The Profitability of Technical Trading Rules in US Futures Markets: A Data Snooping Free Test

by

Cheol-Ho Park and Scott H. Irwin

The Profitability of Technical Trading Rules in US Futures Markets: A Data Snooping Free Test

by

Cheol-Ho Park and Scott H. Irwin[1]

May 2005

AgMAS Project Research Report 2005-04

---

[1] Cheol-Ho Park is a Graduate Research Assistant in the Department of Agricultural and Consumer Economics at the University of Illinois at Urbana-Champaign. Scott H. Irwin is the Laurence J. Norton Professor of Agricultural Marketing in the Department of Agricultural and Consumer Economics at the University of Illinois at Urbana-Champaign. Funding support from the Aurene T. Norton Trust is gratefully acknowledged. Louis Lukac and Wade Brorsen provided invaluable assistance in the development of the trading model for this study. Comments provided by Darrel Good are gratefully acknowledged.

The Profitability of Technical Trading Rules in US Futures Markets: A Data Snooping Free Test

Abstract

Numerous empirical studies have investigated the profitability of technical trading rules in a wide variety of markets, and many of them found positive profits. Despite positive evidence about profitability and improvements in testing procedures, skepticism about technical trading profits remains widespread among academics mainly due to data snooping problems. This study tries to mitigate the problems by confirming the results of a previous study and then replicating the original testing procedure on a new body of data. Results indicate that in 12 futures markets technical trading profits have gradually declined over time. Substantial technical trading profits during the 1978-1984 period are no longer available in the 1985-2003 period.

The Profitability of Technical Trading Rules in US Futures Markets:
A Data Snooping Free Test

Table of Contents

The Profitability of Technical Trading Rules in US Futures Markets: A Data Snooping Free Test

Introduction

Technical analysis is a forecasting method of price movements using past prices, volume, and open interest. Technical analysis includes a variety of forecasting techniques such as chart analysis, pattern recognition analysis, cycle analysis, and computerized technical trading systems. Academic research on technical analysis generally has focused on technical trading systems, which can be readily expressed in mathematical form. Technical trading systems are designed to automatically recognize predictable trends in commodity prices under the expectation that the trends will continue in the future. A system consists of a set of trading rules that result from possible parameterizations and each rule generates trading signals (long, short, or out of market) based on a particular set of parameter values. Popular technical trading systems include moving averages, channels, and momentum oscillators (e.g., Schwager).

There is considerable evidence that both speculators and hedgers in futures markets attribute a significant role to technical analysis. Surveys show that many commodity trading advisors (CTAs) and hedge fund managers rely heavily on computer-guided technical trading systems (Billingsley and Chance; Fung and Hsieh). Irwin and Holt document that such traders can represent a relatively large proportion of total trading volume in many futures markets. Within the agricultural sector, market advisory services, which provide specific hedging advice to farmers about marketing crops and livestock, also make substantial use of technical systems. For example, a prominent service recently began offering a "systematic hedger program" where hedge signals are generated automatically based on 9- and 18-day moving averages (Doane's Agricultural Report).

Academics tend to be skeptical about technical analysis based on the belief that markets are efficient, at least with respect to historical prices. In efficient markets (Fama), any attempt to make economic profits by exploiting currently available information, such as past prices, is futile. This view is summed up in an oft-quoted passage by Samuelson, who argued that "…there is no way of making an expected profit by extrapolating past changes in the futures price, by chart or any other esoteric devices of magic or mathematics. The market quotation already contains in itself all that can be known about the future and in that sense has discounted future contingencies as much as is humanly possible" (p. 44). It should be noted that this view is not universally held within the field of agricultural economics. Brorsen and Anderson report that about 10% of Extension marketing economists use technical analysis to forecast prices.

Given the importance of this topic to understanding market price behavior, numerous empirical studies investigate the profitability of technical trading rules and many find evidence of positive technical trading profits (e.g., Lukac, Brorsen, and Irwin; Brock, Lakonishok, and LeBaron; Chang and Osler). For example, Lukac, Brorsen, and Irwin find that during the 1978-1984 period four technical trading systems, including the dual moving average crossover and the price channel, yield statistically significant monthly portfolio net returns of 1.89%-2.78%, which do not appear to be compensation for bearing systematic risk.[1] Such findings potentially represent a serious challenge to the efficient markets hypothesis and our understanding of price behavior in speculative markets. However, there is reason for skepticism about technical trading profits reported in previous studies. Cochrane argues, "Despite decades of dredging the data, and the popularity of media reports that purport to explain where markets are going, trading rules that reliably survive transactions costs and do not implicitly expose the investor to risk have not yet been reliably demonstrated" (p. 25). As the term "dredging the data" colorfully highlights, data snooping concerns drive much of the skepticism.

Data snooping occurs when a given set of data is used more than once for purposes of inference or model selection (White). If such data snooping occurs, any successful results may be spurious because they could be obtained by chance with exaggerated significance levels (e.g., Denton; Lo and MacKinlay). In the technical trading literature, a fairly blatant form of data snooping is an ex post and "in-sample" search for profitable trading rules. More subtle forms of data snooping are suggested by Cooper and Gulen. Specifically, a set of data in technical trading research can be repeatedly used to search for profitable "families" of trading systems, markets, in-sample estimation periods, out-of-sample periods, and trading model assumptions including performance criteria and transaction costs. As an example, a researcher may deliberately investigate a number of in-sample optimization periods (or methods) on the same dataset to select one that provides the most favorable result. Even if a researcher selects only one in-sample period in an ad-hoc fashion, it is likely to be strongly affected by similar previous research. Moreover, if there are many researchers who choose one individual in-sample optimization method on the same dataset, they are collectively snooping the data. Collective data snooping is potentially even more dangerous because it is not easily recognized by each individual researcher (Denton).

As a method to deal with data snooping problems, a number of studies in the economics literature suggest replicating previous results on a new body of data (e.g., Lovell; Schwert; Sullivan, Timmermann, and White, 2003). It is interesting to note that Jensen emphasized this approach some time ago in the academic literature on technical analysis, stating that "since it is extremely difficult to perform the standard types of statistical tests of significance on results of models like Levy's (and indeed they would be invalid in the presence of possible selection bias anyway), we shall have to rely on the results of replications of the models on additional bodies of data and for other time periods" (p. 82). However, only a handful of empirical studies on technical trading follow this approach (e.g., Sullivan, Timmermann, and White, 1999; Olson) and the focus in these studies has been on financial and currency markets. That few technical trading studies have followed Jensen's suggestion may be due to difficulties in collecting sufficient new data or incomplete documentation about trading model assumptions and procedures.

Tomek provides important guidelines with regard to replication. As a solution for the problem of unstable empirical results, which include data snooping and other specification problems, he advocates a "confirmation" and "replication" methodology, where confirmation (or "duplication") means an attempt to fit the original model with the original data and replication is

[1] Park and Irwin report that among over 90 technical trading studies that have been published since the mid-1980s, about two-thirds show results in favor of technical analysis.

to fit the original specification to new data (p. 6). For a study in the technical trading literature to be a good candidate for confirmation and replication, three conditions should be met. First, the markets and trading systems tested in the original study should be comprehensive, in the sense that results can be considered broadly representative of the actual use of technical systems. Second, testing procedures must be carefully documented, so they can be 'written in stone' at the point in time the study was published. Third, the original work should be old enough that a follow-up study can have a sufficient sample size.

To determine whether technical trading rules have been profitable in US futures markets, this study confirms and replicates a well-known 1988 study by Lukac, Brorsen, and Irwin. In the technical trading literature, Lukac, Brorsen, and Irwin's study meets the above three conditions. This study included comprehensive tests on 12 US futures markets using a wide range of technical trading systems, trading rule optimization, and out-of-sample verification. An additional benefit in the present context is that the 12 futures markets are weighted towards agricultural and natural resource commodities (commodities: corn, soybeans, cattle, pork bellies, sugar, cocoa and lumber; metals: copper and silver; financials: British pound, Deutsche mark and US T-bills). The original framework is duplicated as closely as possible by preserving all the trading model assumptions in Lukac, Brorsen, and Irwin's work, such as trading systems, markets, optimization method, out-of-sample verification length, transaction costs, rollover dates, and other important assumptions.

In the confirmation step, the original annual portfolio mean gross returns obtained by Lukac, Brorsen, and Irwin are compared to gross returns calculated by applying our trading model to their optimal parameters. Gross returns are a better performance measure to compare results from both studies because they are not contaminated by differences in the way transactions costs can be handled. In addition, correlation coefficients between annual net returns derived from our trading model and theirs are calculated and sign consistency of annual net returns from both trading models is checked. In the replication step, the trading model is applied to a new set of data from 1985-2003. Parameters of each trading system are optimized based on the mean net return criterion and then out-of-sample performance is evaluated. Statistical significance of technical trading returns is measured via a stationary bootstrap, which is generally applicable to weekly dependent stationary time series. By minimizing, if not eliminating, the deleterious impacts of data snooping this study provides a true out-of-sample test for the profitability of technical trading rules.

Two possible outcomes are expected. If technical trading rules consistently generate economic profits using the new data, this implies that Lukac, Brorsen, and Irwin's original finding of positive profits was not the result of data snooping, and thus US futures markets are indeed inefficient. Otherwise, their findings resulted from data snooping or temporary inefficiency of futures markets. It is possible that profitable technical strategies in the late 1970s and early 1980s were not profitable in subsequent years due to structural changes in futures markets (Kidd and Brorsen).

Data

Lukac, Brorsen, and Irwin investigated 12 futures markets over the 1975-1984 period. Their out-of-sample period begins in 1978 since data for three years from 1975-1977 are used to optimize trading rules. This study extends their sample period to the 1975-2003 period for the same 12 futures markets, which include highly traded agricultural commodities, metals, and financials. Specifically, they are corn and soybeans from the Chicago Board of Trade (CBOT), live cattle, pork bellies, lumber, British pound, Deutsche mark, and US T-bills from the Chicago Mercantile Exchange (CME), silver and copper from the Commodity Exchange, Inc. (COMEX), and sugar (world) and cocoa from the Coffee, Sugar, and Cocoa Exchange (CSCE). Daily price data for each futures market from 1975 through 2003 are used to evaluate in- and out-of-sample performances of technical trading rules, with the exception of the three financials that have slightly shorter sample periods: 1977-2003 for British pound, 1977-1998 for Deutsche mark, and 1977-1996 for T-bills. The full out-of-sample period, 1978-2003, is divided into two subperiods: 1978-1984 and 1985-2003, for the purposes of confirmation and replication. The first subperiod is the same sample period that Lukac, Brorsen, and Irwin analyzed.

Table 1 presents a description of each futures contract, including exchange, contract size, value of one tick, daily price limits, and contract months used. It is important to incorporate accurate daily price limits into the trading model because for certain futures contracts price movements are occasionally locked at the daily allowable limits. Since trend-following trading rules typically generate buy (sell) signals in up (down) trends, the daily price limits imply that buy (sell) trades will be actually executed at higher (lower) prices than those at which trading signals were generated. This may result in seriously overstated trading returns if trades are assumed to be executed at the limit 'locked' price levels. The history of daily price limits for each contract was obtained from exchanges' statistical yearbooks and the annual *Reference Guide to Futures/Options Markets* and *Source Book* issues of *Futures* magazine.

Technical Trading Systems

A technical trading system is composed of a set of trading rules that can be used to generate trading signals. In general, a simple trading system has one or two parameters that are used to vary the timing of trading signals. Trading rules contained in a system are the results of the parameterizations. For example, the Dual Moving Average Crossover system with two parameters (a short moving average and a long moving average) can produce hundreds of trading rules by altering combinations of the two parameters. This study duplicates the 12 technical trading systems that Lukac, Brorsen, and Irwin examined. The 12 trend-following technical trading systems consist of moving averages, price channels, momentum oscillators, filters, and a combination system. Table 2 provides general information about the 12 trading systems.

Moving average based trading systems are the simplest and most popular trend-following systems among practitioners (Taylor and Allen; Lui and Mole). The first analysis of moving averages can be found in the 1930s (e.g., Gartley). Moving average systems take different forms according to the method used to average past prices in the moving average calculations. For example, the simple moving average uses equal weighting on each past price considered, while the exponential moving average gives comparatively more weight to recent prices. Their effect is to smooth out price actions, thereby avoiding false signals generated by erratic short-term price movements, and identifying the true underlying trend. In this study, two moving average systems are simulated: the Simple Moving Average with Percentage Price Band (MAB) and the Dual Moving Average Crossover (DMC). The MAB system uses a simple moving average with a price band centered around it. A trading signal is triggered whenever the closing price breaks outside the band, and an exit signal is triggered when the price re-crosses the moving average. The DMC system involves comparison of two moving averages, generating a buy (sell) signal when a short-term moving average rises (falls) above (below) a long-term moving average. This system is a reversing system that is always in the market, either long or short.

Next to moving averages, price channels are also extensively used technical trading strategies. The price channel is sometimes referred to as "trading range breakout" or "support and resistance." The history of price channels dates back to the early 1900s (Wyckoff). The fundamental characteristic underlying price channel systems is that market movement to a new high or low suggests a continued trend in the direction established. All the price channels generate trading signals based on a comparison between today's price level with price levels of some specified number of days in the past. Three different price channel systems are simulated. The Outside Price Channel (CHL) system generates a buy (sell) signal anytime the closing price is higher (lower) than the highest (lowest) price in a specified time interval (i.e., price channel). Similarly, the L-S-O Price Channel system (LSO) compares today's closing price to the price action of a cluster of consecutive days some time in the past. The LSO system uses stop orders as an exit rule. In the M-II Price Channel (MII) system, long or short positions are established and maintained by comparing today's close with the theoretical high or low of the first day of the price channel. While the CHL and MII systems are reversing systems, the LSO system can go neutral, i.e., out of the market.

Unlike the price channel systems that rely on absolute price levels, momentum oscillators detect trends by quantifying the magnitude of price changes. The momentum values are very similar to standard moving averages, in that they can be regarded as smoothed price movements. However, momentum oscillators may identify a change in trend in advance because the momentum values generally decrease before a reverse in trend has taken place. Trading signals are generated typically by comparing a momentum indicator to pre-determined entry thresholds. Four momentum oscillator systems are examined. They are the Directional Indicator (DRI), the Range Quotient (RNQ), the Reference Deviation (REF), and the Directional Movement (DRM) systems. In the DRI system, a trending period is recognized as one having a significant excess of either up or down price movement measured by price changes. The RNQ system generates trading signals based on an indicator, termed Range Quotient, which accounts for the relationship between the average daily price range and the total price range over a period of time. The REF system uses a moving average as a reference point and derives a reference index by assessing daily price deviations from the moving average. The DRM system measures the relative strength of a market over a fixed time period. It produces two directional indicators from positive and negative price movements, respectively, and generates trading signals by comparing the two indicators. The DRM system uses stop orders as both entry and exit rules. All the momentum oscillator systems can go neutral.

Filter systems “filter” out smaller price movements by constructing trailing stops for price movements above or beneath the current trend and generating trading signals only on the larger price changes. The trailing stops have various forms such as some predetermined amount of past extreme prices (Alexander’s Filter Rule) or particular weighted averages of past prices (the Parabolic Time/Price system). Alexander’s Filter Rule (ALX) system generates a buy (sell) signal when today’s closing price rises (falls) by *x*% above (below) its most recent low (high). The Parabolic Time/Price (PAR) system uses the trailing stop that works as a function of both the direction of price movement and the time over which the movement takes place. If the price movement does not materialize or goes in the other direction, the stop reverses the current position and a new time period begins. These filter systems are reversing systems that always take positions in the market.

Combination systems consist of two or more trading systems to improve their performance. Since simple technical trading systems may not reflect a wide variety of market situations, they often lead to periodic large losses. Combination trading systems attempt to reduce the possible losses by confirming or filtering trading signals with multiple trading systems. As a combination system, the Directional Parabolic (DRP) system trades only when the Parabolic Time/Price (PAR) system is in accordance with the Directional Movement (DRM) system. If both systems indicate the same direction, then take the Parabolic trade, and if they indicate different directions, then skip the Parabolic trade. One exception is that if the directional movement changes while out of the market, then the Parabolic entry point becomes the entry point of the directional movement.

The Directional Movement (DRM), Parabolic Time/Price (PAR), and Directional Parabolic (DRP) systems were introduced by Wilder, and all the other systems except Alexander’s Filter Rule (ALX) and Wilder’s three systems were presented by Barker. According to Lukac, Brorsen, and Irwin, each trading system was selected to be representative of the various types of systems that had been suggested by actual traders, previous studies and books. Trading mechanics and parameters for each of the12 trading systems are described next.

Moving Average Systems

Simple Moving Average with Percentage Price Band (MAB)

A major problem associated with moving averages is that they do not perform well in congested markets and are subject to “whipsawing.” This is particularly true of a moving average system that always keeps traders in the market and has no criteria for standing aside during periods of congestion. The problem of whipsawing, however, can be avoided by allowing a band surrounding the trend line (moving average) above and below. The Simple Moving Average with Percentage Price Band system literally uses a simple moving average with a price band centered around it. A trading signal is triggered whenever the closing price breaks outside the band, and an exit signal is triggered when the price re-crosses the moving average. The upper and lower price bands act as a neutral zone that has the effect of keeping traders out of the market during non-trending conditions. By standing aside and not trading while prices are fluctuating within the price bands and the market is seeking a direction, traders may significantly increase the probability of profitable trades.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. Moving Average over n days at time t $(MA_t) = \sum_{i=1}^{n} P_{t-i+1}^{c} / n,$ where P_t^c is the closing price at time t and $n \leq t$.

2. Upper Band Limit $(UBL_t) = MA_t + (b)MA_t$, where b is the fixed band multiplicative value.

3. Lower Band Limit $(LBL_t) = MA_t - (b)MA_t$.

B. Trading rules

1. Buy long at P_{t+1}^{o} if $P_t^c > UBL_t$, where P_{t+1}^{o} is the open at time $t+1$. Sell offset at P_{t+1}^{o} if $P_t^c < MA_t$.

2. Sell short at P_{t+1}^{o} if $P_t^c < LBL_t$. Buy offset at P_{t+1}^{o} if $P_t^c > MA_t$.

C. Parameters

1. n = 3, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 (15 values).

2. b = 0, 0.001, 0.003, 0.005, 0.01, 0.015, 0.02, 0.025, 0.03, 0.035, 0.04, 0.045, 0.05, 0.055, 0.06 (15 values).

Dual Moving Average Crossover (DMC)

According to Neftci, the (dual) moving average method is one of the few technical trading procedures that is statistically well defined, because it generates trading signals by depending only on data available at the present time. The Dual Moving Average Crossover system employs a similar logic to that of the Simple Moving Average with Percentage Price Band system by trying to find when the short-term trend rises above or falls below the long-term trend. The moving average method developed here is a reversing system that is always in the market, either long or short. As market participants, such as brokers, money managers or advisers, and individual investors, were known to extensively use the Dual Moving Average Crossover system, many academics have tested this system since the early 1990s.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. Shorter Moving Average over s days at time t $(SMA_t) = \sum_{i=1}^{s} P_{t-i+1}^{c} / s$, where P_t^c is the closing price at time t and $s < t$.

2. Longer Moving Average over l days at time t $(LMA_t) = \sum_{i=1}^{l} P_{t-i+1}^{c} / l$, where $s < l \leq t$.

B. Trading rules

1. Buy long at P_{t+1}^{o} if $SMA_t > LMA_t$, where P_{t+1}^{o} is the open at time $t+1$.

2. Sell short at P_{t+1}^{o} if $SMA_t < LMA_t$.

3. The system is reversing, always in the market, either long or short.

C. Parameters

1. s = 2, 3, 5, 7, 10, 15, 20, 25 (8 values).

2. l = 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 (13 values).

Price Channel Systems

Outside Price Channel (CHL)

The Outside Price Channel system is analogous to a trading system introduced by Donchian, who used only two preceding calendar weeks' ranges as a channel length. This system generates a buy signal anytime the closing price is higher than the highest price in a channel length (specified time interval), and generates a sell signal anytime the closing price is lower than the lowest price in the price channel. The system is reversing and always in the market, either long or short.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. Price channel = a time interval including today, n days in length.

2. The Highest High $(HH_t) = \max\{P_{t-1}^{h}, \ldots, P_{t-n+1}^{h}\}$, where P_{t-1}^{h} is the high at time $t-1$.

3. The Lowest Low $(LL_t) = \min\{P^l_{t-1}, \ldots, P^l_{t-n+1}\}$, where P^l_{t-1} is the low at time $t-1$.

B. Trading rules

1. Buy long at P^c_t if $P^c_t > HH_t$, where P^c_t is the close at time *t*.

2. Sell short at P^c_t if $P^c_t < LL_t$.

3. If trading on the close is not possible due to limit move conditions, trade on the next day's open.

C. Parameter

1. *n* = 2, 3, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 (16 values).

L-S-O Price Channel (LSO)

The L-S-O Price Channel system is another type of price channel. Most price channel methods are reversing systems–always in the market, either long or short. However, the L-S-O Price Channel system can be long, short, or out of the market. In this system, today's closing price is compared to the price action of a cluster of consecutive days some time in the past. The cluster of days is termed the Reference Interval (RI).

Specifications of the system are as follows:

A. Definitions and abbreviations

1. *n* = the number of days in the price channel including today's price activity.

2. Reference Interval $(RI_t) =$ cluster of consecutive days at the opposite end of the price channel from time *t*, *l* days in length.

3. Reference Interval High $(RIH_t) =$ the highest high in the RI_t.

4. Reference Interval Low $(RIL_t) =$ the lowest low in the RI_t.

5. Stop $= (RIH_t + RIL_t)/2$.

B. Trading rules

1. Buy long at P^c_t if $P^c_t > RIH_t$, where P^c_t is the close at time *t*.

2. Place a sell stop order half way between the RIH_t and the RIL_t, or $(RIH_t + RIL_t)/2$. This is a standard intraday stop order, not a stop close only order. Calculate a new stop everyday.

3. Sell short at P_t^c if $P_t^c < RIL_t$.

4. Place a buy stop order half way between the RIH_t and the RIL_t, or $(RIH_t + RIL_t)/2$. Calculate a new stop everyday.

5. If a stop close only order is not, or cannot be executed due to limit-up or limit-down conditions, enter on the next day's open using a market order.

C. Parameters

1. *n* = 2, 3, 4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 (17 values).

2. *l* = 1, 2, 3, 4, 5, 6, 7, 9, 14, 19, 24, 29, 34, 39, 44, 49, 54, 59, 64 (19 values).

