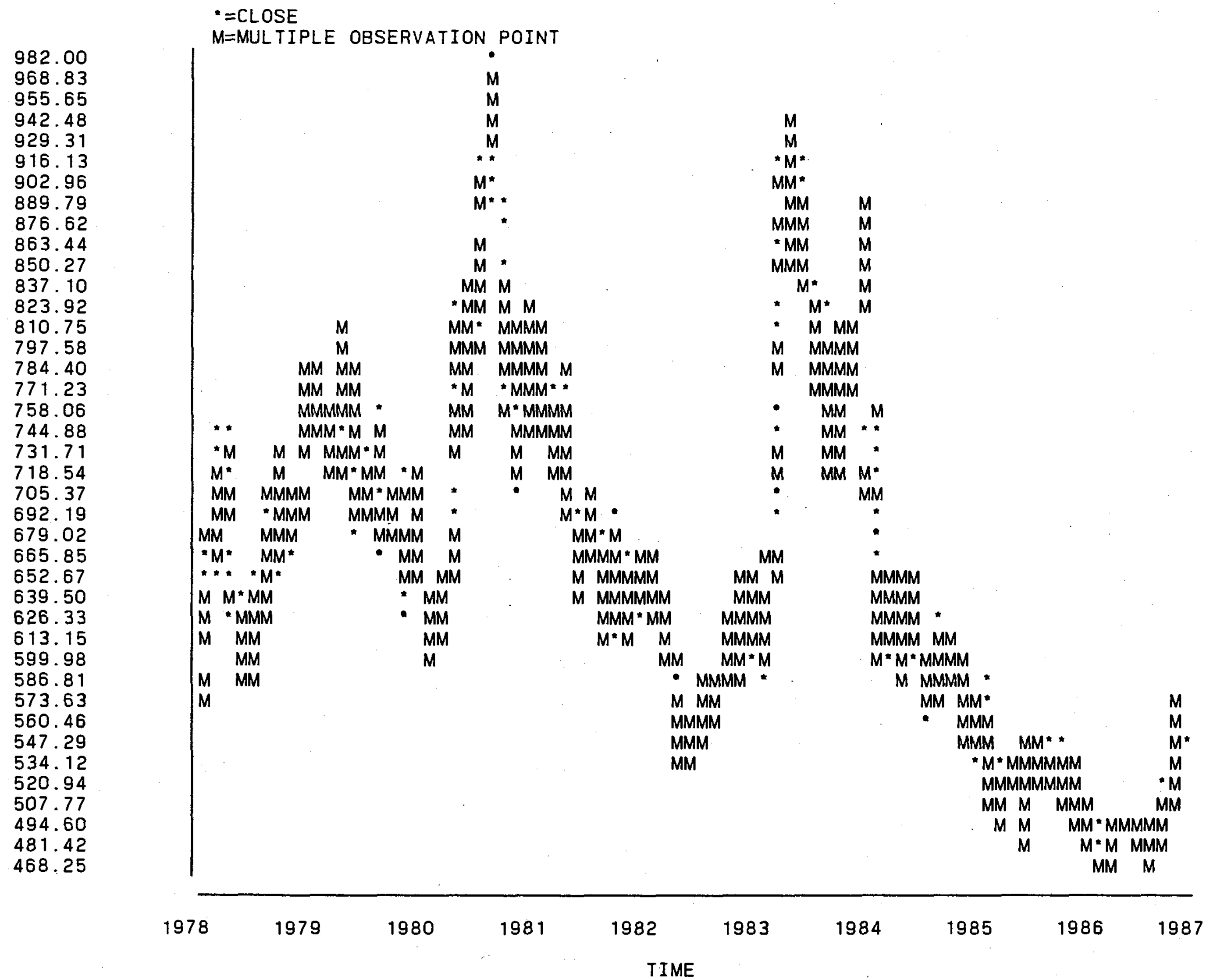


FIGURE 3

SOYBEAN MEAL - CLOSING PRICES FEBRUARY 1, 1978 TO MAY 31, 1987

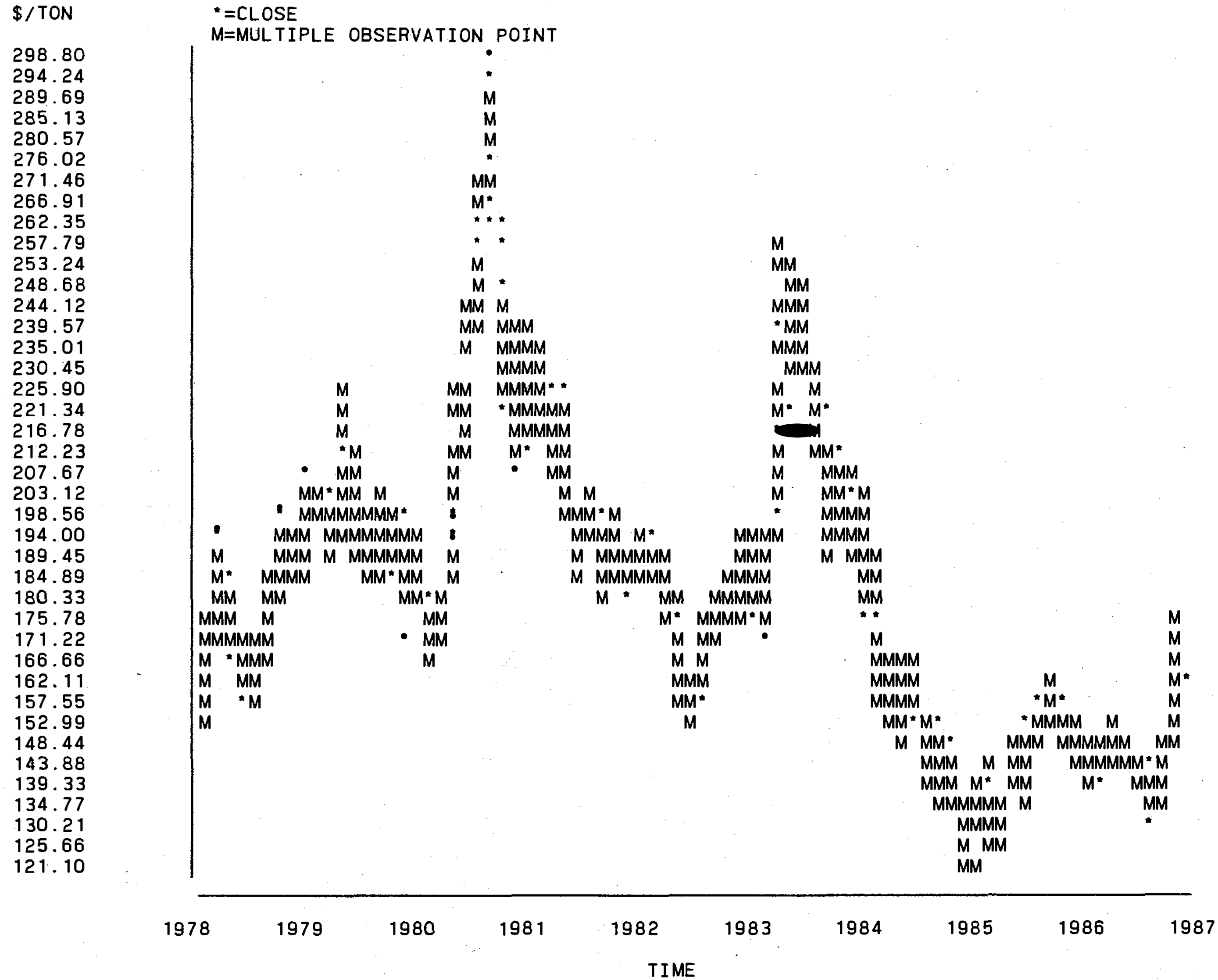
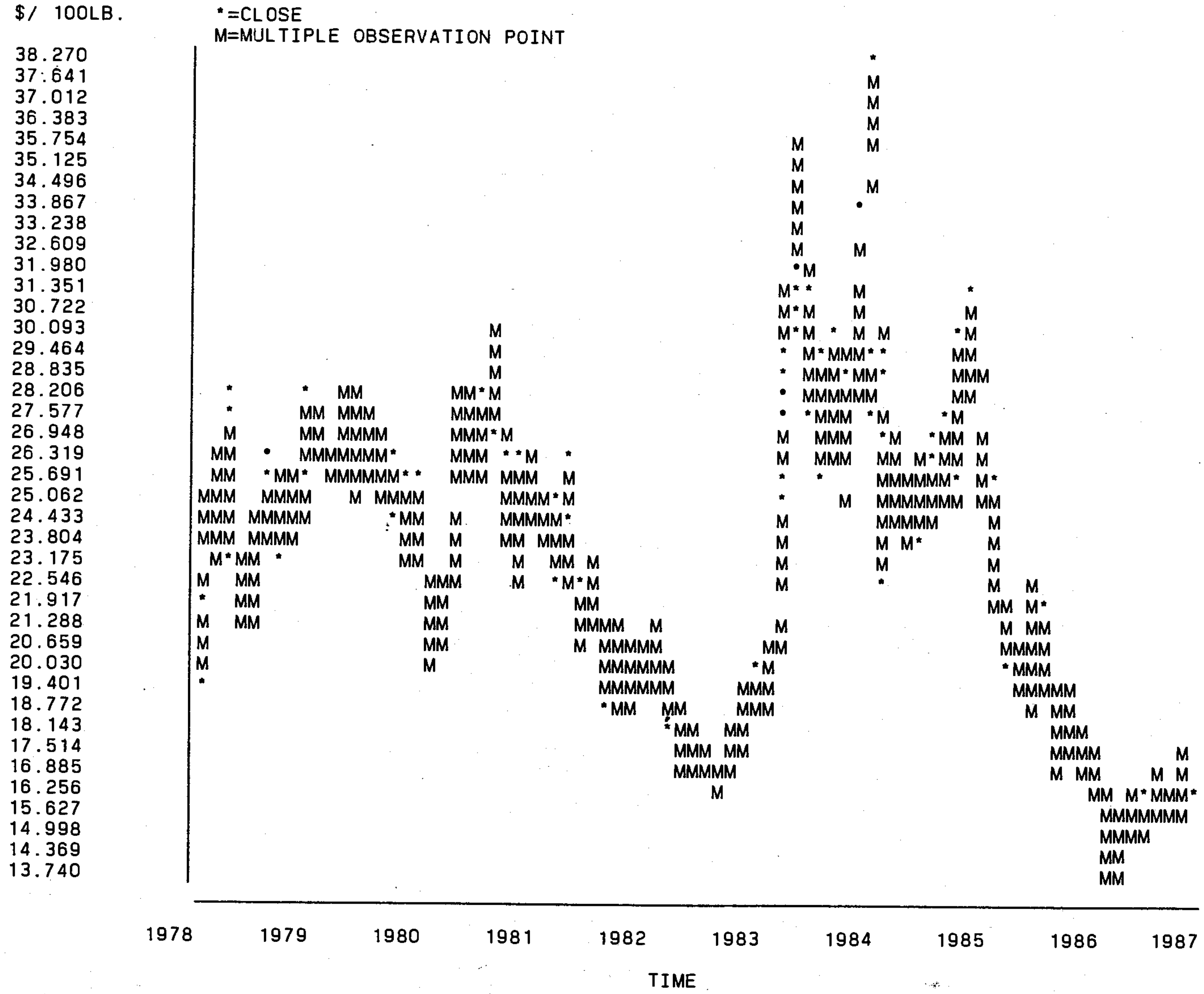


