Technical Analysis - A Search for the Holy Grail?

By

Scott H. Irwin and J. William Uhrig

TECHNICAL ANALYSIS -- A SEARCH FOR THE HOLY GRAIL?

Scott H. Irwin and J. William Uhrig*

The first academic challenge to chartists was issued by Working [21] in 1934. Economists continue to be participants in the debate concerning technical analysis.[1] The focus of the debate is clear-cut: Do trading strategies based on technical analysis generate consistent profits? On one hand, academicians and "fundamentalist" traders find little credibility in naive, extrapolative techniques which lack a solid base in economic theory. On the other hand, technical analysts argue the proof is in their profits. Unfortunately, they have been reluctant to publish research which would validate their claims. This may be due to a fear of trading methods becoming obsolete upon publication.

Technical analysis, either indirectly or directly, has been the subject of numerous academic studies. The majority of research has made use of the framework provided by the efficient market hypothesis (EMH). This model assumes there are no systematic biases in prices, which implies technical methods will not generate sustained, consistent profits [8]. To test this assertion trading systems are simulated over past price series and the resulting profits or losses examined [15, 17, 18]. In a different vein, agricultural economists have recently concentrated on testing the application of technical trading systems to farmer hedging strategies [9, 10, 14]. This was done in response to the poor price forecasting performance of econometric models during the 1970s and early 1980s [10, 13].

---

* The authors are, respectively, Graduate Research Assistant and Professor in the Agricultural Economics Department at Purdue University.

Previous research suffers from three major flaws. First, studies have failed to sample adequately the available range of technical trading systems. Second, the time periods considered have generally been inadequate. Third and most important, out-of-sample trading results have not been presented. Research which addresses the previous criticisms has important implications for technical analysis users, who lately have become a rapidly growing group. For example, future fund managers, who control over 420 million dollars, rely almost exclusively on technical analysis to guide their trading decisions [1]. Farmers have become increasingly interested in technical analysis as evidenced by the ever-growing number of seminars, workshops, and popular publications which emphasize the use of bar charts, point-and-figure charts and trading systems. With such a growth in popularity an objective assessment of the potential of technical strategies to generate profits is needed.

This paper presents the results of simulating four technical trading systems over the 1960 to 1983 period. These results will be used to discuss: 1) the usefulness of technical trading systems, 2) the usefulness of other technical methods, and 3) the efficiency of U.S. futures markets.

I. Technical Analysis and Market Efficiency

The EMH provides a general framework for analyzing the usefulness of technical analysis. According to Fama [8], the ultimate consequence of efficiency is that prices always fully reflect available information. These characteristics result from an ideal world where (i) there are no transaction costs, (ii) all relevant information is costlessly available to all market participants, and (iii) all agree on the implications of current information for the current price and distributions of futures prices.

Testing for significant departures from efficiency in futures markets has taken two paths. The first is based upon the assertion that prices follow a martingale process in an efficient market [16, 18]. This implies:

$$E_t(P_{t+1}) = P_t \quad (1)$$

where E_t is the mathematical expectation operator as of period t., P_{t+1} is price at time t+1, and P_t is price at time t. To test this assertion one simply tests for zero autocorrelation in the observed sequence of price changes, which are typically daily. An impressive number of studies have been dedicated to this task with results implying rejection of the zero autocorrelation hypothesis for futures markets in the United States [3], United Kingdom [19], and Australia [11].

Caution is needed, though, to interpret the results of the previous autocorrelation tests. Danthine [5] criticized such tests as simultaneously testing (1) market efficiency, (2) perfect competition, (3) risk neutrality, (4) constant returns to scale, and (5) the impossibility of corner optima. Accordingly, Danthine suggested checking the impossibility of various trading strategies as an alternative to autocorrelation tests.

Trading system tests are based on the assertion that all information potentially leading to expected profits is exploited in an efficient market. More specifically, if the information set is past prices then the expected profit of a technical trading system will be no greater than zero. These applications have been less numerous than autocorrelation tests. In-sample profits have been found [15, 17] but their significance has been difficult to assess without concurrent out-of-sample analysis.

To summarize, the efficiency of U.S. futures markets will be tested by examining the profits of four technical trading systems and comparing them to a zero profits benchmark. Importantly, both in-sample and out-of-sample results will be analyzed.

II. Data and Models

Data

Eight series of daily futures price closes serve as the price data for this study. The prices were obtained from the Dunn & Hargitt data bank. A description of each series is found in Table 1.