M-II Price Channel (MII)

The M-II Price Channel system is yet another variant of technical trading systems based on the price channel. This system is a reversing system that is always in the market. Long or short positions are established and maintained by comparing today's close with the theoretical high or low of the first day of the price channel. For example, if today's close is above the Reference Day Theoretical High (RDTH), a long position is established on the close and is maintained until the market moves below the Reference Day Theoretical Low (RDTL) at which time the long position is liquidated and a short position is simultaneously established–offset and reverse (OAR).

Specifications of the system are as follows:

A. Definitions and abbreviations

1. Price channel = *n* consecutive days price action including today.

2. Reference Day (RD) = the first day of the price channel.

3. Reference Day Theoretical High $(RDTH_t) = \max\{P_{RD}^h, P_{RD-1}^c\}$, where P_{RD}^h is the high of the RD day and P_{RD-1}^c is the close of the $RD-1$ day.

4. Reference Day Theoretical Low $(RDTL_t) = \min\{P_{RD}^l, P_{RD-1}^c\}$, where P_{RD}^l is the low of the RD day.

B. Trading rules

1. Buy long at P_t^c if $P_t^c > RDTH_t$, where P_t^c is the close at time *t*.

2. Sell short at P_t^c if $P_t^c < RDTL_t$.

3. The system is always in the market, either long or short. After the initial position, the system offsets and reverses.

4. If trading on the close is not possible due to limit move conditions, trade on the next day's open at the market.

C. Parameter

1. *n* = 2, 3, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80 (19 values).

Momentum Oscillator Systems

Directional Indicator (DRI)

The Directional Indicator system is a prominent example of momentum oscillators. Since the directional indicator is sensitive to changes in market volatility, it clearly and precisely defines congestion, despite its relative simplicity (Barker). A trending period can be characterized as one having a significant excess of either up or down movement. This system generates trading signals based on the excess.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. *n* = the number of days used to calculate the directional indicator.

2. Net Price Change $(NPC_t) = P_t^c - P_{t-n}^c$, where P_t^c is the close at time *t*.

3. Total Price Change $(TPC_t) = \sum_{i=1}^{n} | P_{t-i+1}^c - P_{t-i}^c |$.

4. Directional Indicator $(DI_t) = (NPC_t / TPC_t) \times 100$.

5. *et* = the entry threshold: the level of the directional indicator (positive or negative) which, when crossed by DI, generates a buy or sell signal.

6. Neutral Zone (NZ) = all DI values between the positive and negative entry thresholds.

B. Trading rules

1. Buy long at P_{t+1}^{o} if $DI_t \geq +et$, where P_{t+1}^{o} is the open at time $t+1$. Sell (offset) at P_{t+1}^{o} if $DI_t \leq 0$.

2. Sell short at P_{t+1}^{o} if $DI_t \leq -et$. Buy (offset) at P_{t+1}^{o} if $DI_t \geq 0$.

C. Parameters

1. n = 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 (13 values).

2. et = 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57, 60, 63, 66, 69, 72, 75, 78, 81, 84, 87, 90 (30 values).

Range Quotient (RNQ)

The Range Quotient system is also a member of the momentum oscillators, but is quite different from any other oscillator systems in that it can contain more information about recent price patterns in a single number, i.e., Range Quotient. This system is based on the relationship between the average daily price range and the total price range over some time interval. According to Barker, simple (unsmoothed) technical trading systems often provide superior performance to their exponentially smoothed counterparts. One problem with unsmoothed methods is that data being discarded has as significant an impact on the results as today's price data. The Range Quotient system, without a smoothing process, virtually eliminates this problem as the discarded data can never increase the total price range.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. n = the number of days used to calculate the Range Quotient, including today.

2. Theoretical High $(TH_t) = \max\{P_t^h, P_{t-1}^c\}$, where P_t^h is the high at time t and P_{t-1}^c is the close at time $t-1$.

3. Theoretical Low $(TL_t) = \min\{P_t^l, P_{t-1}^c\}$, where P_t^l is the low at time t.

4. Daily Price Range $(DR_t) = TH_t - TL_t$.

5. Average Daily Price Range $(ADR_t) = \sum_{i=1}^{n} DR_{t-i+1} / n.$

6. The Highest High $(HH_t) = \max\{P_{t-1}^h, \ldots, P_{t-n+1}^h\}.$

7. The Lowest Low $(LL_t) = \min\{P_{t-1}^l, \ldots, P_{t-n+1}^l\}.$

8. Total Price Range $(TR_t) = HH_t - LL_t.$

9. Range Quotient $(RQ_t) = [1 - (ADR_t / TR_t)] \times 100,$ where $RQ_t = +RQ_t$ if $P_t^c \geq P_{t-n+1}^c,$ and $RQ_t = -RQ_t,$ otherwise.

10. *et* = the entry threshold: the RQ value beyond which buy or sell signals are generated.

B. Trading rules

1. Buy long at P_{t+1}^o if $RQ_t > +et,$ where P_{t+1}^o is the open at time $t+1.$ Offset long at $P_{t+1}^o,$ when the sign of RQ_t changes from (+) to $(-)$.

2. Sell short at P_{t+1}^o if $RQ_t < -et.$ Offset short at $P_{t+1}^o,$ when the sign of RQ_t changes from $(-)$ to (+).

C. Parameters

1. *n* = 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 (13 values).

2. *et* = 50, 55, 60, 65, 70, 75, 80, 85, 90 (9 values).

Reference Deviation (REF)

The Reference Deviation system is an oscillator-type system that uses a moving average as a reference point. This system is analogous to other oscillator methods in the sense that buy and sell signals are generated by comparing the reference index with arbitrary fixed threshold levels.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. Reference Moving Average over *n* days at time *t* $(RMA_t) = \sum_{i=1}^{n} P_{t-i+1}^c / n,$ where P_t^c is the closing price at time *t* and $n \leq t.$

2. Daily Reference Deviation $(DRD_t) = P_t^c - RMA_t$.

3. Net Deviation Value $(NDV_t) = \sum_{i=1}^{n} DRD_{t-i+1} / n.$

4. Total Deviation Value $(TDV_t) = \sum_{i=1}^{n} | DRD_{t-i+1} | / n.$

5. Reference Deviation Value $(RDV_t) = (NDV_t / TDV_t) \times 100.$

6. *et* = the entry threshold: the fixed value of the reference deviation value beyond which buy and sell signals are triggered.

B. Trading rules

1. Buy long at P_{t+1}^o if $RDV_t > +et$, where P_{t+1}^o is the open at time $t+1$. Sell (offset long) at P_{t+1}^o, when $RDV_t < 0$.

2. Sell short at P_{t+1}^o if $RDV_t < -et$. Buy (offset short) at P_{t+1}^o, when $RDV_t > 0$.

C. Parameters

1. *n* = 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 (10 values).

2. *et* = 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90 (18 values).

Directional Movement (DRM)

The Directional Movement system is an oscillator-type technical trading system designed by Wilder. The objective of this system is to determine whether a market is likely to experience a trending or trading range environment. A trending market will be better signaled by the adoption of trend-following indicators such as moving averages, whereas a trading range environment is more suitable for oscillators (Pring, p. 247). The Directional Movement measures the relative strength of a market over a fixed time period. It produces two directional indicators ranging from 0 to 100%, and buy or sell signals are generated by comparing the two indicators.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. *n* = the number of days used to calculate the directional indicator.

2. Directional Movement $(DM_t) = \max\{(P_t^h - P_{t-1}^h), (P_{t-1}^l - P_t^l)\}$, where P_t^h and P_t^l are the high and the low at time *t*, respectively. Of course, if $+DM (= P_t^h - P_{t-1}^h)$ is greater than $-DM (= P_{t-1}^l - P_t^l)$, the –DM is disregarded, and vice versa. When an inside day (yesterday's range covers today's range) or an equal day (yesterday's range equals today's range) occurs, both +DM and –DM are equal to zero.

3. True Range $(TR_t) = \max\{|P_t^h - P_t^l|, |P_t^h - P_{t-1}^c|, |P_t^l - P_{t-1}^c|\}$, where P_{t-1}^c is the close at time $t-1$.

4. Directional Indicator (DI_t):

$$+DI_t = \sum_{i=1}^{n} (+DM)_{t-i+1} / \sum_{i=1}^{n} TR_{t-i+1} \quad \text{and}$$
$$-DI_t = \sum_{i=1}^{n} (-DM)_{t-i+1} / \sum_{i=1}^{n} TR_{t-i+1}.$$

5. Extreme Point Rule (EPR): On the day that +DI and –DI cross, use the extreme price made that day as the reverse point. If the current position is long, the reverse point is the 'low' made on the day of crossing. If short, the reverse point is the 'high' on the day of crossing. Stay with this point, if not stopped out, even if the indexes stay crossed contrary to the current position for several days.

B. Trading rules

1. When +DI crosses above –DI, enter a buy stop on the next day using the high price on the day of crossing. This order is maintained until it is executed and as long as +DI remains higher than –DI.

2. When –DI crosses above +DI, enter a sell stop on the next day using the low price on the day of crossing. This order is maintained until it is executed and as long as –DI remains higher than +DI.

3. Trading simulation begins 30 days before the first day (rollover date) of actual trade.

C. Parameter

1. n = 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39 (13 values).

Filter Systems

Alexander's Filter Rule (ALX)

This system was first introduced by Alexander and exhaustively tested by numerous academics until the early 1990s. Since then, however, its popularity among academics has been replaced by moving average methods. This system generates a buy (sell) signal when today's closing price rises (falls) by x% above (below) its most recent low (high).

Specifications of the system are as follows:

A. Definitions and abbreviations

   1. High Extreme Point (HEP) = the highest closing price obtained while in a long trade.

   2. Low Extreme Point (LEP) = the lowest closing price obtained while in a short trade.

   3. x = the percent filter size.

B. Trading rules

   1. Buy long on the close, if today's close rises x% above the LEP.

   2. Sell short on the close, if today's close falls x% below the HEP.

   3. The system is reversing, always in the market, either long or short.

   4. Trading simulation begins 51 days before the first day (rollover date) of actual trade.

C. Parameter

   1. x = 0.005, 0.01, 0.015, 0.02, 0.025, 0.03, 0.035, 0.04, 0.045, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19, 0.20 (25 values).

Parabolic Time/Price (PAR)

The Parabolic Time/Price system is another technical trading system introduced by Wilder. It receives its name from the fact that the pattern formed by the trading stops resembles a parabola. The stop is referred to as the Stop and Reverse (SAR) since a position is closed out and reversed at the point. The idea behind the parabolic system is well described by Pring (p. 252).

One of the most valid criticisms of trend-following systems is that the implied lags between the turning points and the trend-reversal signals obliterate a significant amount of the potential profitability of a trade. The Parabolic System is designed to address this problem by increasing the speed of the trend, so far as stops are concerned, whenever prices reach new profitable levels. The concept draws on the idea that time is an enemy, and unless a trade or investment can continue to generate more profits over time, it should be liquidated.

Like the moving average systems, the parabolic system develops trading signals from smoothing past prices, although it utilizes a particular weighting method. The trading stop in the parabolic system works as a function of both the direction of price movement and the time over which the movement takes place. The stop moves by an incremental constant every day only in the direction in which a position has been established. The time/price concept allows so much time for the price to move favorably. If the price movement does not materialize or goes in the other direction, the stop reverses the current position and a new time period begins.

Specifications of the system are as follows:

A. Definitions and abbreviations

1. Extreme Price (EP) = the highest (lowest) price made while in the long (short) trade.

2. Significant Point (SIP) = if entered long (short), the SIP is the lowest (highest) price reached while in the previous short (long) trade.

3. Acceleration Factor (AF) = a smoothing parameter. The AF rises by an Incremental Constant (IC) whenever a new EP is made. It begins at the IC and can be increased up to 0.20 at which it is maintained for the duration of the trade. Never increase the AF beyond 0.20. The AF is reset to the initial value whenever a new position is taken.

4. Stop and Reverse (SAR):

    1) For both the first day of entry and the day that a position is reversed, the SAR is equal to the SIP. To obtain the SIP, prices during 20 trading days prior to the first day of entry are simulated, as suggested by Wilder.

    2) For the second day and thereafter, the SAR is calculated as follows: If long (short), find the distance between the highest (lowest) price made while in the trade and the SAR for today. Multiply the difference by the AF and add (subtract) the result to (from) the SAR today to obtain the SAR for tomorrow. The mathematical representation is as follows:

If long: $SAR_{t+1} = SAR_t + AF_t \mid EP_t - SAR_t \mid$.

If short: $SAR_{t+1} = SAR_t - AF_t \mid EP_t - SAR_t \mid$.

3) Never move the SAR into the previous day's range or today's range. More specifically, if the current position is long (short), never move tomorrow's SAR above (below) the previous day's low (high) or today's low (high). If tomorrow's SAR is calculated to be above (below) the previous day's low (high) or today's low (high), then use the lower low (higher high) between today and the previous day as the new SAR. Make the next day's calculations based upon this SAR.

B. Trading rules

1. Go long on the close of the first day of trade (i.e., rollover day) if the market is in a general up trend. Offset long and reverse at the SAR if the SAR penetrates above today's low price and is in today's range. If the SAR moves above today's high price, offset long and reverse at today's close.

2. Go short on the close of the first day of trade if the market is in a general down trend. Offset short and reverse at the SAR if the SAR penetrates below today's high price and is in today's range. If the SAR moves below today's low price, offset short and reverse at today's close.

3. Offset an existing position on the close of the last day of trade (i.e., next rollover day).

4. Trading simulation begins 51 days before the first day (rollover date) of actual trade.

C. Parameter

1. IC = 0.014, 0.015, 0.016, 0.017, 0.018, 0.019, 0.020, 0.021, 0.022, 0.023, 0.024 (11 values).

Combination System

Directional Parabolic (DRP)

The idea of the Directional Parabolic system is to trade the Parabolic Time/Price system only in accordance with the Directional Movement system. If +DI is greater than –DI (DM is up) then take only the long Parabolic trades, whereas if +DI is less than –DI (DM is down) then take only the short Parabolic trades. Therefore, if both systems indicate the same direction, then take the Parabolic trade, and if they indicate different directions, then skip the Parabolic trade.

One exception is that if DM changes while out of the market, then the Parabolic entry point becomes the DM entry point.

Specifications of the system are as follows:

A. Trading rules

1. Suppose that a long position is held and DM is up (down). If the Parabolic stop (SAR) is penetrated and the Parabolic Time/Price System signals short, then exit (reverse) at the Parabolic stop.

2. Suppose that a short position is held and DM is down (up). If the Parabolic stop is penetrated and the Parabolic Time/Price System signals long, then exit (reverse) at the Parabolic stop.

3. Suppose that no position is held and DM is up (down). If the Parabolic Time/Price System signals long (short), take a long (short) position at the Parabolic stop.

4. Suppose that no position is held and DM changes from up (down) to down (up). If the Parabolic Time/Price System signals short (long), enter a sell (buy) stop on the next day using the low (high) price on the day of crossing of DI's.

B. Parameters

1. n = the number of days use to calculate the directional movement; 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39 (13 values).

2. IC = the Incremental Constant (IC) in the Parabolic Time/Price System; 0.014, 0.015, 0.016, 0.017, 0.018, 0.019, 0.020, 0.021, 0.022, 0.023, 0.024 (11 values).

Benchmark

Technical trading returns in a market are often compared with returns to a benchmark strategy in order to test the efficient markets hypothesis. The buy-and-hold strategy has long been used as a benchmark for the stock market in which a general up-trend in asset prices is observed. However, several researchers (e.g., Leuthold) have questioned whether the buy-and-hold strategy should be used for futures markets as a benchmark, because the stock and the futures markets have different market structures. Peterson and Leuthold argue that zero mean profits should be a benchmark for futures markets because of two reasons: (1) regular dividend payments in the stock market represent the equilibrium expected profits or returns, while share price increases become the excess returns (Fama). However, because futures contracts have no guaranteed return, there is nothing analogous to a dividend payment. The equilibrium expected profits or returns are, therefore, zero; (2) unlike the stock market, the futures market is a zero-sum game in which there are an equal number of longs and shorts, so that gains for one side are equal to losses for the other side. Empirical evidence (e.g., Lukac, Brorsen, and Irwin; Silber; Kho) also shows that buy-and-hold returns in most futures markets are nearly zero or negative. Thus, consistent with previous studies (e.g., Peterson and Leuthold; Irwin and Uhrig; Lukac, Brorsen, and Irwin; Lukac and Brorsen), zero mean profits are used as a benchmark.

Trading Model

The trading model is a general procedure to process input data and produce the required output by programming trading strategies and other relevant assumptions. The trading model typically consists of input data, technical trading systems, performance measures, the optimization method, and other important assumptions. When run on computer, it emits specific results for performance of technical trading rules. As mentioned in the introduction, this study duplicates Lukac, Brorsen, and Irwin's trading model as closely as possible for the purpose of confirmation and replication, thereby employing the same trading systems, optimization method, out-of-sample verification length, transaction costs, rollover dates, and other assumptions. Each component of the trading model is described next.

Input Data

The trading model uses daily futures price series as the input data. Since futures contracts have a limited life span, there are several ways to construct a data series to simulate technical trading systems. One of the frequently used approaches in the literature is to make a continuous price series by simply linking the contracts closest to expiration, i.e., the nearby contracts (Levich and Thomas; Szakmary and Mathur). However, this approach has two problems. The first problem arises when price differences between the old and new nearby contracts are large enough to create discontinuous breaks in the price series. The second problem in using the linked nearby contract series is that trading signals on the new nearby contract are affected by price movements of the old nearby contract for some periods after the rollover between the two contracts occurs. To avoid these problems, researchers (e.g., Lukac, Brorsen, and Irwin; Silber; Sullivan, Timmermann, and White) propose another approach in which an existing position in the current 'dominant' contract is liquidated on a rollover date and a new position in the next 'dominant' contract is simultaneously established according to a trading signal generated by applying a given trading rule to past data of the new 'dominant' contract. The dominant contract is defined as a contract which has the highest open interest among contracts (Dale and Workman). In most cases, the dominant contract accords with the nearby contract, but does not always. This study assumes that the current dominant contract rolls over the new dominant contract on the second Tuesday of the month preceding its delivery month. According to Lukac, Brorsen, and Irwin, this approach is consistent with the price series used by actual technical traders.

Performance Measures

Past studies, including Lukac, Brorsen, and Irwin's work, that evaluated the performance of technical trading systems in futures markets often measured trading profits in terms of dollar returns and/or percent returns to total investment. However, several recent studies (e.g., Kho; Szakmary and Mathur; Sullivan, Timmermann, and White) measure a holding period return or the continuously compounded (log) return per unit. These return measures allow a direct comparison between futures trading returns and returns on alternative investments, because studies of the stock market or the foreign exchange market typically compute trading profits as percent returns per unit. Although defining a rate of return may be problematical because there is no initial investment except for a margin deposit in the futures market, Kho argues that "it provides a sufficient statistic for testing the profitability of trading rules because there exists a one-to-one correspondence between a daily price change and dollar gains" (p. 252). The continuously compounded daily gross return on a technical trading rule *k* at time *t* can be calculated by:

(1) $$r^{G}_{k,t+1} = [\ln(P_{t+1}) - \ln(P_t)]S_{k,t},$$

where P_{t+1} and P_t are futures prices at time $t+1$ and *t*, respectively, and $S_{k,t}$ is an indicator variable that takes one of three values: +1 for a long position, 0 for a neutral position (i.e., out of the market), and –1 for a short position.[2] Measuring trading returns on a daily basis is consistent with the process of the daily settlement (marking-to-market) in the futures market.

The net return provides a measure of trading returns beyond transaction costs. Therefore, this study uses net return as a performance measure to choose optimal trading rules during in-sample periods and evaluate their out-of-sample performance. Net return per trade is calculated by subtracting an estimated transaction cost per trade from gross return per trade. This calculation includes every rollover trade. The daily net trading return is given by:

(2) $$r_{k,t+1} = r^{G}_{k,t+1} + d_{t+1}\left(\frac{n_k}{N^{in}_k}\right)\ln(1-c),$$

where n is the number of round-trip trades for a contract, N^{in} is the number of days "in" the market (e.g., $N^{in} = N - N^{out}$, where N^{out} is the number of days "out" of the market), d_{t+1} is an indicator variable having a value of 1 for in-days and 0 for out-days, and *c* is round-trip proportional transaction costs.

Jensen's definition of the efficient markets hypothesis implies that a technical trading rule is profitable only if its risk-adjusted profits exceed transaction costs incurred from implementing trades. Several techniques have been used in the technical trading literature to explicitly measure the risk-adjusted performance of trading rules. One of the most widely used risk-adjusted performance criteria is the Sharpe ratio that accounts for the excess return per unit of total risk. Since futures traders can deposit Treasury bills for margin requirement, there is no need to sacrifice the risk-free return in order to participate in an alternative investment. Thus, the ex post measure of the Sharpe ratio (SR_k) of a trading rule *k* can be calculated by:

---

[2] P_t may differ depending on the execution price of a trade. It could be today's closing price, tomorrow's open price, or a daily stop.

(3) $SR_k = \bar{r}_k / \hat{\sigma}_k$,

where $\bar{r}_k$ and $\hat{\sigma}_k$ indicate the annualized mean net return and standard deviation, respectively, during a sample period.

Transactions Costs

It is apparent that transaction costs are an important factor that influences net trading returns. Following Lukac, Brorsen, and Irwin, this study applies round-trip proportional transaction costs corresponding to dollar transaction costs of $100 per contract per round-trip trade for the entire sample period. The $100 transaction costs include both the brokerage commission and the bid-ask spread, which is also referred to as execution costs, liquidity costs, or skid error.[3] Since data for the bid-ask spread in futures markets are not formally available, they have been estimated in various ways. Table 3 presents estimation methods and results of previous studies. The table indicates that estimates of the bid-ask spread in the 12 futures markets analyzed in this study range $3-$25 per contract, although they differ depending on the estimation methods and sample periods.[4] This implies that brokerage commissions assumed in Lukac, Brorsen, and Irwin's study would be equal to or more than $75 per round-turn, which is quite conservative compared to those of other studies. For example, Szakmary and Mathur (1997) and Wang assumed a brokerage commission of $25 per contract per round-turn, and Levich and Thomas estimated a much smaller brokerage commission of $11.00. Commissions through discount brokers are around $12.50 per round turn (Lukac, Brorsen, and Irwin; Lukac and Brorsen), and even lower for both high volume traders and electronic trades introduced in the early 1990s. Thus, this study assumes a second scenario for transaction costs by lowering brokerage commissions after Lukac, Brorsen, and Irwin's sample period as follows: $50 for 1985-1994 and $25 for 1995-2003 period. As a result, transaction costs for the second scenario are $100 for 1978-1984, $75 for 1985-1994, and $50 for 1995-2003.