FIGURE 4

CRUDE SOYBEAN OIL - CLOSING PRICES FEBRUARY 1, 1978 TO MAY 31, 1987



The fundamental difference between the GPM and the component series is that the GPM is characterized by more frequent and larger oscillations than the individual markets. While this characteristic makes medium to long term speculation quite difficult, (as this would cause large swings in open equity) the present scope is much finer, as the rule developed below attempts to capitalize on price changes between the open and close of a given day.

Rule and Results

While the motivation for the present test came from a visual examination of the data, the descriptive statistics presented in Table 4 provide enough insight into the short term price changes which the strategy developed below attempts to exploit.

Tables 4, a to d reveal some very interesting statistics. First, while none of the return correlation coefficients are statistically significant for the individual commodities, very significant negative correlations are found for all selected returns for the GPM. The largest in absolute magnitude is the correlation between close to open and open to close returns, which is an indication of opening reversals (the tendency of prices to change direction on the open).

Table 4

Daily return specifications, GPM, soybeans, and soybean meal and oil. February 1, 1978 to May 29,1987. Selected contracts.

a. GPM

Return	Mean Daily Return	Stnd. Dev.	t-value	Coeff. of Variation
	(¢/bu.)		*Ho: mean=0*	
open to open	0.0021	3.655	0.028	1,778.10
close to close	0.0042	2.789	0.073	674.35
close to open	-0.081	2.727	-1.44	-33.63
open to close	0.085	2.837	1.45	33.30

Correlation Coefficients		t-value
open to open vs. lag(open to open)	-0.39	-20.63
close to close vs. lag(close to close)	-0.26	-12.89
close to open vs. open to close:	-0.49	-12.89

b. Soybeans

Return	Mean Daily Return	Stnd. Dev.	t-value	Coeff. of Variation
	(¢/bu.)		*Ho: mean=0*	
open to open	-0.00011	1.097	-0.005	-1,020.80
close to close	-0.00013	1.046	-0.006	-826.41
close to open	0.081	0.659	0.085	56.87
open to close	-0.00129	0.803	0.078	-62.54

Correlation Coefficients		t-value
open to open vs. lag(open to open)	-0.027	-1.31
close to close vs. lag(close to close)	0.009	0.43
close to open vs. open to close	0.015	0.70

table 4 cont'd.

c. Soybean Meal

Return	Mean Daily Return	Stnd. Dev.	t-value	Coeff. of Variation
	($/Ton)		*Ho: mean=0*	
open to open	0.0038	3.04	0.061	794.74
close to close	0.0040	2.86	0.067	723.24
close to open	0.025	1.837	0.662	73.83
open to close	-0.021	2.24	0.454	-107.18

Correlation Coefficients		t-value
open to open vs. lag(open to open)	-0.038	-1.84
close to close vs. lag(close to close)	0.017	0.82
close to open vs. open to close:	-0.019	0.92

d. Soybean oil

Return	Mean Daily Return	Stnd. Dev.	t-value	Coeff. of Variation
	($/100lb.)		*Ho: mean=0*	
open to open	-0.00163	0.461	-0.17	-283.31
close to close	-0.00164	0.422	-0.19	-257.45
close to open	-0.00225	0.278	-0.39	-123.10
open to close	0.00062	0.327	0.09	530.46

Correlation Coefficients		t-value
open to open vs. lag(open to open)	-0.041	-1.99
close to close vs. lag(close to close)	0.030	1.45
close to open vs. open to close	-0.035	-1.70

Secondly, with respect to the coefficients of variation, (a measure of volatility in that it is calculated by expressing the standard deviation as a percentage of the mean) the open to open and close to close coefficients are substantially greater than those for the close to open and open to close returns for the GPM, soybeans and meal. For the oil, the coefficient of variation for the open to close returns is substantially greater, in absolute magnitude, than the other returns. However, the coefficient of variation for the open to close returns in the GPM (the only returns which are traded in the present evaluation) is the lowest in absolute magnitude relative to all other returns of all the series. Third, all of the returns for each commodity are not significantly different from zero. This implies that a buy and hold strategy over the present sample (with rollover as built into the data) in any one of the commodities would have earned a return less than the return offered from buying T-Bills.

In order to test the exploitability of the open reversals in the GPM, the following day trading program was developed:

If the GPM on the open is less/greater than the previous day's close, a reverse crush/crush spread is opened. The position is then liquidated on the close of the same day.