Table 1. Futures Market Price Series

Commodity	Exchange[a]	Years	Contracts
Corn	CBT	1960-83	All
Soybeans	CBT	1960-83	All
Wheat, Chi.	CBT	1960-83	All
Sugar (World)	CS&CE	1962-83	All
Cocoa	CS&CE	1960-83	All
Copper	CMX	1960-83	All
Cattle (Live Beef)	CME	1966-83	All
Hogs (Live)	CME	1970-83	All

[a] Commodity exchange symbols: CBT = Chicago Board of Trade; CME = Chicago Mercantile Exchange· CS & CE = Coffee, Sugar, Cocoa Exchange, Inc.· CMX = Commodity Exchange, Inc.

The Futures Trading Model

An important issue is how the daily futures prices should be organized to form the needed continuous price series. The method used in nearly all previous studies has been to consider each contract, i.e. the March corn contract, as a single discrete unit and then form a string of the contracts. In the previous example this would take the form of March 1960, March 1961, March 1962, . . . to avoid overlap each contract would be traded over one calendar period.

Constructing the price series in the aforementioned manner is a poor approximation of the actual use of futures markets. A more appropriate arrangement is one where the dominant contract is continuously used. Dale and Workman [4, p. 82] describe this arrangement:

> The dominant contract, i.e., the one with the highest open interest, is used to obtain price series that reflect the most important market characteristics. The price series in this study began with the March 1976 T-bill futures contract, which was used until the June 1976 contract became dominant, and June 1976 was used until the September 1976 contract became dominant, etc.

Thus, the general trading model "rolls-over" trading from the old dominant futures contract to the new dominant futures contract on the first notice day of the old dominant contract. This procedure estimates the period when a contract has the highest open interest[2] and is therefore dominant.

Transaction costs are another area that can dramatically alter the results of simulated trading depending on how they are handled. Estimated commission costs were subtracted from the gross profits or losses of the trading systems for each trade, including the roll-over trade from the switching to the new dominant contract. The historical commission charges used were estimated by Britton [2] and are the charges the general public would pay and are not necessarily as low as commissions charged to floor traders or large traders. A second transaction cost, execution or "skid" error, is the difference between the price which an order to buy or sell would actually have been executed and the quoted market price in a price series. The procedure integrated into the general model to account for skid charges was to double the commission cost for each trade. The inclusion of skid charges potentially introduce a bias against trading rules, and thus strengthen any evidence for rejection of efficiency.

The trading model includes several other important assumptions. First, a position is not allowed to be entered or exited on a day when the high price equals the low price and both of these equal the closing price. This accounts for the possibility of the price being "locked" up or down the daily allowable limit and the attendant restrictions on trading. The procedure was adopted because a historical record of daily trading limits was not readily available. Second, all trading is on a one-contract basis only. Third, no pyramiding of positions or reinvestment of profits is allowed. Last, enough capital is assumed available to meet any drawdown in trading funds due to losses.

Technical Trading Systems

Four technical trading systems are tested within the framework of the general trading model. The systems were selected in response to criticism of previous studies which did not adequately sample the available range of trading systems. With the aid of Dunn [7] the systems were selected as being representative of the three main types of trading systems -- price channels, moving averages, and momentum oscillators. The ensuing sections discuss the mechanics of each system.

The DONCH system, also known as the weekly method, is part of a family of technical systems known as price channels. The system generates a buy signal any time the daily high price is outside (greater than) the highest price in a specified time interval. A sell signal is generated any time the daily high breaks outside (lower than) the lowest price in the same interval. For example, if a nine week rule was being used to trade corn futures a buy signal would be given if today's high was above the highest corn futures price (in the dominant contract) over the last nine weeks; a sell signal would be generated if today's low was below the lowest price over the last nine weeks. The system always generates a signal for the trader to take a position, long or short, in the futures market.

The MAPB system belongs to a technical family derived from moving averages. Moving averages come in many forms, i.e. simple moving averages, exponentially weighted, linearly weighted, etc. A technical analyst's justification for utilizing moving averages follows:

> The chief value of moving averages as helpful tools in commodity price analysis rests on the following very simple premise: No commodity can ever stage an uptrend without first showing evidence of the preponderance of buying over selling by rising above a moving average. And no commodity can stage a downtrend without first showing evidence of more selling than buying by falling below a moving average. [6, p. 36]

The MAPB system employs a simple moving average with a band based on a percentage of price centered around it. A signal to initiate a position occurs whenever the closing price breaks outside the band. A signal to exit a position occurs when the price recrosses the moving average. The band creates a neutral zone in which the trader is neither long nor short. This is an attempt to reduce "whipsawing", which occurs during "nontrending" periods.