The dollar transaction costs can be converted into a percentage transaction cost per unit by dividing the dollar transaction costs by an average contract value, which is in turn obtained from multiplying the number of units of a contract by an average closing price. Since the average contract value differs across contracts, the percentage transaction cost also differs. For example, if the March and May corn contracts have average contract values of $10,000 and 12,500, respectively, the percentage transaction costs for each contract would be 1% (= 100/10,000) and 0.8% (= 100/12,500) for the dollar transaction costs of $100. Given the dollar transaction costs, the larger the contract value, the less the percentage transaction costs.

---

[3] There are also miscellaneous fees, such as the clearing fee, exchange fee, and floor brokerage fee, imposed by exchanges. However, these fees are negligible, totaling of approximately $2 per contract (Wang, Yau, and Baptiste).

[4] Note that there is another component of transaction costs that is not reflected in the bid-ask spread: market-impact (or price-impact) effects. Market-impact arises in the form of price concessions for large trades and its magnitude depends on market depth, which is defined as the maximum number of shares that can be traded within a given price range. In general, when a market is tight (wide bid-ask spread), it lacks depth (Engle and Lange, 2001).

Optimization and Other Assumptions

Optimization refers to a method of determining the best parameter or parameter combination of a trading system based on a performance measure. According to the survey results by Brorsen and Irwin, most CTAs select parameters of their trading systems by optimizing over historical data, although there is no consensus on how much data to use to select the parameters.[5] Taylor argues that the correct procedure to assess the profitability of technical trading is to choose the optimal parameter using the first part of the available data (optimization) and then evaluate the parameter upon the remaining data (out-of-sample verification), since traders cannot guess the best trading rule ahead of time. Out-of-sample verification is also an important factor in testing the performance of technical trading strategies due to the danger of data snooping (or model selection) biases. If an optimal trading rule would perform well both in- and out-of-sample periods, it is less likely that the trading rule was chosen by snooping data. Of course, there still remains the possibility that the trading rule was profitable during the in- and out-of-sample periods just by chance.

This study uses the same three-year re-optimization method as in Lukac, Brorsen, and Irwin without 'snooping' for a well-performing optimization method. For each trading system and each market, the optimization method simulates trading using the past three-years of data over a wide range of parameters. The parameters showing the best performance over the three-year period are then used for the out-of-sample trading in the next year. At the end of the next year, new optimal parameters are selected, and this procedure is repeated during the rest of the sample period. For example, the optimal parameters of a trading system for 1993 are parameters that generate the highest mean net return from 1990 through 1992. The optimal parameters are then used for out-of-sample trading in 1993, and at the end of 1993 new optimal parameters for 1994 are selected using the data from 1991 through 1993, and so forth. This procedure ensures that all the technical trading systems are adaptive and all the trading results are out-of-sample.

For futures markets having daily price limits, no trading occurs when a price moves more than the daily allowable limit above or below the previous day's settlement price. Thus, it is important to correctly account for the effect of daily trading limits. In this study, neither the current position is closed out nor a new position is taken if the high, low, and closing prices in a day are equal (lock-limit day), or if the execution price (e.g., today's closing or next day's opening prices) is up or down the daily allowable limit. Instead, the deferred order is placed at the next execution price as long as the new trading signal still holds and the price is not subject to the daily price limit.

Several other important assumptions are included in the trading model. First, all trading is on a one contract basis, i.e., only one contract is used for each transaction. Second, no pyramiding of positions or reinvestments of profits is allowed. Third, sufficient funds are assumed available to meet the margin requirement that may occur due to trading losses.

---

[5] About 30% of the advisors used historical data over five years and some used all the historical data they had available. The smallest amount of data used was two years.

Statistical Tests

Most previous technical trading studies applied the traditional *t*-test, the standard bootstrap, or the model-based bootstrap to measure statistical significance of technical trading profits. However, the *t*-test and standard bootstrap methods, which assume independently and identically distributed (IID) observations, may not be relevant for high-frequency time series data that is highly likely to be time-dependent. The model-based bootstrap can also deliver inconsistent estimates if the structure of serial correlation is not tractable or is misspecified (Maddala and Li, p. 465). Therefore, this study employs the stationary bootstrap, introduced by Politis and Romano. As a resampling procedure that is generally applicable to weekly dependent stationary time series, the stationary bootstrap preserves both enough of the dependence and stationarity of the original time series in the resampled pseudo-time series by resampling blocks of random length from the original series, where the block length follows a geometric distribution. Thus, the standard bootstrap can provide more improved statistical tests than the traditional statistical methods.

To test whether a technical trading rule *k* generates a mean net return superior to that of a benchmark strategy, the following form of a performance statistic, which is defined as differences in mean net returns between optimal trading rules and the benchmark, is constructed:

$$(4) \qquad \bar{Y}_k = N^{-1}\sum_{t=0}^{N-1} Y_{k,t+1},$$

where $Y_{k,t+1} = r^{G}_{k,t+1} + d_{t+1}(n_k / N^{in}_k)\ln(1-c),$ since zero mean profits are assumed as a benchmark. The null and alternative hypotheses are then defined as $H_0 : E(Y) = 0$ and $H_1 : E(Y) > 0$. This study uses the following resampling algorithm of the stationary bootstrap proposed by White (p. 1104): (i) Start by selecting a smoothing parameter $q = 1/b = q_N$, $0 < q_N \le 1$, $q_N \to 0$, $Nq_N \to \infty$ as $N \to \infty$. Since *q* is inversely related to the block length, a larger value of *q* may be used for data with little dependence, while a smaller value of *q* may be appropriate for data with more dependence. (ii) Set $t = 0$. Draw $\eta(0)$ at random, independently and uniformly from $\{0,\ldots, N-1\}$, where $\eta(t)$ denotes the random index at time *t*. (iii) Increment *t*. If $t > N-1$, stop. Otherwise, draw a standard uniform random variable *U* (supported on [0,1]) independently of all other random variables. (a) If $U < q$, draw $\eta(t)$ at random, independently and uniformly from $\{0,\ldots, N-1\}$. (b) If $U \ge q$, set $\eta(t) = \eta(t-1)+1$; if $\eta(t) > N-1$, reset to $\eta(t) = 0$. (iv) Repeat (iii). By implementing this resampling algorithm with a smoothing parameter $q = 0.1$, this study generates 1,000 bootstrap samples, $\bar{Y}^{*}_{k,i} = N^{-1}\sum_{t=0}^{N-1} Y^{*}_{k,\eta(t)+1}$, i = 1, …, 1,000, and then obtains the bootstrap *p*-value by comparing the sample value of $\bar{Y}_k$ to the percentiles of $\bar{Y}^{*}_{k,i}$.

Confirmation Results

To confirm Lukac, Brorsen, and Irwin's original out-of-sample results for 1978-1984, their annual portfolio mean gross returns are compared to gross returns calculated by applying the trading model of this study to their optimal parameters. Gross returns are a better performance measure to compare results from both studies because they are not contaminated by differences in the way transactions costs can be handled. Since Lukac, Brorsen, and Irwin calculated returns by the total investment method in which total investment was composed of a 30% initial investment in margins plus 70% held back for potential margin calls, continuously compounded returns calculated in this study are converted into the same return measure. The formula used is as follows:[6]

(5) $$r_{LBI} = (r_{PI} \times \bar{V}) / \{[(M/100) \times \bar{V}]/0.3\},$$

where r_{LBI} denotes returns measured by the total investment method, r_{PI} denotes continuously compounded returns, $\bar{V}$ denotes average contract value, and M denotes percent margin. The formula can be reduced to:

(6) $$r_{LBI} = r_{PI} \times (30/M).$$

In the original study, the percent margin was assumed to be 0.5% for T-bills, 5% for currencies, and 10% for other contracts. Therefore, Lukac, Brorsen, and Irwin's returns can be approximated by multiplying continuously compounded returns by 60 for T-bills, 6 for currencies, and 3 for other contracts.

Table 4 provides the results. The first three columns, labeled (1) to (3) in the table, present Lukac, Brorsen, and Irwin's original out-of-sample results and include annual portfolio gross returns, net returns, and transaction costs for each trading system across the 12 futures markets.[7] The next three columns, labeled (4) to (6), show the corresponding results obtained from applying our trading model to their optimal parameters, and the last three columns, labeled (7) to (9), indicate results obtained from applying our trading model to our optimal parameters. When comparing the original results (column (1)) and our results with the original optimal parameters (column (4)), the trading model developed in this study generates similar annual gross returns to those of the original study in the DMC, DRM, PAR, and DRP systems. For other trading systems, however, gross returns are quite different. In particular, the 5 trading systems (MAB, LSO, DRI, RNQ, and REF) that generated negative gross returns in the original study produce positive gross returns using our trading model. Trading models from both studies generate positive gross returns in the CHL, MII, and ALX systems, but differences in the size of gross returns are non-trivial. The last set of results (column (7)) show that annual gross returns for our trading model using our optimal parameters are higher than or equal to those for our trading model using the original optimal parameters for 9 of the 12 trading systems, although average gross returns are quite similar (42.2% and 35.8%, respectively). Average gross returns for our trading model using our optimal parameters are also not dramatically different from the returns for the original model using the original optimal parameters (42.2% and 28.2%, respectively). However there are large differences in transaction costs.

Similar results are found in the correlation analysis. Since Lukac, Brorsen, and Irwin reported only annual net returns for each trading system across markets and sample years, we calculate correlation coefficients between annual net returns derived from our trading model and

[6] We thank Wade Brorsen for providing us with the formula.

[7] We use Lukac, Brorsen, and Irwin's original results as reported in their 1990 book. This book contains the same results as reported in their 1988 study with more details, including optimal parameters for each trading system and performance in each sample year.

theirs. For each trading system, 78 pairs of annual net returns are obtained.[8] Results show that correlation coefficients range from 0.60 for the CHL system to 0.82 for the MII system, with an average correlation coefficient of 0.71. The CHL, DRI, RNQ, ALX, and PAR systems appear to have lower correlation coefficient than the average. In addition, for 650 of 858 possible cases (about 76%) annual net returns from both trading models have the same signs.[9] Sign consistency is lower than average in the MAB, CHL, DRI, RNQ, and REF systems, ranging 67%-72%.

Differences in our results versus the original study can be caused by various factors. Lukac, Brorsen, and Irwin used a different version of the CHL system from that in Barker, while this study adopted Barker's original version because of its simplicity and generality. Results for the ALX, PAR, and DRP may differ because the initial trend and extreme points (local high and low prices) can be determined arbitrarily by researchers. The DRM system may also produce different returns, depending on how an initial entry point into trading is set. On the other hand, the continuously compounded returns used in this study have slight downward (upward) biases against Lukac, Brorsen, and Irwin's positive (negative) returns that were calculated by using the total investment method. In addition, when converting dollar transaction costs into percentage transaction costs, the average contract value that affects the size of net returns may differ depending on which prices are used in the calculation. Other sources, such as programming errors, clerical errors, and differences in data (original prices and daily price limits), may also cause differences in results. For example, several clerical errors were found in table A.12 in Lukac, Brorsen, and Irwin (1990), which includes optimal parameters for the ALX system. As another example, results for the MAB system in the original study are questionable. Since both the MAB and the DMC systems are based on moving averages, they tend to produce similar returns. However, gross returns for the two systems in Lukac, Brorsen, and Irwin's study have the opposite sign and the magnitude of the difference in returns between both systems seem to be excessively large (83.2% per year in terms of the annual net return). In the light of the positive gross returns for the MAB system generated in both sets of results for the present study, this points towards some type of programming error for the MAB system in the original study.

Despite the differences in results detailed above, average gross returns across the 12 systems for our trading model using our optimal parameters and Lukac, Brorsen, and Irwin's original optimal parameters are quite similar. Moreover, average gross returns for our trading model using our optimal parameters are comparable to those for the original model using the original optimal parameters, although there are large differences in transaction costs. Overall, we find even more evidence of profits than in the original study, confirming the basic thrust of Lukac, Brorsen, and Irwin's conclusions.

---

[8] Note that the 3 financial contracts have 5-year out-of-sample periods and the other 9 contracts have 7-year out-of-sample periods. Annual net returns of the LSO system are not included in the calculation of correlation coefficients because Lukac, Brorsen, and Irwin misspecified values of the second parameter (reference interval), which must not exceed values of the first parameter (price channel).

[9] The 858 cases are derived from the following calculation: [3 (financial markets) × 5 (sample years) × 11 (trading systems)] + [9 (the rest of markets) × 7 (sample years) × 11 (trading systems)]. The LSO system is not counted due to the same reason cited in footnote 8.

Replication Results

The next step in the procedure is to replicate Lukac, Brorsen, and Irwin's trading model on a new set of data from 1985-2003. Parameters of each trading system are optimized based on the mean net return criterion using the past three years of price data, and then the optimal parameters are used for next year's out-of-sample trading. Tables A.1-A.12 in appendix provide the optimal parameters across trading systems and markets for the entire sample period and tables 5-9 report the performance of optimal trading rules for each sample period, including the original sample period, 1978-1984. The original sample is included in order to apply consistent statistical tests to the entire time period under study.[10]

As noted previously, statistical significance tests on technical trading returns are performed by implementing the stationary bootstrap algorithm. In this resampling procedure, a bootstrap sample represented as a mean net return is obtained by randomly resampling daily net return series during a sample period, with a bootstrap smoothing parameter of 0.1 that implies a mean block length of 10. The smoothing parameter produces serial dependence in the net return series, and the random length of blocks follows a geometric distribution. By repeating the procedure 1,000 times, for individual trading systems and an equally weighted portfolio of 12 trading systems, we construct 1,000 bootstrap samples and obtain a *p*-value by comparing an actual mean net return in a sample period to the quantiles of the 1,000 bootstrap samples. A slightly different procedure is used to bootstrap portfolio returns for 12 markets. Specifically, since trading days differ slightly from market to market, return series on an equally weighted portfolio of 12 markets in each trading system consists of monthly net returns, and 1,000 bootstrap samples are constructed with a bootstrap smoothing parameter of 1 under the assumption that monthly net returns are independent.[11]

As shown in table 5, during the first out-of-sample period (1978-1984 for agricultural commodities and metals; 1980-84 for financials) technical trading strategies generate economically and statistically significant profits in 6 of 12 markets. Specifically, significant annual mean net returns are found in corn by 4 (LSO, MII, DRI, and RNQ) out of the 12 systems, lumber by 5 systems (DMC, LSO, MII, DRI, and RNQ), sugar by 5 systems (MII, RNQ, DRM, ALX, and DRP), silver by 3 systems (ALX, PAR, and DRP), Deutsche mark by 9 systems (MAB, DMC, MII, DRI, RNQ, REF, DRM, PAR, and DRP), and T-bills by 6 systems (MAB, LSO, DRM, ALX, PAR, and DRP). An equally weighted portfolio of 12 trading systems generates statistically significant annual mean net returns in 4 markets: 24.48% for sugar, 21.65% for silver, 7.64% for mark, and 2.37% for T-bills. The corresponding Sharpe ratios are 0.74, 0.80, 0.96, and 0.76, respectively. All of the 12 trading systems, except the CHL system, show significant returns in more than one market. Among the trading systems, 5 systems (MII, DRI, REF, DRM, and DRP) generate significant returns (6.42%, 4.35%, 6.04%, 8.09%, and 5.52%, respectively) for an equally weighted portfolio of 12 markets, with Sharpe ratios ranging from 0.50 to 0.67. Lukac, Brorsen, and Irwin found that 4 systems (DMC, CHL, MII, and DRP) had statistically significant portfolio mean net returns during the same sample period. The

[10] Statistical tests using the stationary bootstrap appear to be slightly more conservative than those using conventional *t*-tests. The results of *t*-tests are available from the authors upon request.

[11] Results of statistical tests for the portfolio are insensitive to bootstrap smoothing parameters over 0.8.

portfolio annual mean net return across the 12 markets and 12 trading systems is 4.13% with a Sharpe ratio of 0.53, and is statistically significant at the 10% level. Overall, it is evident that technical trading rules were profitable in futures markets during the earlier sample period, even on a risk-adjusted basis.

Table 6 presents the replication results for the new set of data from 1985 through 2003. During this later sample period the profitability of technical trading rules declined sharply across all 12 futures markets, compared to the earlier sample period. Technical trading strategies make statistically significant profits only in two markets, the mark and T-bills. For the mark, the REF system generates an annual mean net return of 4.10% with a Sharpe ratio of 0.38, and for T-bills the ALX, PAR, and DRP systems generate annual mean net returns of 0.69%, 0.47%, and 0.44% with Sharpe ratios of 0.56, 0.39, and 0.42, respectively. The poor performance of individual trading systems results in statistically insignificant positive portfolio returns for both the mark (1.85%) and T-bills (0.17%), and negative returns for the rest of 10 markets. Note that the mark and T-bills have shorter out-of-sample periods, which are 1985-1998 and 1985-1996, respectively. In addition, no trading system earns positive net returns for a portfolio of 12 futures markets. As a result, the portfolio annual mean net return across the 12 markets and 12 trading systems drops to -5.82%.

To investigate whether the drop in trading rule profits is related to the assumptions for transaction costs, we re-simulate all 12 trading systems with lower transaction costs of $75 for the 1985-94 period and $50 for the 1995-2003 period. As presented in table 7, results show that trading returns for a portfolio of 12 trading systems are still negative for all but financial markets (0.18% for the pound, 2.36% for the mark, and 0.23% for T-bills), although the portfolio returns increase slightly across all markets. Moreover, portfolio returns for three financial markets are still statistically insignificant. With the lower transaction costs, the portfolio annual mean net return across the 12 markets and 12 trading systems is still only -3.80% and statistically insignificant. Hence, the profitability of technical trading strategies in the earlier and relatively short sample period disappears in the subsequent long sample period.

Table 8 presents the performance of technical trading rules for the full sample period, 1978-2003. As suggested by previous results, during the full sample period technical trading strategies generate statistically significant returns only for the mark and T-bills. Six trading systems (MAB, CHL, MII, REF, DRM, and DRP) yield statistically significant returns for the mark, and 6 systems (MAB, LSO, DRM, ALX, PAR, and DRP) for T-bills. For both markets, a portfolio of 12 trading systems yields statistically significant returns of 3.38% and 0.82% with Sharpe ratios of 0.42 and 0.44, respectively. When compared to the earlier performance, however, profit levels and the number of profitable markets and trading systems are greatly reduced. The portfolio annual mean net return across the 12 markets and 12 trading systems is -3.14%. As indicated in table 9, assuming lower transaction costs over the 1985-2003 period has no substantial effect on the results. The aggregate portfolio return increases only to -1.67%. Hence, if a hypothetical investor would trade in all 12 futures markets using all trading systems during the 1978-2003 period, the investor would have earned negative profits despite his/her successful achievement in the earlier period.

Further examination of the results of the full sample period documents that the profitability of technical trading strategies has declined over time. The following simple regression equation is estimated:

(7) $y_{j,t} = \alpha_j + \beta_j x_t + \varepsilon_{j,t}$,

where α_j is the intercept parameter, β_j is a linear trend parameter, $y_{j,t}$ is annual mean net returns of a portfolio *j*, x_t is a time trend, and $\varepsilon_{j,t}$ is an error term. Table 10 presents estimation results for equation (7). Interpretation of the coefficients is quite straightforward. For example, the estimates for corn suggest that the annual mean net return across all 12 technical trading systems begins at 4.85% in 1978 and then declines by around 0.70 percentage points each year until 2003. As shown in table 10, the trend coefficient is negative in 10 of the 12 markets, and the negative coefficients are statistically significant in six markets (corn, sugar, silver, pound, mark, and T-bills) at the 10% level. Although the trend coefficient shows positive values for two markets (live cattle and copper), it is not much different from zero with insignificant *t*-statistics. Results for the individual trading systems provide even stronger evidence of the decreasing profitability of technical trading strategies. The trend coefficient is significantly negative for all 12 trading systems at the 10% significance level, and for 9 of them it is statistically significant at the 1% level. As a result, the portfolio return generated by the 12 trading systems has declined by an average of 0.52 percentage points each year over 1978-2003.

Figures 1-3 show the declining pattern of technical trading profitability for representative markets and trading systems and the portfolio of 12 futures markets. Dark bold lines in the figures indicate the linear trend. Figure 3 vividly illustrates that technical trading strategies on average performed well in the earlier sample period (1978-1984) and that their performance has gradually deteriorated during the later sample period (1985-2003).

Summary and Conclusions

Previous empirical studies often find that technical trading strategies are profitable in a variety of speculative markets. However, most academics are skeptical about the positive evidence mainly due to data snooping problems. In the technical trading literature, data snooping practices appear to be widespread because researchers have a strong tendency to search for profitable "families" of trading systems, markets, and trading model assumptions, as well as profitable trading rules in a trading system. This study, as suggested by a number of researchers in economics, addresses the data snooping problem by confirming the results of an original study of technical trading rules and then replicating the procedures on a new body of data. Specifically, to determine whether technical trading rules have been profitable in US futures markets, this study confirms and replicates a well-known 1988 study by Lukac, Brorsen, and Irwin.

The Lukac, Brorsen, and Irwin study included comprehensive tests on 12 US futures markets using a wide range of technical trading systems, trading rule optimization, and out-of-sample verification. An additional benefit in the present context is that the 12 futures markets are weighted towards agricultural and natural resource commodities (commodities: corn, soybeans, cattle, pork bellies, sugar, cocoa and lumber; metals: copper and silver; financials: British pound, Deutsche mark and US T-bills). The original framework is duplicated as closely as possible by preserving all the trading model assumptions in Lukac, Brorsen, and Irwin's work, such as trading systems, markets, optimization method, out-of-sample verification length, transaction costs, rollover dates, and other important assumptions.

In the confirmation step, the original annual portfolio mean gross returns obtained by Lukac, Brorsen, and Irwin were compared to gross returns calculated by applying our trading model to their optimal parameters. Gross returns are a better performance measure to compare results from both studies because they are not contaminated by differences in the way transactions costs can be handled. In addition, correlation coefficients between annual net returns derived from our trading model and theirs were calculated and sign consistency of annual net returns from both trading models was checked. In the replication step, the trading model was applied to a new set of data from 1985-2003. Parameters of each trading system were optimized based on the mean net return criterion and then out-of-sample performance was evaluated. Statistical significance of technical trading returns was measured via a stationary bootstrap, which is generally applicable to weekly dependent stationary time series. By minimizing, if not eliminating, the deleterious impacts of data snooping this study provided a true out-of-sample test for the profitability of technical trading rules.