Filters increasing by multiples of 1¢ per bushel are then applied. Real time trading results were calculated net of trading costs which are believed to cover both commissions and the difference of expected executions from the open and close quotations used.

In trading the 10 soybean, 12 meal and 9 oil contract spread, a 1¢ per bushel change in the GPM represents $500.00 on the position. However, in the discussion to follow, a spread entailing 20 soybean, 24 meal and 18 oil contracts is assumed. In this way, a 1¢ per bushel change in the GPM represents $1000.00 on the spread.

The trading results are not adjusted by, nor compared to, any "naive strategy" since it is felt that using a standard such as a buy and hold would not be appropriate. This is because the crush margin average rates of return are not significantly different from zero on either an open to open or a close to close basis. Furthermore, the trading costs used, 1.5¢ per bushel per trade, are believed to be significantly greater than the returns offered by such a passive strategy. Using a benchmark, such as a risk-free rate, is deemed to be unnecessary since no interest income is added to cash balances - increases in equity or starting equity - as would be realized in trading such a strategy. Furthermore, a daily rate of interest, even up to annual rates of 50 percent would only amount to a return of 0.06 cents per bushel per day. (Based on capital requirements of 44¢ per bushel - 20.5¢ to cover initial margin and 23.5¢ to cover potential draw downs on equity or strings of losses.)

On the other hand, however, one could use the zero-filter strategy as a base to which filtered results can be compared, but this would adjust the returns upwards in all filtered cases.

In addition to this possible source of criticism, an additional possible source may be due to sampling bias. However, as there is no optimization outside of selecting a filter size, it is believed that any such criticism would be unwarranted.

While the results are catastrophic for a rule without any sort of filter, employing filters of 1, 2 and 3 cents, statistically significant average returns of

0.3, 1.0, and 1.69 cents per bushel ***per trade*** were recorded. This amounts to **average annual profits of 43, 70 and 56 thousand dollars per year for the respective filter sizes.** This would translate to mean returns of 210, 342 and 273 percent per year based on $20,500 margin; or average annual rates of return of 98, 159 and 127 percent for the respective filters if one was to also include a reserve to cover draw downs of $23,500. The margin requirements for the three commodities for outright as well as hedge and spread orders are tabled in Table 5.

Table 5
Margin Requirements
All amounts are in $ per contract ***a***

Commodity (CBOT)	Speculative Outright		Hedge		Spread	
	I	**M**	**I**	**M**	**I**	**M**
Soybeans	1,500	1,250	1,250	1,250	500	500
Soybean Meal	1,000	800	800	800	250	250
Crude Soybean Oil	600	500	500	500	500	500

I: Initial, M: Maintenance
a. *Source: Rosenthal - Collins Group Ltd.*
As of May 24, 1989.

As presented in Table 6, as the filter is increased to 1, 2 and 3 cents, the mean per trade return consistently increases in steps of roughly 0.7 cents ber bushel . The filter increases result in an average increase of $470.00 in average profits while average loss increases by only $100.00. While the trading record also improves as the filter is increased, due to the diminishing number of transactions, the overall effect on annual returns is moderated. In spite of this fact, the mean annual returns are very impressive.

Table 6 *a*

Trading Performance all strategies

Filter	0.00	1.00	2.00	3.00
Mean per trade return	-0.40	0.31	1.00	1.69
Stnd. Dev.	5.97	2.13	1.77	1.52
Sharpe Ratio	-0.15	0.15	0.57	1.11
Profit	2.02	2.31	2.73	3.42
Stnd. Dev.	4.95	1.62	1.51	1.37
Sharpe Ratio	0.93	1.43	1.81	2.50
Loss	1.91	1.75	1.86	2.10
Stnd. Dev	3.46	1.15	0.82	0.63
Sharpe Ratio	1.25	1.52	2.27	3.33
Number of Trades	2328	1286	654	307
Percent Profitable Trades	38.32	50.78	62.23	68.73
Adjusted Sharpe Ratio *b*	-0.42	-0.02	0.27	0.67
Average Annual Return	-101.20	43.0	70.0	56.0
Annualized Sharpe Ratio	-0.88	1.05	2.07	1.92
Largest Draw Down	N/A	23.0	20.0	20.0

a.*All returns standard deviations and draw downs are expressed cents per bu. or $ 000's and all calculations are net of trading costs.*

b. *Weighted average of profit and loss Sharpe ratios - weighted by the respective percentages of winning and losing trades.*