The DMAC system employs logic similar to the MAPB system by seeking to find when the short-term trend rises above or below the long-term trend. The MAPB represents the short-term trend by the daily price and the long-term trend by the moving average. The DMAC uses a short-term moving average and long-term moving average to represent the short and long-term trend. A change in the price trend is signaled when these two moving averages cross. Specifically, a buy signal is generated when the shorter moving average is greater than (above) the longer moving average, and a sell signal when the shorter moving average is less than (below) the longer moving average. Also, the system is reversing such that a trader always maintains a long or short position in the futures market.

The DI system is from a technical family known as momentum oscillators. Whereas the previous systems outlined in this section deal with the futures price level, oscillators deal with price changes. The logic employed by the directional indicator system is that any trending period can be characterized as having a significant excess of either positive or negative price movement. Periods when prices are quickly moving upwards will have more upward price change than downward price change and vice versa. It is this relative price change that the DI estimates. The trading rules are more complicated for this system and the reader is referred to [12] for a thorough explanation.

III. Trading System Results

Each trading system was "optimized" over the 1960-1978 period. In this process a large number of parameters are tested over each futures price series in an effort to find the one parameter, or set of parameters, which optimizes a given criterion. For example, all combinations of two moving averages from 5 to 25 days might be simulated with the highest profit combination selected as optimal. Such a process was employed in this study to select the highest profit parameter over the in-sample 1960-1978 period as optimal. Finally, each optimized system was simulated over the out-of-sample 1979-1983 period.

A summary of the returns generated over the 1960-1978 period by the optimization procedure for the DONCH, MAPB, DI, and DMA systems is presented in Table 2. A total of 2272 parameters were tested with 87.5% profitable after transactions costs. Soybeans sugar, copper, and cocoa trading

Table 2. Frequency Distribution of All Trading System Parameters and Profits and Losses Generated During Optimization

Profit/Loss (dollars)	Commodity (Trading Period)								
	Corn (1960-78)	Soybeans (1960-78)	Wheat (1960-78)	Sugar (1962-78)	Cocoa (1960-78)	Copper (1960-78)	L. Cattle (1966-78)	L. Hogs (1970-78)	Totals
less than 0	80[a] (28.2)[b]	15 (5.3)	43 15.1)	10 3.5)	32 11.3)	21 (7.4)	43 (15.1)	40 (14.1)	284 (12.5)
0 - 24,999	204 (71.8)	19 (6.7)	131 (46.1)	10 (3.5)	45 (15.9)	16 (5.6)	177 (62.3)	244 (86.0)	846 (37.2)
25,000 - 49,999	0 (0.0)	73 (25.7)	110 (38.7)	29 (10.2)	149 (52.5)	162 (57.0)	64 (22.5)	0 (0.0)	587 (25.8)
50,000 - 74,999	0 (0.0)	133 (46.8)	0 (0.0)	185 (65.1)	58 (20.4)	85 (29.9)	0 (0.0)	0 (0.0)	461 (20.3)
75,000 - 100,000	0 (0.0)	44 (15.5)	0 (0.0)	50 (17.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	94 (4.1)
TOTALS	284 (100.0)	284 (100.0)	284 (100.0)	284 (100.0)	284 (100.0)	284 (100.0)	284 (100.0)	284 (100.0)	2272 (100.0)

a This is the number of parameters tested which generated a profit in given range.
b This is the percentage of parameters tested which generated a profit in given range.

generated all of the parameters which were in the two highest profit categories. This implies price movements of these commodities tended to contain more, or longer, patterns than the other four commodities. Other relevant information is that the largest loss for a single set of parameters was $133,935 and 49 parameters (2.2%) had losses greater than $25,000.

Criticism has been directed to trial-and-error optimization techniques. Tomek and Querin [19, p. 19] state:

> "To recapitulate, if the price series is based on random fluctuations from the previous price, then on average a system based on historical price behavior cannot profitably forecast future price behavior, but <u>ex post</u> it is likely that a system can be found that profitably simulates some particular historical time period. By chance, this system may be profitable when applied to current prices. This is merely the consequence of the principles of probability, and therefore it is not surprising that technicians can find "profitable" rules even if the prices were generated by a random walk process."

One must question the application of such logic to futures prices in light of the evidence presented. With nearly 90% of the <u>ex post</u> parameters generating profits, and 25% generating profits in excess of $50,000, it is unlikely the results were a "chance" discovery due to the principles of probability.