The results confirmed Lukac, Brorsen, and Irwin's original positive findings on profitability. During the earlier out-of-sample period (1978-1984), technical trading rules generated statistically significant economic profits in 6 (corn, lumber, sugar, silver, mark, and T-bills) of 12 futures markets. The portfolio annual mean net return across the 12 markets and 12 trading systems was 4.13% with a Sharpe ratio of 0.53, and was statistically significant at the 10% level. However, the replication results on new data showed that the earlier successful performance of the technical trading rules did not persist in the later sample period, l985-2003. Trading systems continued to generate statistically significant profits only for the mark and T-bills. As a result, the portfolio annual mean net return across the 12 markets and 12 trading systems dropped to -5.82%. Regression analysis showed that a time trend coefficient was significantly negative for all 12 trading systems at the 10% level, so that the portfolio return generated by the 12 trading systems declined by an average of 0.52 percentage points each year over 1978-2003. In sum, the substantial trading profits in the earlier sample period were no longer available in the subsequent sample period.

There are three possible explanations for the disappearance of technical trading profits in the 1985-2003 period: (1) data snooping biases (or selection bias) in previous studies, (2) structural changes in futures markets, and (3) the inherently self-destructive nature of technical trading strategies. To begin, the results of this study showed that over a relatively long time period US futures markets were informationally efficient at least with respect to past prices. Lukac, Brorsen, and Irwin's successful finding, therefore, might result from examination of a relatively short and profitable sample period by chance. As noted previously, data snooping problems can occur by searching for profitable in- and out-of-sample periods, trading systems, and trading model assumptions, as well as profitable trading rules. As another explanation, Kidd and Brorsen report that returns to managed futures funds and commodity trading advisors (CTAs), which predominantly use technical analysis, declined dramatically in the 1990s, and such a decrease in technical trading profits could be caused by structural changes in markets, such as reduced price volatility and increased kurtosis of daily price returns occurring while markets are closed. For example, since technical trading strategies make profits by the process of a market shifting to a new equilibrium, there may be fewer opportunities for profitable trading if prices are not volatile. Finally, financial forecasting methods are likely to be self-destructive (Malkiel; Schwert; Timmermann and Granger). New forecasting models may produce economic profits when first introduced. However, once these models become popular in the industry, their information is likely to be impounded in prices, and thus their initial profitability may disappear. Schwert finds that a wide variety of market anomalies in the stock market such as the size effect and value effect tend to have disappeared after the academic papers that made them famous were published.

These findings and conclusions contribute to the ongoing debate within the agricultural economics profession about what should be taught in marketing Extension programs. Schroeder et al. report that both producers and extension economists believe that pre-harvest hedging and market timing strategies exist that allow producers to increase prices received. The results of the present study do not support this view if it is based upon technical trading systems. More generally, the results cast doubt on the usefulness of including material on technical trading systems in marketing Extension programs. Since this study directly examined only technical trading systems, it is possible that other forms of technical analysis, such as chart patterns, gaps, retracements, and reversals, may still be useful to producers in their marketing decisions. Nonetheless, the evidence provided by this study suggests a great deal of caution should be used in presenting to farmers any form of technical analysis as an effective method of predicting price movements.

Lastly, despite their usefulness, replication studies are by definition limited to the trading systems and markets analyzed in the original study. Timmerman and Granger argue that such a fixed approach may not uncover profitable models in dynamic markets. They suggest a strategy of testing a broad set of models in a large set of markets to uncover “hot spots of forecastability.” However, examining more trading systems, parameters, and/or contracts may result in data snooping biases unless dependencies across all trading rules tested are taken into account. Such data snooping biases may be properly accounted for through recently introduced statistical procedures, such as White’s Bootstrap Reality Check methodology. Future research along these lines would further improve our understanding of the profitability of technical trading rules in futures markets.

References

Alexander, S.S. "Price Movements in Speculative Markets: Trends or Random Walks." *Industrial Management Review*, 2(1961):7-26.

Angrist, S.W. "Futures Shock: Investors Cope with Slippage." *Wall Street Journal*, 30 April 1991, p. C1, C9.

Barker, D. *Commodity Systems Reports*. 1981.

Bhattacharya, M. "Transaction Data Tests of Efficiency of the Chicago Board of Options Exchange." *Journal of Financial Economics*, 12(1983):161-185.

Billingsley, R.S., and D.M. Chance. "Benefits and Limitations of Diversification among Commodity Trading Advisors." *Journal of Portfolio Management*, 23(1996):65-80.

Brock, W., J. Lakonishock, and B. LeBaron. "Simple Technical Trading Rules and the Stochastic Properties of Stock Returns." *Journal of Finance*, 47(1992):1731-1764.

Brorsen, B.W. "Liquidity Costs and Scalping Returns in the Corn Futures Market." *Journal of Futures Markets*, 9(1989):225-236.

Brorsen, B.W., and K.B. Anderson. "Agricultural Economics Research and Extension Marketing Programs: How Well Are They Integrated?" *Journal of Agribusiness*, 17(1999):135-147.

Brorsen, B.W., and S.H. Irwin. "Futures Funds and Price Volatility." *The Review of Futures Markets*, 6(1987):118-135.

Chang, P.H.K., and C.L. Osler. "Methodical Madness: Technical Analysis and the Irrationality of Exchange-Rate Forecasts." *Economic Journal*, 109(1999):636-661.

Cochrane, J.H. *Asset Pricing*. Princeton, NJ: Princeton University Press, 2001.

Cooper, M., and H. Gulen. "Is Time-Series Based Predictability Evident in Real-Time?" *Journal of Business*, forthcoming.

Dale, C., and R. Workman. "Measuring Patterns of Price Movements in the Treasury Bill Futures Market." *Journal of Economics and Business*, 33(1981):81-87.

Denton, F.T. "Data Mining as an Industry." *Review of Economics and Statistics*, 67(1985):124-127.

Donchian, R.D. "High Finance in Copper." *Financial Analysts Journal*, (1960):133-142.

Engle, R.F., and J. Lange. "Predicting VNET: A Model of the Dynamics of Market Depth." *Journal of Financial Markets*, 4(2001):113-142.

Fama, E.F. “Efficient Capital Markets: A Review of Theory and Empirical Work.” *Journal of Finance*, 25(1970):383-417.

Ferguson, M.F., and S.C. Mann. “Execution Costs and Their Intraday Variation in Futures Markets.” *Journal of Business*, 74(2001):125-160.

Fleming, J., B. Ostdiek, and R.E. Whaley. “Trading Costs and the Relative Rates of Price Discovery in Stock, Futures, and Option Markets.” *Journal of Futures Markets*, 16 (1996):353-387.

Followill, R.A., and A.J. Rodriguez. “The Estimation and Determinants of Bid-Ask Spreads in Futures Markets.” *The Review of Futures Markets*, 10(1991):1-11.

Fung, W., and D.A. Hsieh. “Survivorship Bias and Investment Style in the Returns of CTAs.” *Journal of Portfolio Management*, 24(1997b):30-41.

Gartley, H.M. *Profits in the Stock Market*. New York, NY: H.M. Gartley Inc., 1930.

Greer, T.V., B.W. Brorsen, and S.-H. Liu. “Slippage Costs in Order Execution for a Public Futures Fund.” *Review of Agricultural Economics*, 14(1992):281-288.

Irwin, S.H., and B.R. Holt. “The Impact of Large Hedge Fund and CTA Trading on Futures Market Volatility.” In G.N. Gregoriou, V.N. Karavas, F.S. L’Habitant, and F. Rouah (ed.) *Commodity Trading Advisors: Risk, Performance Analysis and Selection* (pp. 151-182). New York: John Wiley & Sons, Inc., 2004.

Irwin, S.H. and Uhrig, J.W. “Do Technical Analysts Have Holes in Their Shoes?” *Review of Research in Futures Markets*, 3(1984):264-277.

Jensen, M.C. “Random Walks: Reality or Myth–Comment.” *Financial Analysts Journal*, 23 (1967):77-85.

Jensen, M.C. “Some Anomalous Evidence Regarding Market Efficiency.” *Journal of Financial Economics*, 6(1978):95-101.

Kho, B. “Time-Varying Risk Premia, Volatility, and Technical Trading Rule Profits: Evidence from Foreign Currency Futures Markets.” *Journal of Financial Economics*, 41(1996): 249-290.

Kidd, W.V., and B.W. Brorsen. “Why Have the Return to Technical Analysis Decreased?” *Journal of Economics and Business* 56(2004):159-176.

Kuserk, G.J., and P.R. Locke. “Scalper Behavior in Futures Markets: An Empirical Examination.” *Journal of Futures Markets*, 13(1993):409-431.

LeBaron, B. "Technical Trading Rule Profitability and Foreign Exchange Intervention." *Journal of International Economics*, 49(1999):125-143.

Leuthold, R.M. "Random Walk and Price Trends: The Live Cattle Futures Market." *Journal of Finance*, 27(1972):879-889.

Levich, R.M., and L.R. Thomas. "The Significance of Technical Trading Rule Profits in the Foreign Exchange Market: A Bootstrap Approach." *Journal of International Money and Finance*, 12(1993):451-474.

Levy, R.A. "Random Walks: Reality or Myth." *Financial Analysts Journal*, 23(1967a):69-77.

Lo, A., and A.C. MacKinlay. "Data Snooping Biases in Tests of Financial Asset Pricing Models." *Review of Financial Studies*, 3(1990):431-467.

Locke, P.R., and P.C. Venkatesh. "Futures Market Transaction Costs." *Journal of Futures Markets*, 17(1997):229-245.

Lovell, M.C. "Data Mining." *Review of Economics and Statistics*, 65(1983):1-12.

Lui, Y.H., and D. Mole. "The Use of Fundamental and Technical Analyses by Foreign Exchange Dealers: Hong Kong Evidence." *Journal of International Money and Finance*, 17(1998): 535-545.

Lukac, L.P., and B.W. Brorsen. "A Comprehensive Test of Futures Market Disequilibrium." *Financial Review*, 25(1990):593-622.

Lukac, L.P., B.W. Brorsen, and S.H. Irwin. "A Test of Futures Market Disequilibrium Using Twelve Different Technical Trading Systems." *Applied Economics,* 20(1988):623-639.

Lukac, L.P., B.W. Brorsen, and S.H. Irwin. *A Comparison of Twelve Technical Trading Systems.* Greenville, SC: Traders Press, Inc, 1990.

Ma, C.K., R.L. Peterson, and R.S. Sears. "Trading Noise, Adverse Selection, and Intraday Bid-Ask Spread in Futures Markets." *Journal of Futures Markets*, 12(1992):519-538.

Maddala, G.S. and H. Li. "Bootstrap Based Tests in Financial Models." In G.S. Maddala and C.R. Rao (ed.) *Handbook of Statistics 14* (pp. 463-488). Amsterdam: Elsevier Science B.V., 1996.

Malkiel, B.G. "The Efficient Market Hypothesis and Its Critics." *Journal of Economic Perspectives*, 17(2003):59-82.

Neftci, S.N. "Naïve Trading Rules in Financial Markets and Wiener-Kolmogorov Prediction Theory: A Study of 'Technical Analysis.'" *Journal of Business*, 64(1991):549-571.

Olson, D. “Have Trading Rule Profits in the Currency Markets Declined over Time?” *Journal of Banking and Finance*, 28(2004):85-105.

Park, C.H., and S.H. Irwin. “The Profitability of Technical Analysis: A Review.” AgMAS Project Research Report No. 2004-04, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, October, 2004. http://www.farmdoc.uiuc.edu/agmas.

Politis, D.N. and J.P. Romano. “The Stationary Bootstrap.” *Journal of the American Statistical Association*, 89(1994a):1303-1313.

Pring, M.J. *Technical Analysis Explained*. New York, NY: McGraw-Hill, 2002.

Roll, R. “A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market.” *Journal of Finance*, 39(1984):1127-39.

Samuelson, P.A. “Proof That Properly Anticipated Prices Fluctuate Randomly.” *Industrial Management Review*, 6(1965):41-49.

Schroeder, T.C., J.L. Parcell, T.L. Kastens, and K.C. Dhuyvetter. “Perceptions of Marketing Strategies: Producers versus Extension Economists.” *Journal of Agricultural and Resource Economics*, 23(1998):279-293.

Schwager, J.D. *Schwager on Futures*: *Technical Analysis*. New York, NY: John Wiley & Sons, 1996.

Schwert, G.W. “Anomalies and Market Efficiency.” In G. Constantinides, M. Harris and R. Stulz (ed.) *Handbook of the Economics of Finance* (pp. 937-972). North-Holland, 2003.

Silber, W.L. “Technical Trading: When It Works and When It Doesn't.” *Journal of Derivatives*, 1(1994):39-44.

Smith, T., and R.E. Whaley. “Estimating the Effective Bid/Ask Spread from Time and Sales Data.” *Journal of Futures Markets*, 14(1994):437-455.

Sullivan, R., A. Timmermann, and H. White. “Data Snooping, Technical Trading Rule Performance, and the Bootstrap.” *Journal of Finance*, 54(1999):1647-1691.

Sullivan, R., A. Timmermann, and H. White. “Forecast Evaluation with Shared Data Sets.” *International Journal of Forecasting*, 19(2003):217-227.

Szakmary, A.C., and I. Mathur. “Central Bank Intervention and Trading Rule Profits in Foreign Exchange Markets.” *Journal of International Money and Finance*, 16(1997):513-535.

Taylor, M.P., and H. Allen. “The Use of Technical Analysis in the Foreign Exchange Market.” *Journal of International Money and Finance*, 11(1992):304-314.

Taylor, S.J. *Modeling Financial Time Series*. Chichester, England: John Wiley & Sons, 1986.

Thompson, S.R., and M.L. Waller. "The Execution Cost of Trading in Commodity Futures Markets." *Stanford Food Research Institute Studies*, 20(1987):141-163.

Thompson, S.R., J.S. Eales, and D. Seibold. "Comparison of Liquidity Costs Between the Kansas City and Chicago Wheat Futures Contracts." *Journal of Agricultural and Resource Economics*, 18(1993):185-197.

Timmermann, A., and C.W.J. Granger. "Efficient Market Hypothesis and Forecasting." *International Journal of Forecasting*, 20(2004):15-27.

Tomek, W.G. "Confirmation and Replication in Empirical Econometrics: A Step toward Improved Scholarship." *American Journal of Agricultural Economics*, 75(1993):6-14.

Wang, G.H.K., J. Yau, and T. Baptiste. "Trading Volume and Transaction Costs in Futures Markets." *Journal of Futures Markets*, 17(1997):757-780.

White, H. "A Reality Check for Data Snooping." *Econometrica*, 68(2000):1097-1126.

Wilder, J.W. *New Concepts in Technical Trading Systems*. Trend Research, Greensboro, NC: Hunter Publishing Company, 1978.

Wyckoff, R.D. *Studies in Tape Reading*. Burlington, VT: Fraser Publishing Company, 1910.

Table 1. Description of Futures Data, 1975-2003

Commodity	Exchange[a]	Contract Size	Value of One Tick	Daily Price Limit	Contract Months Used
Corn (C)	CBOT	5,000 bu.	$12.50	10¢/15¢ per bu., expandable limits, before 7/15/93; 12¢/18¢ per bu., expandable limits, after 7/15/93; 20¢ (no more expanded limits) after 8/27/00.	Mar, May, Jul, Dec
Soybeans (S)	CBOT	5,000 bu.	$12.50	20¢/30¢ per bu., expandable limits, before 10/18/76; 30¢/45¢ per bu., expandable limits, after 10/18/76; 50¢ (no more expanded limits) after 8/27/00.	Jan, Mar, May, Jul, Nov
Cattle-Live (LC)	CME	40,000 lbs	$10.00	1¢/lb through Oct. 1974 contract; 1.5¢/lb beginning with Dec. 1974 contract; 1.5¢ /3¢/5¢ per pound, expandable limits, effective 10/15/03.	Feb, Apr, Jun, Aug, Oct, Dec
Pork Bellies (PB)	CME	36,000 lbs; 38,000 lbs, effective with Feb. 1979 contract; 40,000 lbs from Feb. 87 contract onwards.	$9.00; $9.50; $10.00	1.5¢/lb before 10/1975; 2¢/lb before 10/1/96; 2¢/3¢/4.5¢ per pound, expandable limits, after 10/1/96.	Feb, Mar, May, Jul, Aug
Lumber (LB)	CME	100,000 bd. ft. before 7/28/80; 130,000 before 3/16/88; 150,000 before 9/6/91; 160,000 before March 1996 contract; 80,000 before 8/11/00; 110,000 thereafter.	$10.00; $13.00; $15.00; $16.00; $8.00; $11.00	$5.00/thousand board feet; No limit in spot month beginning with November 1984 contract; $10.00/$15.00, expandable limits, effective 2/3/93.	Jan, Mar, May, Jul, Sep, Nov
British Pound (BP)	IMM	25,000 pounds; 62,500 pounds from Sep. 88 contract onwards	$12.50; $6.25	0.0500, expandable limits, after 3/18/74; No limit after 2/22/85.	Mar, Jun, Sep, Dec
Deutsch Mark (DM)	IMM	125,000 marks	$12.50	0.0060, expandable limits, after 6/9/75; 0.0100, expandable limits, after 9/5/1978; No limit after 2/22/85.	Mar, Jun, Sep, Dec
13-week Treasury Bills (TB)	IMM	$1,000,000	$25.00	0.50, expandable limits, before 6/18/80; 0.60, expandable limits, after 6/19/80; No limit after 12/19/85.	Mar, Jun, Sep, Dec
Cocoa (CC)	CSCE	30,000 lbs. for contract months through 11/80; 10 Metric Tons for contract months beginning with 12/80.	$3 for pound contract; $10 for Metric contract	Pound contract: 4¢, expandable to 6¢; Metric contract: $88, expandable to $132. For both contracts, limits are removed from the spot month on and after the first Notice day. No limit after 1998.	Mar, May, Jul, Sep, Dec
Sugar-World (SB)	CSCE	112,000 lbs.	$11.20	1/2¢, expandable in increments of 1/2¢ to a maximum of 2¢. Limits do not apply to the nearest two months. No limit after 1998.	Mar, May, Jul, Oct
Copper (HG)	COMEX	25,000 lbs.	$12.50	3¢, expandable limits, before 10/11/79; 5¢, expandable limits, before 5/29/87; 20¢, expandable limits, after 6/1/87.	Mar, May, Jul, Sep, Dec
Silver (SI)	COMEX	5,000 Troy oz.	$5.00 $25.00	20¢ before 9/1/79; 40¢, expandable limits, before 12/3/79; 50¢, expandable limits, before 5/29/87; $1.50, expandable limits, after 6/1/87.	Mar, May, Jul, Sep, Dec

[a] CBOT: Chicago Board of Trade.
CME: Chicago Mercantile Exchange.
COMEX: Commodity Exchange Division in the New York Mercantile Exchange.
CSCE: Coffee, Sugar and Cocoa Exchange in the New York Board of Trade.
IMM: International Monetary Market in Chicago Mercantile Exchange.

Table 2. Lukac, Brorsen, and Irwin's Trading Systems Categorized by System Type, Number of Parameters, and Time of Trading

Trading Systems	System Type	Number of Parameters	Time of Trading
Simple Moving Average with Percentage Price Band (MAB)	Moving average	2	Open
Dual Moving Average Crossover (DMC)	Moving average	2	Open
Outside Price Channel (CHL)	Price channel	1	Close
L-S-O Price Channel (LSO)	Price channel	2	Close/Stop
M-II Price Channel (MII)	Price channel	1	Close
Directional Indicator (DRI)	Momentum oscillator	2	Open
Range Quotient (RNQ)	Momentum oscillator	2	Open
Reference Deviation (REF)	Momentum oscillator	2	Open
Directional Movement (DRM)	Momentum oscillator	1	Stop
Alexander's Filter Rule (ALX)	Filter	1	Close
Parabolic Time/Price (PAR)	Filter	1	Stop
Directional Parabolic (DRP)	Combination system	2	Stop

Note: Time of trading denotes when trades are made: Open (Close) denotes that a trade based on today's trading signal is made at tomorrow's opening (today's closing) price; Stop denotes that a stop order was assumed to be given to a broker and the order exercised at the stop price; Close/Stop denotes that every market entrance (exit) is made at today's closing price (stop).