Adjusting the returns for risk, the above-noted improvements are also reflected in the Sharpe Ratios (SR).[1] The SR is a measure of the return per unit of risk where the measure of risk is taken to be the standard deviation of returns. The SR steadily increases with larger filters from -0.15 with no filter to 1.11 with a 3¢ filter. For 1 and 2¢ rules, the SRs are 0.15 and 0.57 respectively.

There are, however, certain weaknesses in using the SR as a return-risk measure, as discussed in Schwager (1984). The first weakness is in the failure of the ratio to distinguish between intermittent and consecutive losses. However, in the context of the present evaluation, we may refer to the largest draw downs on realized equity (or the largest loss) to gauge this aspect. While, with the no filter strategy, the draw down is basically the entire sample period, with a filter of 1¢ the largest draw down amounts to 23¢ per bushel . With the 2 and 3¢ filters, the draw downs diminish to 20¢ per bushel in both cases. Relative to average annual returns, however, these draw downs are 29 and 36 percent of average annual returns for the 2 and 3¢ rules respectively

An additional weakness in using the SR relates to its failure to distinguish between positive and negative fluctuations. In Table 4, an adjusted SR is calculated where the profit and loss SRs are weighted by their frequencies, or the trading records. This adjustment lowers the SRs for all filter rules to -0.42, -0.02, 0.27 and 0.67 for the 0, 1, 2, and 3¢ rules.[2]

While Schwager notes two additional problems in using the Sharpe Ratio: a dependency on time interval and a failure to distinguish between retracements in unrealized profits versus retracements from entry date equity, these are not applicable to the present evaluation. In regards to the dependency on time interval, here, the results are presented for both per trade and per annum bases and the per trade results are manifested in the yearly measures. Also, the time involved in having an open equity position is the same for all strategies, trades are all day trades only. The difference of retracements in open versus closed equity is avoided in that all returns and evaluations are calculated on the basis of the starting equity. There is no reinvestment and given that these are day trading stystems, there is basically no difference in that all retracements on open equity (as can be measured) are realized.

The annualized SRs increase through to the 2¢ rule from -0.88 to 1.05 for the raw strategy and 1¢ rule, to 2.07 for the 2¢ strategy. The annualized SR for the 3¢ rule is 1.92.

Table 7 shows the annual summaries. As can be seen, relatively weaker performance years are generally common to all filter sizes. (1979, 1980, 1985, 1986.) However, for 1981 and 1982, the 0 and 1¢ rules seem to have particularily weak performances yet the 2 and 3 cent results are very strong in both records of profitable trades and expected returns per trade. Both 1983 and 1984 were relatively strong years for all trading rules. Taking the results year by year, we see that for filter sizes of 2 and 3¢, all years were significantly profitable. Annual returns range from 16.3 to 145.3¢ per bushel for the 2¢ rule and from 7 to 123.2¢ per bushel for the 3¢ filter rule. The average returns *per trade* range from $400 to $1,500 and from $530 to $2,420 for the respective filters.

The Sharpe Ratios for the two rules range from 0.16 to 1.26 for the 2¢ and from 0.26 to 3.80 for the 3¢ rule.