Optimal (highest profit) parameters for each system and commodity are shown in Table 3. Each optimal parameter, or pair of parameters, is different for each commodity when comparisons are made within each trading system (the only exceptions are corn, wheat, copper, and live hogs for DONCH). Also, the time span of these optimum parameters is of interest. Specifically, for the storable commodities -- corn, soybeans, wheat, sugar, copper, and cocoa -- the optimum parameters were as long as 50 to 55 days. These are substantially longer in duration than parameters which are

Table 3. Optimal Parameters for Technical Trading Systems

Commodity (Optimization Period)	DONCH	MAPB		DI		DMAC	
	Weeks	MA (days)	BAND (%)	MA (days)	ET (%)	SMA (days)	LMA (days)
Corn (1960-1978)	8[a]	45	3.2	51	12.0	10	54
Soybeans (1960-1978)	9	20	4.0	48	7.0	23	41
Wheat (1960-1978)	5	39	4.2	24	12.0	10	44
Sugar (1962-1978)	8	36	4.8	49	13.0	5	25
Copper (1960-1978)	11	39	1.0	26	8.0	13	29
Cocoa (1960-1978)	7	43	6.2	30	7.0	14	46
Live Cattle (1966-1978)	2	15	1.8	8	13.0	6	15
Live Hogs (1970-1978)	11	10	2.1	58	8.0	3	13

a Highest profit parameter tested over optimization period.

MA--Moving Average
BAND--Band Width
ET--Entry Threshold

SMA--Shorter Moving Average
LMA--Longer Moving Average

published in various other sources such as charting and market advisory services. Contrarily, the non-storable commodities -- live cattle and live hogs -- tended to be associated with very short time frames for the optimum parameters (3 to 15 days).

Profits associated with in-sample trading of the optimal parameters are presented in Table 4. The dollar amounts of the profits are substantial and similar when compared across all four trading systems. For example, the difference in profits for copper between the four systems is no greater than $8,000.

Out-of-sample results address the critical question of whether, on average, a system based on historical price behavior can profitably forecast future price behavior. The results presented in Table 5 indicate this was possible, but success varied greatly across systems and commodities. Corn, sugar, and cocoa trading was profitable for each of the four systems; soybean trading was profitable for two systems; copper trading was profitable for one system: and wheat, live cattle, and live hogs were unprofitable to trade for each of the four systems. Profit, summed over all eight commodities, was positive for the DONCH and DI systems and negative for the MAPB and DMAC systems.

IV. Summary and Conclusions

This study improved upon past studies of trading systems several ways. First, trading systems were optimized and then simulated over out-of-sample data. This provided a better indicator of realizable profits. Second, deductions were made for both commission and "slippage" transactions costs. Third, systems actively used by trading advisors were examined, thus providing a more representative sample of technical trading systems.

Table 4. In-Sample Optimal Parameter Profits for Technical Trading Systems

Commodity (Optimization Period)	Profits ($)			
	DONCH	MAPB	DI	DMAC
Corn (1960-1978)	12,606[a]	13,556	10,188	17,169
Soybeans (1960-1978)	75,331	80,356	86,331	85,391
Wheat (1960-1978)	35,444	34,219	31,113	43,919
Sugar (1962-1978)	81,350	81,844	78,504	86,296
Copper (1960-1978)	57,838	57,088	59,935	65,800
Cocoa (1960-1978)	62,235	59,784	55,800	76,866
Live Cattle (1966-1978)	27,205	32,756	31,910	37,142
Live Hogs (1970-1978)	15,705	18,165	18,082	15,495

a Total profits for all contracts traded (net of transactions costs) and generated by corresponding parameters shown in Table 3.

Table 5. Out-of-Sample Optimal Parameter Profits for Technical Trading Systems

Commodity	Profits ($) (1979-1983)			
	DONCH	MAPB	DI	DMAC
Corn	8,682[a]	7,120	5,963	9,446
Soybeans	21,168	-4,315	16,683	-147
Wheat	-9,790	-1,996	-3,939	-1,140
Sugar	3,201	28,963	26,004	2,616
Copper	12,383	-14,780	-12,887	-15,892
Cocoa	2,890	3,935	6,823	14,370
Live Cattle	-820	-4,090	-15,340	-14,540
Live Hogs	-3,367	-19,529	-7,440	-18,899
Total	34,347	-4,692	15,867	-24,086

[a] Total profits for all contracts traded (net of transactions costs) and generated over 1979-1983 by corresponding parameters shown in Table 3.

Should a trader be skeptical of claims that technical analysis of past prices can successfully forecast subsequent prices? Is technical analysis a "Holy Grail" search for a non-existent perfect trading system? The evidence presented in this paper indicates the previous to be too harsh of a judgement, at least with respect to technical trading systems. The profits generated both in and out-of-sample indicate futures prices exhibited systematic behavior during 1960 to 1983. The implication for other technical methods is not certain. It would be a large, inductive leap-of-faith to say the results imply other methods, most notably charting, would certainly have been profitable. This would require a direct test of the particular method. However, one can strongly suspect that other technical methods profit from the same regularities in price movements as do trading systems. One caution is urged when interpreting the results; the returns were not adjusted for risk or simulated where equity drawdown was considered.