Table 3. Previous estimation results of the bid-ask spread in futures markets

Studies	Markets[a]	Data	Estimation Methods and Results
Thompson and Waller (1987)	Coffee and cocoa futures contracts in the CSCE	Transaction-to-transaction prices from 1981-83	Execution costs were estimated by the average of the absolute value of observed price changes. The average estimated execution costs per contract were $12.60 for nearby cocoa contracts and $32.25 for nearby coffee contracts.
Brorsen (1989)	Corn futures contracts in the CBOT	Intraday prices of 6 different contracts traded for 1983-84	Liquidity costs, which were estimated by Thompson and Waller's (1987) method, were approximately equal to the minimum price changes of $12.50 per contract.
Angrist (1991)	41 futures contracts in various exchanges	Stop-loss orders on 12,000 contracts executed by Lind-Waldock & Co. from 9/90-11/90	This article reported the results of a study, conducted by Lind-Waldock & Co., on slippage costs (execution costs) incurred by its customers. Average slippage per contract was: Eurodollars, $2.85; Five year notes 10.42; Muni bond index, 7.81; T-Bills, 4.17; T-Bonds, 4.60; British pound, 14.81; Canadian dollar, 9.26; Deutsche mark, 13.01; Dollar index, 10.96; Japanese yen, 11.15; Swiss franc, 13.48; Comex gold, 27.41; Copper, 19.96; Gold-kilo contract, 10.72; Palladium, 22.14; Platinum, 25.05; Silver, 20.12; Coffee, 28.06; Cocoa, 11.85; Orange juice, 35.00; Sugar, 17.93; Cotton, 14.95; Lumber, 33.21; Feeder cattle, 10.63; Live cattle, 5.45; Live hogs, 9.35; Pork bellies, 16.53; Soybean oil, 9.00; Corn, 7.39; Oats, 4.41; Soybeans, 5.86; Soybean meal, 8.07; Wheat, 7.21; Crude oil, 33.30; Gasoline, 20.07; Heating oil, 17.50; Natural gas, 46.67; Major market index, 37.50; S&P 500 index, 19.32; NYSE composite index, 37.70; CRB index, 6.25.
Followill and Rodriguez (1991)	4 futures contracts in the CME	Intraday series of price-changing transactions from 8/81-2/83	The effective bid-ask spread was estimated using Roll's (1984) procedure. Mean estimates of bid-ask spread were: T-bills, $17.48 ($25)[b]; Domestic CDs, 11.60 (25); Eurodollar deposits, 17.50 (25); S&P 500 Index, 12.84 (25).
Greer, Brorsen, and Liu (1992)	11 futures contracts in various exchanges	Trading records of a public futures fund from 7/84-12/86	Slippage costs of stop orders used by a large technical trader were investigated. Average slippage costs as a percentage of contract values were: World sugar, 0.21; Coffee, 0.09; Pork bellies, 0.15; Soybean meal, 0.10; Heating oil, 0.16; Japanese yen, 0.03; German mark, 0.04; T-Bills, 0.01; Copper, 0.17; Platinum, 0.43; Gold, 0.19. Average slippage in dollars per contract were: World sugar, 13.63; Coffee, 48.13; Pork bellies, 38.49; Soybean meal, 14.34; Heating oil, 37.35; Japanese yen, 18.53; German mark, 18.06; T-Bills, 62.86; Copper, 25.70; Platinum, 77.92; Gold, 65.80.
Ma, Peterson, and Sears (1992)	4 futures contracts in the CBOT	Intraday tick data from 1980-86	The bid-ask spread was estimated for every 30-minute interval using Bhattacharya's (1983) and Thompson and Waller's (1987) measures. In general, the bid-ask spread in the first and the last half hours of each trading session was significantly higher than the spread for the rest of the day. The mean bid-ask spread estimates were: T-bond, $32.19-$40.00 ($31.25); Silver, 1.06-1.28 (1); Soybeans, 19.85-23.60 (12.50); Corn, 12.90-15.45 (12.50).
Kuserk and Locke (1993)	12 commodity futures contracts in the CME	Computerized Trade Reconstruction (CTR) records from the CME for 7/90-9/90	The representative scalper's mean daily realized bid-ask spreads were measured. Currency and interest rate products appeared to have lower spreads, while agricultural futures had relatively high spreads: British pound, $6.16 ($12.5); Canadian dollars, 7.34 (10); Deutsche mark, 5.62 (12.5); Swiss franc, 7.66 (12.5); Japanese yen, 7.53 (12.5); Eurodollar, 8.14 (25); T-Bills, 14.37 (25); S&P 500 Index, 19.03 (25); Live cattle, 4.44 (10); Live hogs, 12.44 (10); Pork bellies, 11.89 (10); Feeder cattle, 21.24 (11).

[a] CBOT: Chicago Board of Trade.
CME: Chicago Mercantile Exchange.
CSCE: New York Coffee, Sugar, and Cocoa Exchange.
KCBOT: Kansas City Board of Trade.

[b] Numbers in parentheses indicate the minimum tick size per contract for each futures contract.

Table 3 continued.

Studies	Markets[a]	Data	Estimation Methods and Results
Thompson, Eales, and Seibold (1993)	4 wheat futures contracts in the CBOT and the KCBOT	Intraday price data from 1/85-6/85	Liquidity costs were measured using both Roll's (1984) method and Thompson and Waller's (1987) method. For the CBOT contracts liquidity costs were close to the minimum price movement of $12.50, while for the KCBOT contracts liquidity costs were much higher than the CBOT contracts. In general, liquidity costs were greater in contracts distant from maturity and in the delivery month than in those close to maturity but not in the delivery month.
Smith and Whaley (1994)	S&P 500 futures contracts in the CME	Time and sales data for the four nearby contracts for 4/82-10/87	Authors proposed a new estimation method of the bid-ask spread based on the first two moments of absolute price change distribution. The effective bid-ask spread ($25.40) estimated for the nearby S&P 500 futures contract was close to the minimum price movement ($25).
Fleming, Ostdiek, and Whaley (1996)	S&P 500 futures contracts in the CME	Intraday prices from the CME time and sales file in March 1991	The bid-ask spread was inferred using Smith and Whaley's (1994) method of moments spread estimator. For the nearby futures contract, the effective bid-ask spread was $0.0558 per unit, only slightly higher than the minimum tick size ($0.05, or $25.00 per contract).
Locke and Venkatesh (1997)	12 commodity futures contracts in the CME	Trade register data for nearby futures contracts from 1/1/92-6/30/92	The difference between the average purchase price and the average sale price for all futures customers was estimated with prices weighted by transaction size. The results were: Live hog, $7.30 ($10); Pork bellies, 10.32 (10); Live cattle, 3.07 (10); Lumber, 15.92 (16); Feeder cattle, 9.42 (11); Canadian dollar, 6.05 (10); Swiss franc, 20.89 (12.5); Deutsche mark, 14.28 (12.5); Pound sterling, 18.12 (12.5); Japanese yen, 17.47 (12.5); Eurodollars, 4.81 (25); S&P 500 Index, 16.58 (25).
Ferguson and Mann (2001)	14 commodity futures contracts in the CME	Computerized Trade Reconstruction (CTR) records from the CME for 1/92-6/92	Two different customer execution spreads (the mean customer buy price less the mean customer sell price for 5-minute intervals) were estimated. One is for all customer trades and the other is against market makers. The execution spread against market makers was: S&P 500 Index, $7.00 ($25); Mark, 5.92 (12.5); Swiss franc, 8.08 (12.5); Pound, 7.24 (12.5); Yen, 6.32 (12.5); Canadian dollar, 7.28 (10); Eurodollar, 3.81 (25); T-bills, 9.39 (25); LIBOR, 3.40 (25); Live cattle, 3.65 (10); Pork bellies, 11.60 (10); Hogs, 7.26 (10); Feeder cattle, 12.50 (10); Lumber, 25.55 (16).

[a] CBOT: Chicago Board of Trade.
CME: Chicago Mercantile Exchange.
CSCE: New York Coffee, Sugar, and Cocoa Exchange.
KCBOT: Kansas City Board of Trade.

[b] Numbers in parentheses indicate the minimum tick size per contract for each futures contract.

Table 4. Comparison of Annual Portfolio Mean Returns, 1978-1984[a]

Trading Systems	Lukac, Brorsen, and Irwin's Original Results[b]			When Applying the Trading Model of This Study to Lukac, Brorsen, and Irwin's Optimal Parameters[c]			When Using Optimal Parameters Identified by Applying the Trading Model of This Study		
	(1) Gross Returns	(2) Net Returns	(3) Transaction Costs	(4) Gross Returns	(5) Net Returns	(6) Transaction Costs	(7) Gross Returns	(8) Net Returns	(9) Transaction Costs
Simple Moving Average with % Price Band (MAB)	-27.5	-60.5	33.0	26.7	11.5	15.2	42.5	27.2	15.3
Dual Moving Average Crossover (DMC)	49.7	22.7	27.0	43.3	27.0	16.3	37.6	18.2	19.4
Outside Price Channel (CHL)	65.4	33.4	32.0	18.5	3.6	14.9	18.5	3.6	14.9
L-S-O Price Channel (LSO)	-0.3	-31.3	31.0	38.7	19.6	19.1	38.7	19.6	19.1
M-II Price Channel (MII)	65.2	25.2	40.0	38.0	14.7	23.3	47.8	25.9	21.9
Directional Indicator (DRI)	-16.9	-55.9	39.0	20.1	13.3	6.8	30.1	16.9	13.3
Range Quotient (RNQ)	-36.2	-79.2	43.0	36.9	12.4	24.5	33.3	8.7	24.5
Reference Deviation (REF)	-0.4	-28.4	28.0	39.2	24.8	14.4	35.4	21.8	13.6
Directional Movement (DRM)	53.8	12.8	41.0	51.6	26.4	25.2	65.6	43.7	21.9
Alexander's Filter Rule (ALX)	45.9	12.9	33.0	13.8	-1.8	15.5	43.5	29.0	14.6
Parabolic Time/Price (PAR)	59.5	3.5	56.0	46.7	13.3	33.4	55.7	22.8	32.9
Directional Parabolic (DRP)	79.9	31.9	48.0	56.2	27.3	28.9	58.0	31.2	26.8
Average	28.2	-9.4	37.6	35.8	16.0	19.8	42.2	22.4	19.9

[a] Continuously compounded returns obtained from the trading model of this study are converted into returns calculated by the total investment method in Lukac, Brorsen, and Irwin's trading model. Returns based on the total investment method can be approximated by multiplying continuously compounded returns by 60 for T-bills, 6 for currencies, and 3 for other contracts.

[b] These results are found in table 5 in Lukac, Brorsen, and Irwin (1990, p. 17).

[c] As a few exceptions, performance measures for the CHL and LSO systems are estimated using optimal parameters identified by this study, because Lukac, Brorsen, and Irwin used a different version of the CHL system and misspecified parameters in the LSO system. Also, several optimal parameters of the ALX system in Lukac, Brorsen, and Irwin's (1990, p. 58) results have values that go beyond the parameter range of the system. For example, the optimal parameter of the ALX system for sugar in 1978 was 24%, even though Lukac, Brorsen, and Irwin considered parameters ranging from 1% to 20%. These incorrect parameters are replaced with optimal parameters of this study.

Table 5. The Performance of 12 Technical Trading Systems, 1978-1984[a]

Market		Trading System[b]												
		MAB	DMC	CHL	LSO	MII	DRI	RNQ	REF	DRM	ALX	PAR	DRP	Portfolio
Corn	Net Return[c]	5.22	6.66	1.71	8.44*	8.81*	9.76**	7.03*	7.36	7.65	6.72	-11.69	-4.61	4.42
	Sharpe Ratio	0.33	0.39	0.11	0.52	0.51	0.64	0.47	0.48	0.45	0.42	-0.69	-0.30	0.34
Soybeans	Net Return	6.95	8.27	-5.59	1.58	3.20	1.35	0.67	1.10	7.13	0.95	-2.84	6.69	2.45
	Sharpe Ratio	0.33	0.36	-0.26	0.07	0.14	0.06	0.03	0.05	0.31	0.05	-0.12	0.36	0.14
Live Cattle	Net Return	-2.93	-7.14	-1.14	-6.67	-6.30	-5.10	-7.87	-5.58	-4.41	-6.91	-17.79	-8.97	-6.73
	Sharpe Ratio	-0.20	-0.39	-0.07	-0.40	-0.34	-0.36	-0.49	-0.33	-0.24	-0.39	-0.95	-0.55	-0.54
Pork Bellies	Net Return	-4.87	-7.79	-19.73	-8.40	-13.86	-0.01	-15.72	1.91	1.78	-1.43	5.06	8.44	-4.55
	Sharpe Ratio	-0.16	-0.22	-0.61	-0.27	-0.39	0.00	-0.52	0.06	0.05	-0.04	0.14	0.26	-0.19
Lumber	Net Return	9.23	15.34*	5.99	15.46**	15.63*	15.81**	14.09**	7.30	0.73	-5.12	-8.48	-0.26	7.14
	Sharpe Ratio	0.42	0.60	0.27	0.65	0.61	0.77	0.63	0.31	0.03	-0.22	-0.33	-0.01	0.41
Cocoa	Net Return	4.76	-2.15	8.42	-15.70	6.09	-6.28	-3.20	-1.86	6.85	-6.36	-14.32	3.87	-1.66
	Sharpe Ratio	0.17	-0.07	0.31	-0.57	0.20	-0.27	-0.13	-0.07	0.23	-0.22	-0.48	0.15	-0.08
Sugar (world)	Net Return	9.89	17.69	20.80	21.25	38.40**	17.58	21.72*	19.48	49.66***	25.00*	20.15	32.10**	24.48**
	Sharpe Ratio	0.24	0.40	0.50	0.49	0.85	0.45	0.54	0.45	1.10	0.56	0.46	0.89	0.74
Copper	Net Return	-13.38	-26.42	-14.22	-14.42	-10.88	-9.96	-21.21	-0.33	-6.37	-17.97	-5.46	-12.87	-12.79
	Sharpe Ratio	-0.66	-0.97	-0.59	-0.59	-0.40	-0.61	-0.92	-0.01	-0.23	-0.70	-0.20	-0.52	-0.73
Silver	Net Return	19.75	18.31	0.88	19.39	18.34	12.63	3.32	22.66	15.34	50.06***	49.13***	29.94**	21.65*
	Sharpe Ratio	0.60	0.51	0.03	0.56	0.51	0.37	0.09	0.65	0.43	1.44	1.38	0.96	0.80
Pound	Net Return	1.71	4.74	2.03	4.40	4.08	3.84	4.55	4.75	4.61	-4.11	4.87	2.20	3.14
	Sharpe Ratio	0.17	0.44	0.21	0.44	0.38	0.38	0.44	0.45	0.43	-0.38	0.46	0.23	0.39
Mark	Net Return	9.64**	7.90*	4.51	2.96	11.58***	9.56**	7.65*	6.94*	11.40**	3.63	8.03*	7.88*	7.64**
	Sharpe Ratio	0.91	0.74	0.46	0.31	1.07	0.98	0.73	0.67	1.06	0.34	0.76	0.78	0.97
T-bills	Net Return	3.66**	1.61	0.30	2.65*	1.15	0.42	0.96	0.46	4.88***	4.51**	4.05**	3.78**	2.37**
	Sharpe Ratio	0.92	0.38	0.07	0.76	0.27	0.12	0.25	0.11	1.15	1.07	0.97	0.93	0.76
Portfolio	Net Return	4.23	3.48	0.46	3.09	6.42*	4.35*	1.09	6.04*	8.09**	4.58	2.24	5.52**	4.13*
	Sharpe Ratio	0.44	0.36	0.05	0.33	0.58	0.50	0.12	0.59	0.76	0.48	0.21	0.67	0.53

[a] The sample periods for financials (pound, mark, and T-bills) are 1980-1984.

[b] MAB: Simple Moving Average with % Price Band; DMC: Dual Moving Average Crossover; CHL: Outside Price Channel; LSO: L-S-O Price Channel; MII: M-II Price Channel; DRI: Directional Indicator; RNQ: Range Quotient; REF: Reference Deviation; DRM: Directional Movement; ALX: Alexander's Filter Rule; PAR: Parabolic Time/Price; DRP: Directional Parabolic

[c] Net Return denotes the annual mean net return (%).

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Statistical tests are conducted using the stationary bootstrap procedure with 1,000 bootstrap resamples and a bootstrap smoothing parameter of 0.1 for individual trading systems and the portfolio of 12 trading systems. For the portfolio of 12 markets, a bootstrap smoothing parameter of 1 is used.

Table 6. The Performance of 12 Technical Trading Systems, 1985-2003[a]

		Trading System[b]												
Market		MAB	DMC	CHL	LSO	MII	DRI	RNQ	REF	DRM	ALX	PAR	DRP	Portfolio
Corn	Net Return[c]	-5.30	-5.44	-3.80	-8.59	-12.34	-5.95	-6.25	-5.08	-11.73	-6.15	-12.28	-11.44	-7.86
	Sharpe Ratio	-0.34	-0.28	-0.21	-0.48	-0.62	-0.37	-0.42	-0.27	-0.59	-0.32	-0.62	-0.65	-0.59
Soybeans	Net Return	-8.54	-4.89	-7.05	-11.64	-8.11	-4.21	-8.72	-1.58	-5.13	-5.58	-11.35	-9.02	-7.15
	Sharpe Ratio	-0.64	-0.25	-0.38	-0.67	-0.41	-0.28	-0.55	-0.08	-0.26	-0.30	-0.57	-0.50	-0.57
Live Cattle	Net Return	-0.85	-5.20	-2.95	-1.99	-6.30	-0.20	0.53	0.06	-4.45	-1.92	-9.26	-6.89	-3.28
	Sharpe Ratio	-0.10	-0.38	-0.24	-0.16	-0.45	-0.02	0.05	0.01	-0.32	-0.18	-0.67	-0.59	-0.38
Pork Bellies	Net Return	-8.99	-11.18	-9.94	-8.52	-3.81	-2.00	-8.12	2.12	-17.23	-10.04	-10.47	-12.08	-8.35
	Sharpe Ratio	-0.46	-0.33	-0.33	-0.27	-0.11	-0.08	-0.32	0.07	-0.51	-0.30	-0.31	-0.38	-0.39
Lumber	Net Return	-5.06	-12.01	-5.70	-3.55	2.25	-3.25	-2.42	-0.10	3.85	-14.81	2.10	2.26	-3.04
	Sharpe Ratio	-0.24	-0.47	-0.24	-0.15	0.09	-0.15	-0.11	0.00	0.15	-0.60	0.08	0.09	-0.17
Cocoa	Net Return	-12.06	-18.73	-26.71	-9.28	-13.11	-0.03	-4.24	-7.06	-21.30	-10.95	-21.28	-16.95	-13.48
	Sharpe Ratio	-0.89	-0.65	-1.02	-0.35	-0.45	0.00	-0.31	-0.27	-0.73	-0.39	-0.74	-0.67	-0.83
Sugar (world)	Net Return	-4.96	-12.26	-13.46	-10.66	-17.29	-3.43	-8.87	-12.39	-13.30	-7.08	-9.60	-6.16	-9.96
	Sharpe Ratio	-0.16	-0.35	-0.42	-0.32	-0.48	-0.13	-0.30	-0.39	-0.37	-0.21	-0.28	-0.20	-0.40
Copper	Net Return	-2.55	-7.04	-10.27	-2.48	0.27	-2.70	2.18	-0.23	-4.50	-2.82	-7.27	-7.44	-3.74
	Sharpe Ratio	-0.14	-0.30	-0.52	-0.11	0.01	-0.14	0.11	-0.01	-0.19	-0.13	-0.31	-0.36	-0.25
Silver	Net Return	-8.24	-11.57	-13.14	-13.10	-15.59	-7.82	-8.17	-4.20	-13.03	-8.21	-9.27	-8.36	-10.06
	Sharpe Ratio	-0.59	-0.49	-0.63	-0.64	-0.65	-0.49	-0.56	-0.19	-0.54	-0.35	-0.39	-0.40	-0.71
Pound	Net Return	0.24	-1.20	-1.72	-0.24	-0.43	-0.63	-1.27	0.19	0.87	1.69	-0.70	-0.34	-0.30
	Sharpe Ratio	0.03	-0.11	-0.18	-0.03	-0.04	-0.07	-0.14	0.02	0.08	0.17	-0.07	-0.04	-0.04
Mark	Net Return	2.90	1.35	2.69	0.51	1.52	0.61	0.77	4.10*	2.24	1.68	1.03	2.83	1.85
	Sharpe Ratio	0.30	0.12	0.26	0.05	0.13	0.06	0.07	0.38	0.19	0.16	0.09	0.29	0.23
T-bills	Net Return	0.09	0.14	0.06	-0.02	-0.32	0.08	0.26	0.05	0.11	0.69**	0.47*	0.44*	0.17
	Sharpe Ratio	0.08	0.11	0.05	-0.02	-0.25	0.07	0.22	0.04	0.09	0.56	0.39	0.42	0.19
Portfolio	Net Return	-4.89	-7.79	-8.08	-6.21	-6.57	-2.68	-4.00	-2.34	-7.42	-5.59	-7.80	-6.47	-5.82
	Sharpe Ratio	-0.94	-1.11	-1.23	-0.85	-0.81	-0.45	-0.68	-0.34	-0.92	-0.71	-0.93	-0.89	-1.06

[a] The sample periods for financials differ: 1985-1998 for the mark and 1985-1996 for T-bills.

[b] MAB: Simple Moving Average with % Price Band; DMC: Dual Moving Average Crossover; CHL: Outside Price Channel; LSO: L-S-O Price Channel; MII: M-II Price Channel; DRI: Directional Indicator; RNQ: Range Quotient; REF: Reference Deviation; DRM: Directional Movement; ALX: Alexander's Filter Rule; PAR: Parabolic Time/Price; DRP: Directional Parabolic

[c] Net Return denotes the annual mean net return (%).

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Statistical tests are conducted using the stationary bootstrap procedure with 1,000 bootstrap resamples and a bootstrap smoothing parameter of 0.1 for individual trading systems and the portfolio of 12 trading systems. For the portfolio of 12 markets, a bootstrap smoothing parameter of 1 is used.