Table 7

Annual Summaries-All strategies February 01,1978 to May 29, 1987

	Filter			
Year	0.00	0.01	0.02	0.03
All returns are expressed as ¢/bu.				
1978				
Number trades	251	166	96	47
% profitable	48.21	54.22	64.58	78.72
Mean return per trade	0.03	0.54	1.16	2.15
Standard dev.	2.69	2.15	1.80	1.53
Sharpe Ratio	0.01	0.25	0.64	1.41
Annual Return	7.40	89.84	111.09	101.13
1979				
Number trades	247	151	74	37
% profitable	41.7	49.67	58.11	54.05
Mean return per trade	-0.08	0.48	0.92	1.03
Standard dev.	2.85	2.28	1.75	1.44
Sharpe Ratio	-0.30	0.21	0.53	0.72
Annual Return	-20.65	71.76	67.73	37.93
1980				
Number trades	247	155	92	51
% profitable	40.49	51.66	56.52	58.82
Mean return per trade	-0.62	-0.01	0.37	0.53
Standard dev.	3.12	2.62	2.26	2.03
Sharpe Ratio	-0.20	-0.004	0.16	0.26
Annual Return	-153.24	-2.05	34.00	26.93
1981				
Number trades	250	130	66	24
% profitable	36.80	49.23	63.64	70.83
Mean return per trade	-0.49	0.34	1.20	2.20
Standard dev.	2.37	1.86	1.57	1.33
Sharpe Ratio	-0.21	0.18	0.76	1.65
Annual Return	-122.10	44.62	78.99	52.91
1982				
Number trades	249	92	37	8
% profitable	27.31	45.65	67.57	75.0
Mean return per trade	-0.68	0.002	0.72	2.09
Standard dev.	1.38	0.89	0.69	0.55
Sharpe Ratio	-0.49	0.002	1.04	3.80
Annual Return	-169.82	0.16	26.70	16.72

Table 7 continued.

<u>1983</u>				
Number trades	244	148	86	50
% profitable	41.80	56.08	66.28	76.0
Mean return per trade	-0.30	0.55	1.50	2.40
Standard dev.	3.46	2.92	2.44	2.15
Sharpe Ratio	-0.09	0.19	0.62	1.12
Annual Return	-73.00	81.40	129.05	119.90
<u>1984</u>				
Number trades	253	156	90	51
% profitable	44.27	55.13	68.89	74.51
Mean return per trade	-0.11	0.73	1.62	2.42
Standard dev.	3.23	2.77	2.52	2.24
Sharpe Ratio	-0.03	0.26	0.64	1.08
Annual Return	-27.83	113.96	145.33	123.290
<u>1985</u>				
Number trades	253	130	58	21
% profitable	37.15	48.46	56.90	71.43
Mean Return per trade	-0.63	0.003	0.53	1.36
Standard dev.	2.21	1.65	1.20	0.87
Sharpe Ratio	-0.28	0.002	0.44	1.56
Annual Return	-158.07	0.34	30.37	28.55
<u>1986</u>				
Number trades	252	120	44	12
% profitable	30.15	45.83	52.57	50.0
Mean return per trade	-0.63	0.07	0.37	0.59
Standard dev.	1.82	1.34	0.84	0.63
Sharpe Ratio	-0.35	0.05	0.44	0.94
Annual Return	-158.56	8.45	16.26	7.02
<u>1987</u> ***(August, 1987 contract only)***				
Number trades	82	38	11	6
% profitable	29.27	44.74	72.73	66.67
Mean return per trade	-0.81	-0.22	1.06	0.97
Standard dev.	1.59	1.21	0.84	0.66
Sharpe Ratio	-0.50	-0.18	1.26	1.47
Cumulative Return	-66.03	-8.53	11.66	5.83

The trading results for the 1¢ filter were slightly mixed in that annual returns range from -2.05 to 113.96¢ per bushel . (The 1987 results to May 31 posted a cumulative loss of 8.53 cents. However, this should be discounted since this amount is significantly lower than the maximum draw down.) The SRs range from -0.004 to 0.26. (For the four months to May 31, 1987, the SR was -0.18.)

With regards to the basic strategy employing no filter, mean per trade returns range from -0.81 to 0.03¢ per bushel . Adjusted for risk, the Sharpe Ratios range from -0.50 to 0.01. When coupled with the trading records which are consistently less than 50 percent, this amounts to annual returns ranging from -169.82 to 7.4¢ per bushel .