What are the market efficiency implications of the results? The evidence suggests that futures markets were not efficient over the 1960 to 1983 period. Trading system profits were evident *en masse* from 1960 to 1978, and profits were generated over the out-of-sample 1979-1983 period for two of four systems. This leads to the question of why trading system profits existed and indicates an important area for further research is the underlying causes of these profits.

Footnotes

[1] Technical analysis is defined to be any procedure which forecasts short-term commodity futures price movements utilizing only historical prices.

[2] Open interest is defined as the total outstanding contracts for a delivery month.

LIST OF REFERENCES

1. Brorsen, Wade B. and Scott H. Irwin, "Evaluation of Commodity Fund Performance," Review of Research in Futures Markets, (forthcoming).

2. Britton, Ted, Shearson-Loeb-Rhodes, Inc., Indianapolis, IN, Personal Conversations on June 9, 1982 and April 4, 1982.

3. Cargill, Thomas F. and Gordon C. Rausser, "Temporal Price Behavior in Commodity Futures Markets," Journal of Finance, (30):1043-1045, September 1975.

4. Dale, Charles and Rosemarie Workman, "Patterns of Price Movement in Treasury Bill Futures," Journal of Economics and Business, 33(2):81-87, Winter 1981.

5. Danthine, J.P., "Martingale Market Efficiency and Commodity Prices," European Economic Review, 10(1977):1-17.

6. Donchian, Richard D., "Trend Following Methods in Commodity Analysis," Commodity Year Book - 1957, Commodity Research, Inc., 1957, pp. 35-47.

7. Dunn, Dennis, Dunn & Hargitt, Inc., Lafayette, IN, Personal Conversations, Various Dates from January 1981 through October 1982.

8. Fama, Eugene F., "Efficient Capital Markets: A Review of Theory and Empirical Work," Journal of Business, 25(2):383-417, May 1970.

9. Franzeman, Jon, "Estimating Choice 600-700 Pound Carlot Carcass Beef Price," Proceedings of Applied Commodity Price Analysis and Forecasting Conference, April 28-29, 1983, Des Moines, IA, pp. 103-114.

10. Franzeman, Jon, "Moving Averages as an Indicator of Price Direction in Hedging Applications," Proceedings of Applied Commodity Price Analysis and Forecasting Conference, October 12-13, 1981, Ames, IA, pp. 452-465.

11. Hunt, B.F., "Short-Run Price Cycles in the Sydney Wool Futures Market," Australian Journal of Agricultural Economics, 18(1):133-143, April 1974.

12. Irwin, Scott H., Statistical and Trading System Analysis of Weak Form Efficiency in U.S. Futures Markets, Unpublished M.S. Thesis, Purdue University, 1983.

13. Just, Richard E. and Gordon C. Rausser, "Commodity Price Forecasting with Large-Scale Econometric Models and the Futures Market," American Journal of Agricultural Economics, 63(2):197-208, May 1981.

14. Kenyon, David and Craig Cooper, "Selected Fundamental and Technical Pricing Strategies for Corn," North Central Journal of Agricultural Economics, 2(2):137-144, July 1980.

15. Leuthold, Raymond M., "Random Walk and Price Trends: The Live Cattle Futures Market," Journal of Finance, 27(4):879-89, September 1972.

16. Mandelbrot, Benoit, "The Variation of Certain Speculative Prices," Journal of Business, 36(4):394-419, October 1963.

17. Peterson, Paul E. and Raymond M. Leuthold, "Using Mechanical Trading Systems to Evaluate the Weak Form Efficiency of Futures Markets," Southern Journal of Agricultural Economics, 14(1):147-152, July 1982.

18. Samuelson, Paul A., "Proof That Properly Anticipated Prices Fluctuate Randomly," Industrial Management Review, 6(20):41-50, Spring 1965.

19. Taylor, Stephen J., "Tests of the Random Walk Hypothesis Against a Price-Trend Hypothesis," Journal of Financial and Quantitative Analysis, 17(1):37-61, March 1982.

20. Tomek, William G. and Scott F. Querin, "Random Processes in Prices and Technical Analysis," The Journal of Futures Markets, 4(1):15-23, Spring 1984.

21. Working, Holbrook, "A Random Difference Series for Use in the Analysis of Time Series," Journal of the American Statistical Association, 29(195):11-24, March 1934.