Table 7. The Performance of 12 Trading Systems with Lower Transaction Costs, 1985-2003[a]

						Trading System[b]								
Market		MAB	DMC	CHL	LSO	MII	DRI	RNQ	REF	DRM	ALX	PAR	DRP	Portfolio
Corn	Net Return[c]	-1.72	-3.09	-0.68	-5.62	-10.38	-4.90	-5.74	-3.48	-6.34	-4.58	-5.14	-5.50	-4.76
	Sharpe Ratio	-0.11	-0.16	-0.04	-0.32	-0.52	-0.29	-0.33	-0.18	-0.32	-0.24	-0.26	-0.31	-0.35
Soybeans	Net Return	-7.58	-3.07	-4.73	-9.69	-9.28	-2.69	-6.45	-0.04	-3.60	-2.93	-8.06	-6.08	-5.35
	Sharpe Ratio	-0.49	-0.15	-0.25	-0.55	-0.46	-0.18	-0.39	0.00	-0.18	-0.15	-0.40	-0.34	-0.43
Live Cattle	Net Return	-0.37	-2.87	-1.80	-0.24	-6.30	0.23	1.34	-1.77	-3.30	-1.02	-5.29	-3.57	-2.08
	Sharpe Ratio	-0.04	-0.21	-0.14	-0.02	-0.45	0.02	0.13	-0.15	-0.24	-0.09	-0.39	-0.31	-0.23
Pork Bellies	Net Return	-10.61	-9.05	-7.17	-6.63	-6.02	-4.10	-6.56	2.72	-13.42	-7.97	-6.36	-8.69	-6.99
	Sharpe Ratio	-0.47	-0.27	-0.24	-0.21	-0.18	-0.16	-0.25	0.08	-0.39	-0.24	-0.19	-0.28	-0.32
Lumber	Net Return	-0.41	-10.48	1.43	-1.80	2.44	-0.46	-0.78	0.65	6.62	-15.67	5.78	5.62	-0.59
	Sharpe Ratio	-0.02	-0.41	0.06	-0.08	0.10	-0.02	-0.03	0.03	0.26	-0.63	0.22	0.24	-0.03
Cocoa	Net Return	-13.20	-15.63	-19.33	-7.83	-12.39	1.13	-3.89	-4.87	-12.71	-8.67	-12.80	-11.07	-10.11
	Sharpe Ratio	-0.78	-0.54	-0.74	-0.30	-0.43	0.07	-0.26	-0.19	-0.44	-0.31	-0.45	-0.43	-0.62
Sugar (world)	Net Return	-0.17	-6.90	-9.68	-6.74	-17.29	-0.30	-9.47	-10.44	-6.59	-6.02	-1.39	1.67	-6.11
	Sharpe Ratio	-0.01	-0.20	-0.30	-0.21	-0.48	-0.01	-0.30	-0.32	-0.19	-0.18	-0.04	0.05	-0.24
Copper	Net Return	-1.58	-5.41	-11.00	-1.15	0.27	0.35	4.38	0.97	-1.25	-0.78	-2.37	-3.00	-1.71
	Sharpe Ratio	-0.08	-0.23	-0.55	-0.05	0.01	0.02	0.22	0.05	-0.05	-0.03	-0.10	-0.14	-0.11
Silver	Net Return	-6.00	-8.95	-7.28	-11.86	-15.59	-5.89	-8.60	-1.45	-10.16	-8.62	-6.22	-5.37	-8.00
	Sharpe Ratio	-0.42	-0.38	-0.34	-0.56	-0.65	-0.35	-0.52	-0.06	-0.42	-0.36	-0.27	-0.26	-0.55
Pound	Net Return	-0.27	-0.56	-1.27	1.02	0.08	-0.27	-0.26	-0.05	1.33	2.49	-0.11	-0.01	0.18
	Sharpe Ratio	-0.03	-0.05	-0.13	0.11	0.01	-0.03	-0.03	-0.01	0.12	0.25	-0.01	0.00	0.02
Mark	Net Return	1.92	2.87	3.15	1.22	2.23	0.82	1.07	4.69**	3.05	1.68	2.05	3.61*	2.36
	Sharpe Ratio	0.19	0.25	0.30	0.11	0.19	0.08	0.10	0.43	0.27	0.15	0.18	0.37	0.29
T-bills	Net Return	0.14	0.18	0.10	0.06	-0.24	0.16	0.35	0.08	0.16	0.71**	0.51*	0.50**	0.23
	Sharpe Ratio	0.11	0.14	0.08	0.06	-0.19	0.13	0.30	0.07	0.13	0.58	0.41	0.47	0.26
Portfolio	Net Return	-3.58	-5.56	-5.04	-4.43	-6.57	-1.45	-3.11	-1.34	-3.99	-4.46	-3.41	-2.71	-3.80
	Sharpe Ratio	-0.62	-0.78	-0.77	-0.61	-0.81	-0.25	-0.49	-0.19	-0.49	-0.56	-0.41	-0.37	-0.69

[a] The sample periods for financials differ: 1985-2003 for the pound, 1985-1998 for the mark, and 1985-1996 for T-bills.

[b] MAB: Simple Moving Average with % Price Band; DMC: Dual Moving Average Crossover; CHL: Outside Price Channel; LSO: L-S-O Price Channel; MII: M-II Price Channel; DRI: Directional Indicator; RNQ: Range Quotient; REF: Reference Deviation; DRM: Directional Movement; ALX: Alexander's Filter Rule; PAR: Parabolic Time/Price; DRP: Directional Parabolic

[c] Net Return denotes the annual mean net return (%).

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Statistical tests are conducted using the stationary bootstrap procedure with 1,000 bootstrap resamples and a bootstrap smoothing parameter of 0.1 for individual trading systems and the portfolio of 12 trading systems. For the portfolio of 12 markets, a bootstrap smoothing parameter of 1 is used.

Table 8. The Performance of 12 Technical Trading Systems, 1978-2003[a]

		Trading System[b]												
Market		MAB	DMC	CHL	LSO	MII	DRI	RNQ	REF	DRM	ALX	PAR	DRP	Portfolio
Corn	Net Return[c]	-2.47	-2.18	-2.32	-4.01	-6.64	-1.72	-2.67	-1.73	-6.51	-2.68	-12.12	-9.60	-4.55
	Sharpe Ratio	-0.16	-0.11	-0.13	-0.23	-0.35	-0.11	-0.18	-0.10	-0.34	-0.15	-0.63	-0.57	-0.35
Soybeans	Net Return	-4.37	-1.35	-6.66	-8.08	-5.06	-2.71	-6.19	-0.86	-1.83	-3.82	-9.06	-4.79	-4.56
	Sharpe Ratio	-0.28	-0.06	-0.34	-0.43	-0.24	-0.16	-0.35	-0.04	-0.09	-0.20	-0.44	-0.27	-0.33
Live Cattle	Net Return	-1.41	-5.72	-2.46	-3.25	-6.30	-1.52	-1.73	-1.45	-4.44	-3.26	-11.56	-7.45	-4.21
	Sharpe Ratio	-0.13	-0.38	-0.18	-0.24	-0.41	-0.14	-0.15	-0.11	-0.29	-0.25	-0.76	-0.57	-0.43
Pork Bellies	Net Return	-7.88	-10.26	-12.58	-8.49	-6.52	-1.46	-10.17	2.07	-12.11	-7.72	-6.29	-6.56	-7.33
	Sharpe Ratio	-0.35	-0.30	-0.41	-0.27	-0.19	-0.06	-0.38	0.07	-0.35	-0.23	-0.18	-0.21	-0.33
Lumber	Net Return	-1.21	-4.65	-2.55	1.57	5.85	1.88	2.02	1.89	3.01	-12.20	-0.75	1.58	-0.30
	Sharpe Ratio	-0.06	-0.18	-0.11	0.07	0.23	0.09	0.09	0.08	0.12	-0.50	-0.03	0.07	-0.02
Cocoa	Net Return	-7.53	-14.27	-17.26	-11.01	-7.94	-1.71	-3.96	-5.66	-13.72	-9.72	-19.41	-11.35	-10.29
	Sharpe Ratio	-0.41	-0.49	-0.65	-0.41	-0.27	-0.09	-0.23	-0.21	-0.47	-0.35	-0.67	-0.45	-0.59
Sugar (world)	Net Return	-0.97	-4.20	-4.24	-2.07	-2.30	2.22	-0.63	-3.81	3.65	1.56	-1.59	4.14	-0.69
	Sharpe Ratio	-0.03	-0.11	-0.12	-0.06	-0.06	0.07	-0.02	-0.11	0.10	0.04	-0.04	0.13	-0.02
Copper	Net Return	-5.46	-12.26	-11.33	-5.70	-2.73	-4.65	-4.12	-0.26	-5.00	-6.90	-6.78	-8.90	-6.18
	Sharpe Ratio	-0.29	-0.50	-0.54	-0.25	-0.11	-0.26	-0.20	-0.01	-0.20	-0.30	-0.28	-0.41	-0.39
Silver	Net Return	-0.71	-3.53	-9.37	-4.35	-6.45	-2.32	-5.08	3.04	-5.39	7.48	6.46	1.95	-1.52
	Sharpe Ratio	-0.03	-0.13	-0.38	-0.17	-0.23	-0.10	-0.23	0.11	-0.19	0.28	0.24	0.08	-0.08
Pound	Net Return	0.54	0.04	-0.94	0.73	0.51	0.30	-0.05	1.14	1.65	0.48	0.46	0.19	0.42
	Sharpe Ratio	0.06	0.00	-0.10	0.08	0.05	0.03	-0.01	0.11	0.15	0.05	0.04	0.02	0.06
Mark	Net Return	4.68**	3.07	3.17*	1.15	4.17*	2.97	2.58	4.85**	4.65**	2.19	2.87	4.16**	3.38**
	Sharpe Ratio	0.47	0.28	0.31	0.11	0.37	0.29	0.24	0.45	0.41	0.20	0.26	0.42	0.42
T-bills	Net Return	1.14**	0.57	0.13	0.77*	0.11	0.18	0.47	0.17	1.51***	1.81***	1.53***	1.42***	0.82**
	Sharpe Ratio	0.48	0.23	0.05	0.36	0.05	0.08	0.20	0.07	0.60	0.72	0.61	0.60	0.44
Portfolio	Net Return	-2.43	-4.75	-5.78	-3.70	-3.07	-0.79	-2.63	-0.08	-3.25	-2.85	-5.10	-3.24	-3.14
	Sharpe Ratio	-0.10	-0.17	-0.22	-0.13	-0.10	-0.03	-0.11	0.00	-0.10	-0.10	-0.16	-0.12	-0.14

[a] The sample periods for financials differ: 1980-2003 for the pound, 1980-1998 for the mark, and 1980-1996 for T-bills.

[b] MAB: Simple Moving Average with % Price Band; DMC: Dual Moving Average Crossover; CHL: Outside Price Channel; LSO: L-S-O Price Channel; MII: M-II Price Channel; DRI: Directional Indicator; RNQ: Range Quotient; REF: Reference Deviation; DRM: Directional Movement; ALX: Alexander's Filter Rule; PAR: Parabolic Time/Price; DRP: Directional Parabolic

[c] Net Return denotes the annual mean net return (%).

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Statistical tests are conducted using the stationary bootstrap procedure with 1,000 bootstrap resamples and a bootstrap smoothing parameter of 0.1 for individual trading systems and the portfolio of 12 trading systems. For the portfolio of 12 markets, a bootstrap smoothing parameter of 1 is used.

Table 9. The Performance of 12 Trading Systems with Lower Transaction Costs, 1978-2003[a]

							Trading System[b]							
Market		MAB	DMC	CHL	LSO	MII	DRI	RNQ	REF	DRM	ALX	PAR	DRP	Portfolio
Corn	Net Return[c]	0.15	-0.46	-0.04	-1.83	-5.21	-0.95	-2.30	-0.56	-2.57	-1.54	-6.91	-5.26	-2.29
	Sharpe Ratio	0.01	-0.02	0.00	-0.11	-0.27	-0.06	-0.14	-0.03	-0.13	-0.08	-0.36	-0.31	-0.17
Soybeans	Net Return	-3.67	-0.02	-4.96	-6.66	-5.92	-1.61	-4.53	0.27	-0.71	-1.89	-6.65	-2.64	-3.25
	Sharpe Ratio	-0.21	0.00	-0.25	-0.35	-0.28	-0.09	-0.25	0.01	-0.03	-0.10	-0.32	-0.15	-0.23
Live Cattle	Net Return	-1.06	-4.02	-1.62	-1.97	-6.30	-1.20	-1.14	-2.80	-3.60	-2.61	-8.65	-5.02	-3.33
	Sharpe Ratio	-0.09	-0.27	-0.12	-0.14	-0.41	-0.11	-0.10	-0.21	-0.24	-0.20	-0.57	-0.39	-0.33
Pork Bellies	Net Return	-9.07	-8.71	-10.55	-7.11	-8.13	-3.00	-9.03	2.50	-9.33	-6.21	-3.29	-4.08	-6.33
	Sharpe Ratio	-0.37	-0.26	-0.35	-0.22	-0.24	-0.11	-0.33	0.08	-0.27	-0.18	-0.10	-0.13	-0.28
Lumber	Net Return	2.18	-3.53	2.66	2.85	5.99	3.92	3.22	2.44	5.04	-12.83	1.94	4.04	1.49
	Sharpe Ratio	0.10	-0.14	0.11	0.12	0.23	0.18	0.14	0.11	0.20	-0.52	0.08	0.17	0.08
Cocoa	Net Return	-8.37	-12.00	-11.86	-9.95	-7.41	-0.87	-3.70	-4.06	-7.44	-8.05	-13.21	-7.05	-7.83
	Sharpe Ratio	-0.41	-0.41	-0.45	-0.37	-0.25	-0.05	-0.21	-0.15	-0.25	-0.29	-0.46	-0.27	-0.45
Sugar (world)	Net Return	2.54	-0.28	-1.47	0.79	-2.30	4.52	-1.07	-2.39	8.55	2.33	4.41	9.87*	2.13
	Sharpe Ratio	0.08	-0.01	-0.04	0.02	-0.06	0.14	-0.03	-0.07	0.22	0.06	0.12	0.30	0.08
Copper	Net Return	-4.76	-11.06	-11.87	-4.72	-2.73	-2.42	-2.51	0.62	-2.63	-5.41	-3.20	-5.66	-4.70
	Sharpe Ratio	-0.25	-0.45	-0.56	-0.21	-0.11	-0.13	-0.12	0.03	-0.11	-0.23	-0.13	-0.26	-0.29
Silver	Net Return	0.93	-1.61	-5.08	-3.44	-6.45	-0.91	-5.39	5.04	-3.29	7.18	8.68*	4.14	-0.02
	Sharpe Ratio	0.04	-0.06	-0.20	-0.14	-0.23	-0.04	-0.23	0.19	-0.12	0.26	0.32	0.17	0.00
Pound	Net Return	0.14	0.54	-0.58	1.73	0.92	0.59	0.74	0.95	2.01	1.12	0.93	0.45	0.79
	Sharpe Ratio	0.02	0.05	-0.06	0.18	0.09	0.06	0.08	0.09	0.19	0.11	0.09	0.05	0.11
Mark	Net Return	3.95*	4.20*	3.50*	1.68	4.69**	3.12	2.81	5.28**	5.25**	2.19	3.62*	4.74**	3.75**
	Sharpe Ratio	0.39	0.38	0.34	0.16	0.41	0.30	0.26	0.49	0.46	0.20	0.32	0.48	0.47
T-bills	Net Return	1.17**	0.60	0.16	0.83**	0.17	0.24	0.53	0.19	1.55***	1.83***	1.55***	1.47***	0.86**
	Sharpe Ratio	0.49	0.24	0.06	0.39	0.07	0.11	0.23	0.08	0.61	0.73	0.62	0.61	0.47
Portfolio	Net Return	-1.48	-3.13	-3.56	-2.40	-3.08	0.11	-1.98	0.65	-0.74	-2.02	-1.89	-0.49	-1.67
	Sharpe Ratio	-0.06	-0.11	-0.14	-0.09	-0.10	0.00	-0.08	0.02	-0.02	-0.07	-0.06	-0.02	-0.08

[a] The sample periods for financials differ: 1980-2003 for the pound, 1980-1998 for the mark, and 1980-1996 for T-bills.

[b] MAB: Simple Moving Average with % Price Band; DMC: Dual Moving Average Crossover; CHL: Outside Price Channel; LSO: L-S-O Price Channel; MII: M-II Price Channel; DRI: Directional Indicator; RNQ: Range Quotient; REF: Reference Deviation; DRM: Directional Movement; ALX: Alexander's Filter Rule; PAR: Parabolic Time/Price; DRP: Directional Parabolic

[c] Net Return denotes the annual mean net return (%).

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Statistical tests are conducted using the stationary bootstrap procedure with 1,000 bootstrap resamples and a bootstrap smoothing parameter of 0.1 for individual trading systems and the portfolio of 12 trading systems. For the portfolio of 12 markets, a bootstrap smoothing parameter of 1 is used.

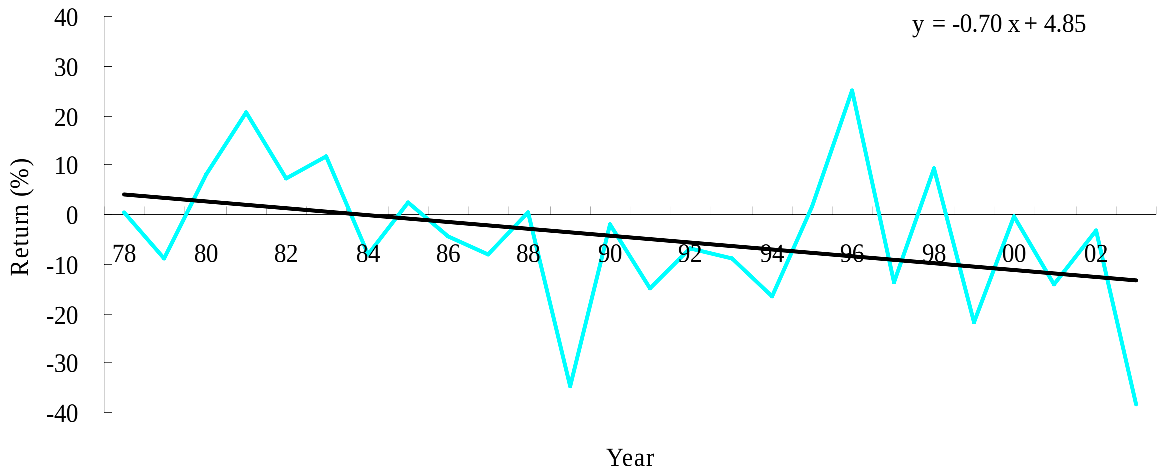
Table 10. Time Trend Regression Results, 1978-2003

	$\hat{\alpha}$	t_α	$\hat{\beta}$	t_β	R^2
Markets					
Corn	4.85	0.87	-0.70	-1.94	0.14
Soybeans	-1.24	-0.28	-0.25	-0.84	0.03
Live Cattle	-7.90	-2.38	0.27	1.27	0.06
Pork Bellies	-1.82	-0.24	-0.41	-0.84	0.03
Lumber	4.56	0.63	-0.36	-0.76	0.02
Cocoa	-6.27	-0.98	-0.30	-0.72	0.02
Sugar (world)	23.84	3.18	-1.82	-3.74	0.37
Copper	-10.35	-1.48	0.31	0.68	0.02
Silver	17.93	1.57	-1.44	-1.95	0.14
Pound	4.99	1.64	-0.37	-1.72	0.12
Mark	9.75	3.49	-0.64	-2.60	0.28
T-bills	2.74	2.79	-0.21	-2.23	0.25
Trading Systems					
Simple Moving Average with % Price Band (MAB)	5.09	3.25	-0.56	-5.50	0.56
Dual Moving Average Crossover (DMC)	3.12	1.44	-0.58	-4.16	0.42
Outside Price Channel (CHL)	-1.05	-0.39	-0.35	-2.00	0.14
L-S-O Price Channel (LSO)	3.29	1.27	-0.52	-3.10	0.29
M-II Price Channel (MII)	6.26	2.11	-0.69	-3.60	0.35
Directional Indicator (DRI)	4.93	2.26	-0.42	-3.00	0.27
Range Quotient (RNQ)	1.39	0.52	-0.30	-1.73	0.11
Reference Deviation (REF)	7.50	3.14	-0.56	-3.63	0.35
Directional Movement (DRM)	6.13	1.92	-0.69	-3.36	0.32
Alexander's Filter Rule (ALX)	4.43	1.35	-0.54	-2.53	0.21
Parabolic Time/Price (PAR)	1.64	0.65	-0.50	-3.07	0.28
Directional Parabolic (DRP)	3.66	1.55	-0.51	-3.34	0.32
Portfolio	3.87	2.45	-0.52	-5.08	0.52

Note: The third and fifth columns indicate *t*-statistics for $H_0 : \alpha_j = 0$ and $H_0 : \beta_j = 0,$ respectively.

Figure 1. Portfolio Annual Mean Net Returns for Corn (a) and Pound (b) Using 12 Trading Systems, 1978-2003

(a)



(b)

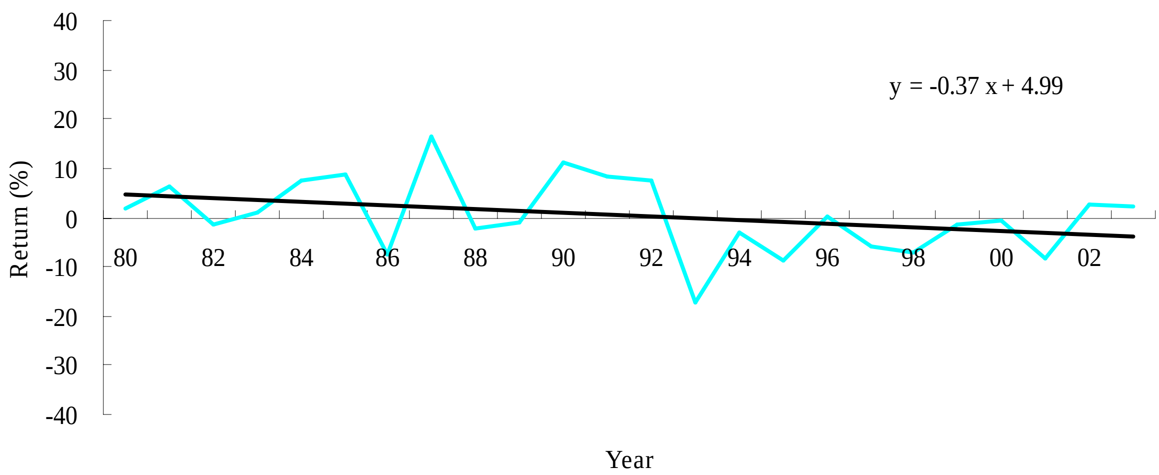
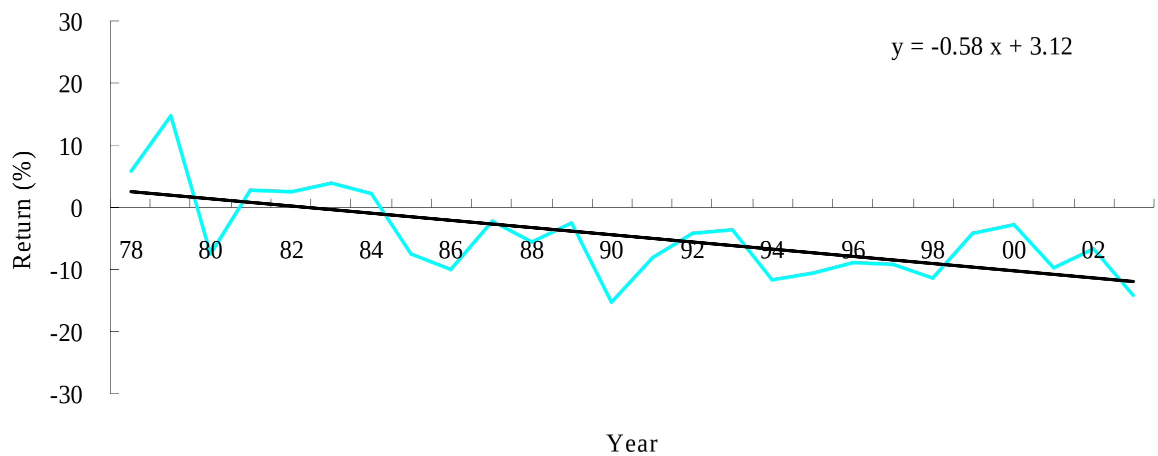


Figure 2. Annual Mean Net Returns of the DMC (a) and the CHL (b) System across 12 Futures Markets, 1978-2003

(a)



(b)