To see if there is a significant difference between long and short trades, performance summaries of long only and short only opening-gap strategies were calculated. This distinction relates back to the mean daily open to close return calculated in Table 4. While not statistically significant at the selected level of confidence, the mean return of 0.085 cents per bushel is statistically significant at a confidence level of 90 percent. Thus, one may expect better performance of long trades. These results are tabled in Table 8.

Table 8

Long/ Short only filter strategies

All returns in ¢/bu. or $ 000's

	FILTER 1	2	3
Long only			
Mean Return	0.31	1.09	1.74
Standard Dev.	1.77	1.35	1.12
Number trades	694	333	155
% profitable	50.0	65.2	70.3
Short only			
Mean Return	0.33	0.89	1.60
Standard Dev.	1.77	1.34	1.13
Number trades	608	330	156
% profitable	52.5	59.7	67.3

While for the 1¢ rule the mean per trade returns are almost equal, they begin to diverge as the filter is increased to 2 and 3 cents. As the proportion of long trades is basically equal to one half in each of the three scenarios, there is no apparent bias in either the direction of the opening-gaps or their magnitude. Therefore, the performances of long and short trades are basically the same in terms of mean per trade returns, number of trades and standard deviation of returns for each filter size. In this way, **both types of trades contribute equally to the overall performance of the three strategies.**

These real time trading results for the noted strategies provide strong evidence of (the so called weak-form) inefficiency in the soybean complex futures markets. Significant dependencies (as indicated by the significant returns from the trading strategies) indicate that CBOT soybean, soybean meal and soybean oil futures prices are not random *per se* since while the departures implied by the posted simulations may be intemporally random, the realized returns of the trading rules, especially the 2 and 3¢ filter strategies, offer systematic significant "excess" returns.

This result is consistent with the result of "irregular dependencies" (or irregular regularities) for the commodities of the soybean complex as found by Helms et al (1984).

The short term reversals found herein complement similar evidence found in Dooley and Shafer (1983) for the New York foreign exchange market. However, while Stevenson and Bear (1970) reported similar results for soybeans and corn futures over the twelve year period 1957 to 1968, the evidence for soybean futures was only significant for large filters and even then, the performance over a buy and hold was only equal to $8,554 on the basis of two contract positions. This return represents an annual average return of $713. On the basis of comparable margin requirements of $1500 per contract, this corresponds to an average annual rate of return of 24%. Additionally, the estimated one period lag serial correlations for soybeans found in the present sample are considerably less than those reported in Stevenson and Bear.

As the entire results are net of reasonable trading costs, on the basis of the reported results, hypotheses such as Jensen's (1978) EMH and the RWH can be rejected with high levels of confidence.

VII SUMMARY AND CONCLUSION

In this paper, day trading strategies have been used for the Chicago Board of Trade soybean complex for the period 1978 to 1987 to test for both dependencies in price changes and a possible profitable exploitation of these dependencies.

Strong evidence of dependency was found. The correlation is sufficiently great for a trading strategy to yield annual average net returns of up to 70 cents per bushel , or $70,000 on a spread made up of 20 soybean, 24 soybean meal and 18 crude soybean oil futures contracts. With conservative criteria, inefficiency is indicated by persistent profitability of a very basic rule based on trading the opening-gap in the crush margin of soybean processors. These results lead to the rejection of the hypothesis that price changes are independent of previous price changes and suggest that models of speculative competitive markets with diffuse information such as those of Grossman (1976) and Grossman and Stiglitz (1976) require additional constraints in the structure of the market for information.

As an explanation for the existence of the results, it is proposed that due to the absence of enforceable property rights with respect to the technology of speculation and hedging, the informational aspect of securities markets ought to be structured as a monopolistic competitive market. **The critical implication of this proposal is that efficiency in the pricing of securities is not possible.**

NOTES

1. The Sharpe Ratio was calculated as:

$$\frac{\textit{expected rate of return}}{\textit{standard deviation of expected rate of return}}$$

2. The adjusted Sharpe Ratio was calculated as:

(% profitable trades)(SR(profit)) - (% losers)(SR(losers))

The mean profit and loss are in ¢/bu or $ 000's return.

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