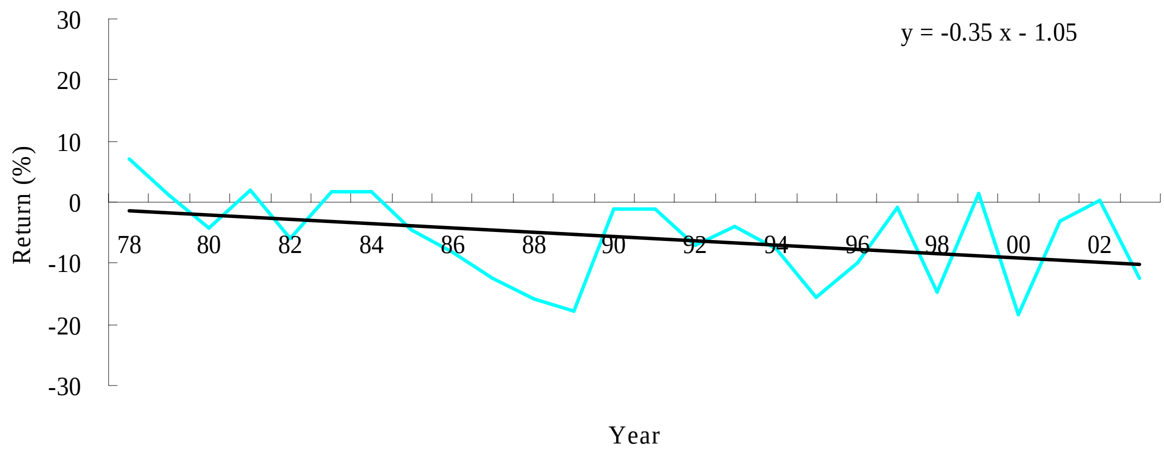
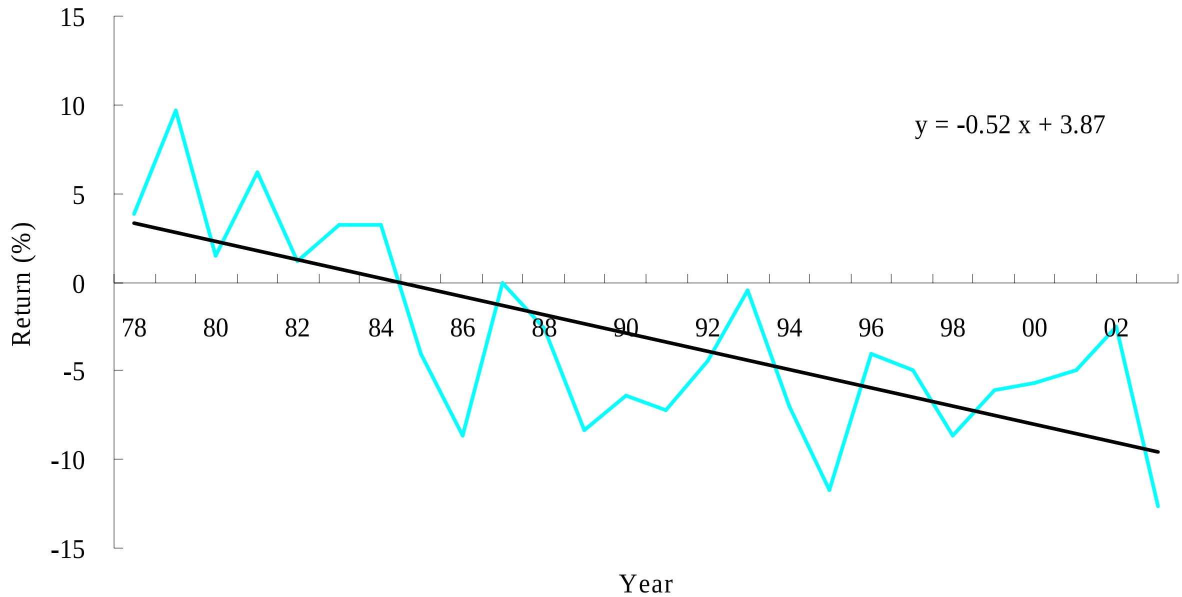


Figure 3. Portfolio Annual Mean Net Returns for an Equally-Weighted Portfolio of 12 Futures Markets Using 12 Trading Systems, 1978-2003



Appendix

Table A.1. Optimal Parameters for the Simple Moving Average with Percentage Price Band (MAB) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	65, 0.010	30, 0.000	25, 0.025	60, 0.010	35, 0.030	50, 0.050	60, 0.055	55, 0.040	3, 0.040	NA	NA	NA
1979	65, 0.030	20, 0.050	55, 0.045	65, 0.015	3, 0.020	45, 0.001	60, 0.050	65, 0.060	10, 0.060	NA	NA	NA
1980	40, 0.015	65, 0.000	45, 0.015	25, 0.035	65, 0.045	35, 0.010	50, 0.050	65, 0.060	65, 0.025	50, 0.000	40, 0.005	20, 0.005
1981	35, 0.035	55, 0.025	45, 0.030	30, 0.045	30, 0.055	45, 0.030	20, 0.060	40, 0.060	35, 0.040	20, 0.001	40, 0.005	25, 0.003
1982	40, 0.020	65, 0.015	5, 0.030	10, 0.060	65, 0.010	45, 0.030	15, 0.060	40, 0.060	40, 0.015	10, 0.003	65, 0.001	25, 0.003
1983	65, 0.010	65, 0.015	15, 0.050	10, 0.060	65, 0.003	45, 0.025	20, 0.060	7, 0.060	45, 0.015	60, 0.001	55, 0.001	30, 0.000
1984	65, 0.010	45, 0.005	25, 0.015	10, 0.060	60, 0.015	45, 0.025	55, 0.025	5, 0.055	15, 0.003	60, 0.055	65, 0.001	30, 0.000
1985	35, 0.050	65, 0.015	15, 0.050	3, 0.030	65, 0.020	55, 0.015	55, 0.020	5, 0.055	15, 0.003	65, 0.015	45, 0.001	30, 0.000
1986	20, 0.040	65, 0.015	55, 0.040	25, 0.055	30, 0.060	3, 0.050	55, 0.015	15, 0.040	15, 0.000	50, 0.005	40, 0.000	60, 0.000
1987	30, 0.035	10, 0.050	50, 0.055	25, 0.020	30, 0.060	5, 0.045	60, 0.035	10, 0.035	15, 0.060	50, 0.020	65, 0.025	40, 0.003
1988	30, 0.030	5, 0.060	45, 0.050	45, 0.001	45, 0.060	5, 0.045	65, 0.035	55, 0.060	5, 0.035	50, 0.020	65, 0.025	45, 0.000
1989	30, 0.025	50, 0.055	45, 0.040	60, 0.030	3, 0.030	10, 0.060	45, 0.055	40, 0.050	5, 0.035	50, 0.020	25, 0.020	50, 0.000
1990	3, 0.025	50, 0.035	65, 0.020	5, 0.055	10, 0.045	25, 0.060	35, 0.050	45, 0.050	5, 0.035	35, 0.001	25, 0.005	40, 0.000
1991	3, 0.025	3, 0.050	25, 0.035	5, 0.055	10, 0.035	3, 0.060	35, 0.055	45, 0.050	65, 0.015	35, 0.001	25, 0.025	55, 0.001
1992	3, 0.035	5, 0.020	3, 0.010	60, 0.060	65, 0.030	3, 0.060	3, 0.060	7, 0.060	30, 0.025	65, 0.035	65, 0.035	60, 0.005
1993	50, 0.040	5, 0.045	5, 0.015	3, 0.045	60, 0.001	5, 0.050	3, 0.060	45, 0.045	5, 0.035	15, 0.003	65, 0.035	65, 0.005
1994	5, 0.040	7, 0.040	60, 0.035	5, 0.060	25, 0.015	50, 0.040	7, 0.060	45, 0.015	5, 0.060	30, 0.020	60, 0.020	45, 0.000
1995	15, 0.050	25, 0.035	25, 0.030	3, 0.045	20, 0.001	65, 0.025	60, 0.060	50, 0.015	5, 0.045	35, 0.040	5, 0.015	45, 0.000
1996	15, 0.055	10, 0.045	55, 0.045	60, 0.050	15, 0.020	10, 0.060	60, 0.060	50, 0.010	3, 0.040	10, 0.030	50, 0.015	50, 0.003
1997	60, 0.030	5, 0.060	40, 0.025	60, 0.050	15, 0.020	10, 0.060	3, 0.050	65, 0.050	3, 0.060	55, 0.045	50, 0.015	NA
1998	65, 0.015	55, 0.050	60, 0.045	3, 0.045	3, 0.035	5, 0.060	3, 0.050	55, 0.010	3, 0.050	3, 0.010	55, 0.015	NA
1999	65, 0.010	25, 0.040	60, 0.040	3, 0.060	15, 0.015	5, 0.060	65, 0.055	55, 0.010	15, 0.035	15, 0.030	NA	NA
2000	25, 0.015	65, 0.000	60, 0.045	3, 0.060	5, 0.055	3, 0.060	65, 0.060	10, 0.045	15, 0.025	15, 0.030	NA	NA
2001	15, 0.035	15, 0.025	30, 0.030	3, 0.060	55, 0.040	3, 0.060	65, 0.055	5, 0.030	3, 0.045	3, 0.015	NA	NA
2002	60, 0.001	45, 0.010	40, 0.060	15, 0.055	65, 0.001	5, 0.060	7, 0.045	10, 0.060	10, 0.050	5, 0.015	NA	NA
2003	35, 0.055	45, 0.010	40, 0.060	25, 0.060	60, 0.060	7, 0.050	60, 0.015	15, 0.060	5, 0.020	65, 0.003	NA	NA

[a] The 2 parameters of the Simple Moving Average with Percentage Price Band (MAB) system are the number of days used to calculate the moving average and the fixed percent band. For example, the optimal parameters (65, 0.010) for corn in 1978 indicate that a 65-day moving average rule with a 1% band produced the highest mean net return over the previous three years, 1975-1977.

Table A.2. Optimal Parameters for the Dual Moving Average Crossover (DMC) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	15, 40	20, 45	20, 55	7, 50	5, 20	7, 60	25, 60	7, 45	20, 65	NA	NA	NA
1979	10, 65	20, 40	20, 50	15, 65	2, 20	25, 45	25, 60	10, 15	20, 65	NA	NA	NA
1980	15, 45	20, 40	2, 40	3, 25	2, 20	15, 20	10, 55	7, 60	20, 65	7, 15	7, 15	7, 10
1981	10, 65	3, 45	2, 40	5, 65	20, 65	15, 40	15, 20	3, 15	15, 25	7, 15	5, 20	3, 30
1982	15, 65	7, 55	15, 45	3, 15	25, 60	20, 30	20, 45	25, 40	10, 50	20, 45	7, 65	3, 20
1983	25, 65	3, 65	20, 60	5, 65	25, 65	20, 35	7, 15	10, 25	10, 50	20, 45	7, 60	2, 25
1984	15, 25	7, 30	3, 40	10, 25	25, 45	20, 35	20, 65	25, 60	20, 50	20, 45	7, 45	15, 20
1985	5, 65	7, 30	15, 25	15, 25	25, 45	3, 40	15, 65	10, 25	2, 15	20, 60	7, 45	7, 45
1986	5, 65	3, 65	10, 65	15, 25	25, 45	15, 20	2, 60	10, 25	2, 15	25, 65	20, 65	15, 40
1987	20, 65	20, 55	20, 45	5, 20	25, 45	5, 50	3, 65	7, 25	20, 50	25, 65	3, 10	15, 40
1988	5, 35	25, 55	20, 50	5, 65	15, 40	10, 50	3, 65	15, 65	15, 45	25, 35	25, 60	2, 50
1989	5, 20	20, 65	7, 55	5, 65	7, 65	10, 45	5, 35	25, 35	25, 60	10, 35	10, 20	2, 20
1990	20, 65	20, 65	7, 45	5, 55	10, 40	25, 30	5, 35	25, 35	20, 35	5, 25	5, 25	25, 30
1991	20, 65	20, 65	15, 60	25, 35	5, 15	15, 60	3, 55	25, 50	20, 65	5, 25	5, 25	5, 55
1992	20, 65	25, 65	20, 65	25, 35	3, 45	25, 65	10, 20	25, 50	20, 65	10, 50	5, 25	20, 45
1993	10, 40	25, 60	25, 60	20, 55	3, 15	7, 45	20, 30	20, 55	25, 65	5, 55	25, 55	20, 45
1994	10, 40	7, 25	25, 60	20, 30	20, 45	25, 60	20, 30	20, 35	25, 50	25, 45	15, 55	2, 45
1995	10, 25	10, 20	20, 25	20, 65	5, 15	7, 30	25, 60	20, 35	25, 50	10, 15	25, 40	10, 35
1996	7, 30	20, 25	25, 55	20, 30	5, 15	15, 65	25, 60	25, 65	25, 50	25, 30	20, 30	10, 25
1997	10, 65	20, 25	10, 35	25, 65	3, 5	5, 65	25, 60	25, 65	20, 25	25, 50	25, 40	NA
1998	25, 55	15, 45	10, 35	20, 30	25, 40	20, 60	5, 65	25, 65	2, 65	10, 20	20, 35	NA
1999	25, 55	20, 55	10, 30	15, 20	2, 10	25, 65	3, 60	25, 65	5, 10	7, 30	NA	NA
2000	7, 25	15, 50	15, 60	5, 30	5, 55	25, 65	25, 45	3, 10	5, 10	5, 10	NA	NA
2001	20, 55	10, 25	20, 25	15, 60	20, 65	25, 65	25, 40	3, 10	5, 10	5, 10	NA	NA
2002	5, 55	10, 25	25, 65	10, 40	20, 25	20, 65	25, 40	3, 10	3, 25	3, 55	NA	NA
2003	5, 55	15, 35	20, 60	10, 35	25, 45	20, 65	7, 50	15, 45	3, 20	3, 55	NA	NA

[a] The 2 parameters of the Dual Moving Average Crossover (DMC) system are the numbers of days used to calculate the short moving average and the long moving average. For example, the optimal parameters (15, 40) for corn in 1978 indicate that a rule with a 15-day short moving average and a 40-day long moving average produced the highest mean net return over the previous three years, 1975-1977.

Table A.3. Optimal Parameters for the Outside Price Channel (CHL) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	30	10	20	25	15	50	25	30	10	NA	NA	NA
1979	20	15	20	25	5	60	25	55	35	NA	NA	NA
1980	35	15	20	15	65	2	35	35	10	15	15	3
1981	30	25	20	30	55	15	30	30	25	25	20	7
1982	30	25	20	10	55	15	35	30	25	40	15	2
1983	65	60	20	10	60	15	10	60	25	40	35	2
1984	65	15	20	60	55	15	55	65	10	40	55	2
1985	65	10	65	20	40	40	60	65	7	35	7	15
1986	65	10	65	20	20	15	40	55	7	7	7	20
1987	10	65	3	5	20	3	30	7	3	7	7	25
1988	10	40	3	15	20	3	30	65	65	50	50	3
1989	10	15	25	45	35	5	20	65	3	35	45	3
1990	10	15	30	45	35	65	15	65	55	30	35	5
1991	25	7	35	50	45	65	10	15	55	30	60	40
1992	55	3	65	50	45	65	50	15	55	65	60	55
1993	25	3	60	50	7	60	35	50	65	10	60	60
1994	15	10	60	45	15	20	50	20	7	15	40	20
1995	20	10	40	45	5	20	60	25	20	15	35	15
1996	50	40	35	35	10	10	65	30	20	20	25	10
1997	50	45	35	35	5	65	60	55	20	3	15	NA
1998	35	55	40	25	5	65	60	30	25	3	20	NA
1999	10	7	30	65	5	60	65	55	30	20	NA	NA
2000	10	7	25	65	5	3	35	7	7	20	NA	NA
2001	15	10	40	65	10	65	35	7	7	65	NA	NA
2002	15	30	40	30	50	45	10	7	10	20	NA	NA
2003	35	20	40	30	50	3	10	7	35	50	NA	NA

[a] The single parameter of the Outside Price Channel (CHL) system is the number of days in the price channel used to calculate previous support and resistance levels. For example, the optimal parameter (30) for corn in 1978 indicates that a rule with a 30-day price channel produced the highest mean net return over the previous three years, 1975-1977.

Table A.4. Optimal Parameters for the L-S-O Price Channel (LSO) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	35, 5	20, 2	10, 2	60, 3	15, 2	40, 4	25, 3	35, 14	65, 19	NA	NA	NA
1979	35, 5	20, 2	10, 5	40, 5	55, 2	50, 3	50, 1	15, 2	55, 3	NA	NA	NA
1980	45, 6	40, 5	25, 5	20, 6	20, 14	15, 2	35, 4	60, 6	65, 4	35, 5	25, 5	4, 3
1981	65, 14	40, 5	25, 6	50, 44	60, 6	40, 1	15, 1	20, 7	15, 1	30, 4	25, 5	15, 5
1982	65, 14	55, 4	55, 3	55, 14	60, 4	20, 6	60, 6	35, 7	15, 1	10, 2	15, 2	15, 3
1983	60, 9	50, 2	35, 19	50, 44	60, 2	15, 2	15, 1	60, 44	15, 2	65, 6	60, 49	15, 4
1984	65, 1	20, 1	25, 4	50, 6	55, 2	15, 2	50, 4	65, 5	50, 3	65, 3	55, 54	60, 1
1985	65, 9	30, 29	20, 19	25, 3	65, 1	40, 2	50, 4	65, 5	15, 4	55, 1	25, 3	25, 2
1986	65, 9	65, 4	65, 39	15, 1	45, 5	20, 5	50, 4	30, 9	10, 4	55, 1	5, 1	25, 2
1987	55, 1	65, 19	35, 4	15, 2	40, 3	35, 4	40, 3	30, 29	65, 1	45, 7	60, 1	35, 3
1988	45, 19	65, 24	35, 4	55, 9	25, 9	65, 9	40, 4	65, 4	4, 1	45, 7	50, 39	7, 2
1989	15, 9	25, 1	45, 14	40, 4	15, 9	65, 9	30, 7	60, 1	60, 6	50, 49	50, 44	7, 2
1990	20, 19	60, 1	35, 6	35, 1	30, 3	30, 4	35, 7	40, 6	65, 9	30, 14	25, 2	7, 5
1991	55, 6	10, 7	40, 14	40, 4	30, 3	65, 6	25, 1	30, 2	65, 7	20, 6	25, 2	40, 3
1992	55, 6	10, 4	65, 24	65, 1	40, 4	65, 4	30, 24	45, 1	65, 14	65, 5	65, 2	50, 3
1993	45, 39	10, 4	50, 2	65, 1	40, 4	65, 1	30, 24	50, 3	65, 14	40, 2	60, 4	50, 9
1994	40, 39	20, 2	65, 1	65, 2	40, 4	65, 1	45, 7	40, 2	45, 6	40, 2	15, 3	25, 4
1995	50, 44	20, 2	50, 2	65, 6	15, 9	65, 6	60, 39	35, 14	45, 6	50, 44	45, 2	25, 2
1996	50, 7	25, 6	35, 6	55, 2	35, 5	65, 6	55, 14	60, 3	40, 1	25, 24	25, 3	25, 2
1997	50, 3	25, 6	40, 14	65, 7	7, 3	65, 5	60, 59	65, 3	60, 59	60, 6	25, 1	NA
1998	45, 4	20, 1	40, 14	25, 1	65, 2	65, 14	65, 6	65, 3	55, 34	10, 2	35, 1	NA
1999	45, 4	40, 1	50, 34	60, 14	10, 4	55, 7	65, 1	65, 14	55, 14	10, 2	NA	NA
2000	25, 24	7, 5	50, 34	65, 54	15, 9	60, 9	65, 6	65, 14	10, 4	10, 2	NA	NA
2001	35, 34	15, 14	30, 9	50, 2	50, 3	60, 9	65, 6	10, 7	7, 5	10, 2	NA	NA
2002	50, 6	25, 3	60, 59	40, 9	65, 4	65, 19	30, 7	55, 2	10, 7	45, 2	NA	NA
2003	50, 9	50, 9	50, 4	30, 7	65, 4	15, 14	60, 7	55, 5	10, 7	65, 4	NA	NA

[a] The 2 parameters of the L-S-O Price Channel (LSO) system are the number of days in the price channel and the Reference Interval, which is a cluster of consecutive days at the opposite end of the price channel. For example, the optimal parameters (35, 5) for corn in 1978 indicate that a rule with a 35-day price channel and a 5-day Reference Interval produced the highest mean net return over the previous three years, 1975-1977.

Table A.5. Optimal Parameters for the M-II Price Channel (MII) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	65	20	40	55	5	40	20	25	55	NA	NA	NA
1979	65	20	5	55	5	40	50	10	55	NA	NA	NA
1980	60	35	20	15	20	30	65	55	65	30	25	10
1981	50	35	20	25	60	20	25	55	20	5	25	25
1982	50	50	55	10	60	20	65	60	35	5	20	15
1983	50	50	20	10	60	30	65	60	35	60	25	15
1984	60	20	20	45	60	40	55	65	45	60	20	2
1985	65	20	5	25	55	30	55	65	10	55	10	50
1986	65	60	65	15	45	15	50	65	10	55	10	40
1987	65	10	45	15	45	30	30	65	40	55	50	30
1988	30	55	35	55	15	65	35	65	55	35	60	2
1989	30	65	45	55	40	65	30	60	55	35	60	7
1990	60	65	15	55	40	60	30	35	55	40	20	5
1991	60	55	65	35	40	65	45	45	60	15	20	15
1992	60	55	65	65	35	65	65	45	65	60	65	55
1993	35	10	65	65	15	65	65	45	65	40	65	60
1994	35	35	65	65	15	65	50	45	15	25	30	20
1995	20	20	50	55	7	20	40	25	40	10	30	15
1996	55	20	35	55	10	65	55	60	40	35	25	15
1997	65	10	30	50	10	65	65	65	40	3	30	NA
1998	40	25	65	50	60	65	65	65	45	3	25	NA
1999	35	55	30	50	7	65	65	65	45	7	NA	NA
2000	35	25	30	50	35	65	65	65	7	10	NA	NA
2001	35	25	30	50	50	50	40	7	10	10	NA	NA
2002	40	25	60	30	60	65	7	7	10	65	NA	NA
2003	50	30	50	25	60	55	55	55	40	65	NA	NA

[a] The single parameter of the M-II Price Channel (MII) system is the number of days in the price channel used to calculate previous support and resistance levels. For example, the optimal parameter (65) for corn in 1978 indicates that a rule with a 65-day price channel produced the highest mean net return over the previous three years, 1975-1977.

Table A.6. Optimal Parameters for the Directional Indicator (DRI) System, 1978-2003[a]

	Futures Market											
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	20, 21	50, 3	5, 90	40, 18	15, 75	60, 18	50, 21	40, 15	55, 12	NA	NA	NA
1979	20, 54	15, 39	40, 9	55, 3	20, 54	60, 15	50, 6	60, 12	55, 6	NA	NA	NA
1980	30, 12	25, 15	20, 3	20, 9	30, 51	30, 6	40, 21	45, 39	60, 9	40, 12	15, 15	30, 51
1981	65, 9	35, 9	50, 30	50, 21	55, 6	30, 3	15, 27	20, 42	15, 21	10, 6	10, 33	25, 3
1982	65, 12	50, 6	55, 18	50, 21	55, 3	20, 27	10, 42	20, 42	35, 3	35, 27	20, 12	10, 18
1983	65, 6	45, 3	20, 15	50, 21	55, 6	45, 30	55, 9	15, 63	35, 3	60, 3	20, 12	15, 9
1984	65, 3	20, 3	20, 9	50, 24	60, 3	35, 36	65, 3	60, 12	40, 12	60, 3	20, 12	60, 3
1985	65, 3	10, 63	10, 75	60, 15	60, 3	35, 36	50, 3	65, 9	65, 12	55, 3	10, 3	40, 33
1986	65, 3	10, 54	40, 21	60, 9	40, 9	40, 39	50, 3	40, 39	15, 60	50, 6	55, 6	45, 27
1987	45, 18	45, 21	35, 15	60, 12	20, 48	30, 54	35, 6	25, 48	15, 66	50, 6	60, 3	30, 6
1988	30, 42	55, 12	35, 9	35, 27	35, 15	30, 54	35, 6	65, 18	65, 12	60, 6	60, 3	30, 6
1989	20, 33	55, 12	55, 27	50, 15	10, 90	35, 39	25, 9	65, 6	55, 6	30, 21	60, 3	10, 90
1990	35, 39	65, 6	35, 6	25, 15	40, 45	35, 36	15, 27	35, 6	55, 6	25, 12	15, 12	35, 3
1991	45, 6	60, 9	30, 48	45, 15	35, 39	45, 21	30, 48	25, 36	60, 3	15, 36	20, 39	35, 9
1992	35, 33	40, 42	30, 48	45, 15	35, 36	40, 27	65, 24	45, 3	65, 6	65, 6	60, 15	40, 15
1993	35, 24	10, 81	65, 6	65, 9	60, 18	45, 21	30, 39	45, 9	65, 30	40, 6	65, 6	65, 18
1994	45, 39	10, 45	30, 54	65, 9	15, 9	35, 42	30, 39	40, 9	20, 12	40, 3	30, 3	25, 3
1995	20, 27	20, 48	25, 42	65, 6	15, 12	45, 39	40, 12	35, 12	40, 6	15, 57	45, 3	20, 3
1996	65, 15	15, 57	30, 30	50, 15	10, 15	15, 75	10, 69	65, 15	40, 9	15, 57	25, 6	15, 24
1997	60, 9	15, 54	30, 21	60, 27	65, 6	25, 54	35, 27	65, 3	25, 39	65, 12	65, 3	NA
1998	60, 21	30, 27	40, 33	50, 30	60, 9	65, 24	35, 36	65, 3	60, 33	40, 36	30, 27	NA
1999	60, 21	40, 3	65, 24	40, 39	60, 9	60, 24	60, 33	60, 6	30, 48	40, 36	NA	NA
2000	15, 12	40, 18	65, 24	45, 24	5, 87	65, 18	60, 33	65, 18	10, 21	15, 78	NA	NA
2001	65, 6	15, 39	65, 24	45, 24	50, 9	65, 15	30, 42	5, 84	10, 12	5, 90	NA	NA
2002	30, 51	25, 9	30, 36	10, 60	65, 9	65, 18	25, 54	10, 45	20, 60	5, 90	NA	NA
2003	25, 24	30, 12	55, 21	20, 39	65, 9	65, 18	20, 66	10, 54	20, 69	55, 15	NA	NA

[a] The 2 parameters of the Directional Indicator (DRI) system are the number of days used to calculate the directional indicator and the entry threshold. For example, the optimal parameters (20, 21) for corn in 1978 indicate that a rule with a 20-day directional indicator window with an entry threshold of 21 produced the highest mean net return over the previous three years, 1975-1977.

Table A.7. Optimal Parameters for the Range Quotient (RNQ) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	35, 85	20, 65	40, 70	50, 85	40, 75	45, 80	45, 85	30, 85	55, 85	NA	NA	NA
1979	20, 80	15, 80	40, 75	50, 85	5, 75	60, 80	45, 85	65, 90	55, 85	NA	NA	NA
1980	15, 80	40, 70	15, 75	15, 75	55, 90	20, 85	50, 90	65, 80	65, 80	50, 80	15, 70	40, 90
1981	15, 80	40, 80	15, 75	30, 80	55, 85	20, 80	15, 80	30, 90	20, 75	10, 65	10, 70	15, 70
1982	55, 80	50, 75	10, 80	10, 75	60, 80	15, 65	65, 80	20, 80	25, 70	35, 85	25, 80	15, 55
1983	65, 80	50, 75	10, 80	5, 65	60, 80	55, 90	65, 80	15, 85	35, 70	65, 80	40, 80	15, 55
1984	65, 80	20, 75	20, 75	5, 75	60, 80	10, 80	55, 85	60, 80	45, 70	65, 80	40, 75	15, 65
1985	65, 75	20, 70	20, 85	5, 75	60, 80	35, 90	60, 85	15, 85	15, 55	55, 85	40, 75	45, 90
1986	65, 75	10, 80	35, 85	20, 60	45, 85	40, 90	50, 85	65, 90	15, 55	55, 80	65, 85	25, 85
1987	15, 85	50, 90	40, 85	15, 80	25, 85	40, 90	40, 70	65, 90	15, 85	55, 90	60, 85	30, 80
1988	40, 90	30, 90	35, 80	15, 55	25, 85	35, 90	40, 80	65, 90	15, 85	55, 90	60, 85	30, 80
1989	25, 75	65, 85	45, 85	60, 80	15, 85	35, 90	25, 80	65, 90	15, 85	40, 75	15, 85	30, 80
1990	40, 90	65, 85	50, 85	25, 85	15, 85	30, 90	25, 80	40, 75	15, 85	15, 85	20, 70	35, 70
1991	40, 90	55, 75	5, 75	10, 80	10, 80	30, 90	25, 80	40, 85	60, 80	15, 80	20, 70	50, 80
1992	40, 90	40, 90	5, 75	65, 80	45, 90	30, 90	60, 90	45, 80	65, 80	65, 85	65, 85	45, 90
1993	45, 85	35, 90	65, 75	65, 80	40, 75	35, 90	65, 90	45, 80	65, 90	45, 75	60, 85	45, 90
1994	40, 90	5, 70	30, 90	65, 80	40, 75	35, 90	15, 85	45, 75	65, 90	25, 65	30, 70	25, 80
1995	20, 80	5, 70	25, 85	10, 75	15, 55	35, 90	35, 85	45, 75	65, 90	45, 85	30, 75	20, 70
1996	60, 90	15, 85	35, 85	45, 85	10, 65	15, 85	45, 90	65, 85	25, 85	25, 85	30, 80	20, 80
1997	65, 80	15, 85	35, 85	60, 90	5, 50	15, 85	55, 90	65, 85	30, 90	30, 90	45, 75	NA
1998	40, 75	20, 85	50, 90	20, 85	35, 75	5, 75	40, 90	65, 85	15, 85	25, 90	20, 80	NA
1999	40, 75	45, 75	35, 85	60, 90	10, 85	5, 75	60, 90	45, 80	40, 90	25, 90	NA	NA
2000	35, 90	35, 70	45, 85	25, 90	10, 85	50, 85	55, 90	10, 75	5, 60	20, 85	NA	NA
2001	40, 90	10, 70	45, 85	25, 90	50, 80	65, 90	40, 70	5, 65	45, 90	10, 80	NA	NA
2002	30, 90	25, 70	40, 90	20, 80	65, 80	65, 90	40, 90	35, 90	5, 70	15, 85	NA	NA
2003	25, 80	20, 70	50, 85	20, 85	65, 80	10, 80	40, 90	15, 85	10, 80	65, 80	NA	NA

[a] the 2 parameters of the Range Quotient (RNQ) system are the number of days used to calculate the Range Quotient and the entry threshold. For example, the optimal parameters (35, 85) for corn in 1978 indicate that a rule with a 35-day Range Quotient window and an entry threshold of 85 produced the highest mean net return over the previous three years, 1975-1977.

Table A.8. Optimal Parameters for the Reference Deviation (REF) System, 1978-2003[a]

	Futures Market											
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	20, 10	10, 80	5, 85	35, 70	50, 80	50, 55	35, 40	10, 90	45, 10	NA	NA	NA
1979	20, 90	25, 10	35, 5	35, 75	50, 80	50, 75	35, 5	50, 5	50, 15	NA	NA	NA
1980	35, 90	25, 10	15, 90	40, 70	50, 75	25, 25	25, 70	45, 15	50, 5	20, 75	10, 30	35, 45
1981	35, 90	25, 5	10, 65	40, 70	5, 40	20, 30	10, 50	45, 55	15, 30	15, 10	10, 10	5, 40
1982	40, 10	20, 20	20, 30	40, 15	35, 15	20, 10	25, 5	45, 5	25, 10	25, 10	15, 50	10, 5
1983	40, 30	35, 25	25, 45	40, 15	35, 5	20, 10	10, 5	40, 90	25, 10	25, 10	15, 50	10, 5
1984	40, 50	15, 5	15, 25	50, 90	35, 15	20, 70	30, 15	50, 60	50, 50	20, 15	15, 35	45, 15
1985	15, 10	10, 30	25, 90	15, 35	30, 15	20, 90	35, 20	50, 85	50, 45	45, 40	5, 65	10, 20
1986	15, 10	45, 20	30, 90	15, 5	20, 70	35, 5	25, 90	50, 5	50, 35	45, 80	50, 15	20, 90
1987	30, 75	50, 15	30, 90	50, 5	20, 90	40, 50	25, 40	45, 90	50, 10	45, 80	50, 30	15, 85
1988	30, 55	30, 90	25, 80	50, 5	20, 15	50, 30	35, 85	50, 60	50, 10	25, 80	50, 30	20, 5
1989	30, 10	50, 5	50, 90	45, 5	10, 30	50, 30	20, 20	50, 60	50, 40	15, 20	10, 25	25, 50
1990	40, 20	45, 50	50, 90	50, 10	50, 60	15, 80	10, 65	50, 45	50, 45	15, 10	10, 55	20, 5
1991	45, 10	50, 30	40, 70	45, 5	40, 90	45, 45	15, 70	30, 15	40, 15	15, 15	10, 55	20, 50
1992	40, 15	45, 10	35, 10	45, 5	25, 30	30, 90	50, 10	30, 15	50, 60	50, 40	50, 15	30, 90
1993	25, 90	30, 15	35, 10	40, 15	40, 90	40, 35	20, 75	30, 85	45, 40	10, 15	30, 10	30, 65
1994	20, 75	15, 30	40, 85	40, 15	25, 20	40, 40	35, 90	20, 5	30, 5	10, 10	25, 20	15, 85
1995	15, 35	15, 5	30, 80	40, 15	10, 50	40, 40	35, 90	20, 30	30, 5	10, 10	25, 45	15, 25
1996	50, 45	15, 5	30, 80	15, 15	50, 75	40, 55	35, 75	50, 85	15, 70	45, 90	25, 10	15, 30
1997	50, 10	45, 90	15, 10	45, 10	50, 75	40, 45	45, 30	45, 35	15, 70	50, 80	25, 10	NA
1998	35, 15	30, 5	20, 80	40, 50	50, 10	45, 25	45, 20	45, 35	15, 50	50, 85	25, 85	NA
1999	35, 15	30, 5	50, 70	35, 85	50, 90	45, 25	50, 45	40, 10	45, 5	25, 75	NA	NA
2000	35, 20	30, 20	25, 90	10, 90	50, 10	45, 25	30, 15	45, 85	5, 30	5, 40	NA	NA
2001	50, 20	15, 10	15, 90	30, 65	45, 15	50, 85	25, 90	45, 90	50, 55	50, 20	NA	NA
2002	30, 70	15, 15	15, 90	20, 40	45, 40	50, 25	20, 90	45, 85	50, 70	45, 10	NA	NA
2003	30, 20	15, 45	35, 90	20, 10	45, 35	50, 30	25, 90	50, 70	50, 70	45, 45	NA	NA

[a] The 2 parameters of the Reference Deviation (REF) system are the number of days used to calculate the Reference Deviation Value and the entry threshold. For example, the optimal parameters (20, 10) for corn in 1978 indicate that a rule with a 20-day Reference Deviation window and an entry threshold of 10 produced the highest mean net return over the previous three years, 1975-1977.

Table A.9. Optimal Parameters for the Directional Movement (DRM) System, 1978-2003[a]

	Futures Market											
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	33	6	12	39	3	39	9	21	33	NA	NA	NA
1979	24	6	6	15	3	39	9	6	33	NA	NA	NA
1980	24	36	18	15	3	39	9	12	33	24	27	6
1981	24	36	18	12	27	39	39	12	27	6	9	6
1982	15	39	18	12	27	39	39	24	24	36	9	6
1983	27	39	24	12	27	39	39	24	27	36	9	9
1984	24	36	9	6	39	12	39	39	6	36	3	15
1985	27	36	6	36	39	12	30	39	6	36	24	27
1986	18	36	6	18	39	12	30	24	3	39	3	27
1987	15	36	6	6	24	24	27	33	39	39	6	6
1988	21	18	36	27	3	15	24	36	39	39	6	6
1989	21	21	18	27	36	9	12	39	39	30	6	6
1990	9	24	18	21	36	15	3	9	39	12	9	3
1991	36	3	18	12	36	12	36	3	39	30	9	18
1992	27	6	6	12	27	21	36	12	30	12	24	33
1993	24	15	18	6	27	18	36	3	30	12	39	39
1994	24	18	39	6	21	21	21	12	30	12	39	6
1995	15	18	24	6	6	30	12	21	18	9	39	15
1996	9	18	30	6	3	3	9	27	18	6	33	6
1997	27	18	21	3	3	3	36	30	18	36	9	NA
1998	9	39	21	3	3	15	33	30	21	3	12	NA
1999	9	6	36	36	3	21	27	39	3	12	NA	NA
2000	9	15	36	39	3	39	6	3	3	12	NA	NA
2001	6	24	36	39	39	39	6	3	3	9	NA	NA
2002	30	24	36	39	39	39	6	3	15	39	NA	NA
2003	30	24	21	33	39	30	6	39	21	39	NA	NA

[a] The single parameter of the Directional Movement (DRM) system is the number of days used to calculate the directional indicator. For example, the optimal parameter (33) for corn in 1978 indicates that a rule with a 33-day directional indicator window produced the highest mean net return over the previous three years, 1975-1977.

Table A.10. Optimal Parameters for Alexander's Filter Rule (ALX) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	0.080	0.130	0.035	0.100	0.090	0.160	0.160	0.080	0.200	NA	NA	NA
1979	0.080	0.130	0.100	0.120	0.130	0.160	0.150	0.160	0.160	NA	NA	NA
1980	0.090	0.120	0.090	0.140	0.030	0.030	0.150	0.130	0.160	0.045	0.015	0.015
1981	0.090	0.035	0.070	0.140	0.100	0.130	0.180	0.170	0.170	0.040	0.050	0.015
1982	0.110	0.150	0.090	0.200	0.190	0.130	0.180	0.140	0.180	0.020	0.070	0.005
1983	0.110	0.150	0.190	0.100	0.190	0.190	0.180	0.180	0.180	0.020	0.070	0.015
1984	0.110	0.150	0.045	0.070	0.190	0.190	0.180	0.140	0.200	0.025	0.070	0.005
1985	0.110	0.110	0.190	0.110	0.140	0.060	0.150	0.130	0.100	0.040	0.030	0.005
1986	0.080	0.110	0.090	0.160	0.110	0.060	0.180	0.160	0.100	0.040	0.035	0.005
1987	0.060	0.110	0.100	0.160	0.140	0.090	0.180	0.200	0.035	0.040	0.035	0.005
1988	0.050	0.110	0.100	0.140	0.070	0.200	0.180	0.180	0.050	0.040	0.040	0.005
1989	0.090	0.110	0.100	0.160	0.150	0.130	0.130	0.170	0.045	0.040	0.040	0.005
1990	0.080	0.150	0.080	0.140	0.120	0.070	0.170	0.170	0.045	0.035	0.045	0.005
1991	0.080	0.150	0.045	0.140	0.080	0.140	0.170	0.110	0.100	0.025	0.045	0.005
1992	0.080	0.025	0.045	0.090	0.120	0.090	0.200	0.100	0.100	0.080	0.090	0.010
1993	0.080	0.025	0.045	0.180	0.090	0.140	0.200	0.045	0.130	0.070	0.080	0.010
1994	0.180	0.070	0.045	0.180	0.150	0.140	0.090	0.060	0.130	0.070	0.110	0.010
1995	0.110	0.110	0.045	0.170	0.045	0.150	0.160	0.080	0.140	0.140	0.020	0.005
1996	0.110	0.110	0.080	0.170	0.160	0.160	0.160	0.080	0.090	0.140	0.090	0.005
1997	0.120	0.200	0.160	0.090	0.050	0.100	0.140	0.110	0.080	0.010	0.090	NA
1998	0.090	0.070	0.160	0.060	0.150	0.200	0.140	0.110	0.080	0.010	0.035	NA
1999	0.090	0.050	0.070	0.160	0.040	0.160	0.140	0.200	0.070	0.010	NA	NA
2000	0.090	0.060	0.140	0.150	0.120	0.170	0.130	0.200	0.050	0.090	NA	NA
2001	0.090	0.020	0.140	0.110	0.120	0.170	0.130	0.035	0.050	0.090	NA	NA
2002	0.070	0.020	0.060	0.120	0.120	0.170	0.130	0.035	0.050	0.025	NA	NA
2003	0.080	0.070	0.080	0.120	0.130	0.170	0.060	0.035	0.050	0.025	NA	NA

[a] The single parameter of Alexander's Filter Rule (ALX) system is the percent filter size. For example, the optimal parameter (0.08) for corn in 1978 indicates that a rule with a filter size of 8% produced the highest mean net return over the previous three years, 1975-1977.

Table A.11. Optimal Parameters for the Parabolic Time/Price (PAR) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	0.017	0.019	0.017	0.023	0.017	0.014	0.015	0.019	0.015	NA	NA	NA
1979	0.015	0.024	0.022	0.015	0.023	0.015	0.016	0.018	0.017	NA	NA	NA
1980	0.015	0.024	0.017	0.015	0.020	0.015	0.022	0.019	0.018	0.014	0.022	0.016
1981	0.018	0.017	0.018	0.014	0.020	0.021	0.022	0.019	0.014	0.014	0.021	0.015
1982	0.024	0.016	0.018	0.015	0.019	0.018	0.020	0.014	0.014	0.024	0.021	0.015
1983	0.016	0.018	0.022	0.022	0.019	0.014	0.019	0.014	0.014	0.024	0.021	0.015
1984	0.016	0.015	0.019	0.022	0.018	0.014	0.021	0.014	0.014	0.024	0.019	0.016
1985	0.016	0.015	0.020	0.024	0.019	0.015	0.021	0.014	0.015	0.024	0.019	0.019
1986	0.016	0.015	0.024	0.018	0.014	0.020	0.023	0.023	0.019	0.021	0.016	0.019
1987	0.016	0.015	0.015	0.024	0.014	0.014	0.023	0.023	0.024	0.021	0.016	0.015
1988	0.014	0.022	0.015	0.021	0.014	0.014	0.015	0.024	0.023	0.017	0.014	0.017
1989	0.014	0.014	0.015	0.024	0.020	0.014	0.015	0.021	0.022	0.014	0.014	0.017
1990	0.014	0.014	0.015	0.018	0.020	0.024	0.016	0.021	0.022	0.014	0.014	0.024
1991	0.014	0.014	0.016	0.018	0.021	0.020	0.014	0.021	0.022	0.014	0.014	0.021
1992	0.015	0.014	0.021	0.018	0.017	0.020	0.017	0.021	0.015	0.014	0.014	0.022
1993	0.024	0.014	0.014	0.023	0.017	0.018	0.022	0.024	0.014	0.015	0.019	0.021
1994	0.019	0.014	0.020	0.023	0.015	0.023	0.022	0.017	0.015	0.015	0.018	0.024
1995	0.016	0.019	0.020	0.023	0.015	0.018	0.016	0.017	0.016	0.019	0.021	0.014
1996	0.016	0.021	0.019	0.022	0.024	0.014	0.015	0.023	0.016	0.024	0.014	0.014
1997	0.016	0.015	0.019	0.018	0.021	0.015	0.015	0.023	0.017	0.021	0.023	NA
1998	0.016	0.018	0.016	0.018	0.024	0.021	0.014	0.018	0.023	0.021	0.023	NA
1999	0.016	0.018	0.016	0.018	0.023	0.021	0.014	0.020	0.018	0.020	NA	NA
2000	0.015	0.016	0.016	0.019	0.018	0.023	0.018	0.023	0.016	0.020	NA	NA
2001	0.015	0.015	0.017	0.019	0.017	0.017	0.020	0.023	0.016	0.019	NA	NA
2002	0.021	0.015	0.016	0.019	0.014	0.024	0.024	0.020	0.016	0.014	NA	NA
2003	0.024	0.014	0.016	0.016	0.015	0.021	0.024	0.024	0.016	0.014	NA	NA

[a] The single parameter of the Parabolic Time/Price (PAR) system is the incremental constant, which is a kind of smoothing parameter. For example, the optimal parameter (0.017) for corn in 1978 indicates that a rule with a smoothing parameter of 0.017 produced the highest mean net return over the previous three years, 1975-1977.

Table A.12. Optimal Parameters for the Directional Parabolic (DRP) System, 1978-2003[a]

						Futures Market						
Trading Year	Corn	Soybeans	Live Cattle	Pork Bellies	Lumber	Cocoa	Sugar #11	Copper	Silver	Pound	Mark	T-bills
1978	33, 0.019	30, 0.019	12, 0.015	33, 0.017	3, 0.014	39, 0.014	24, 0.015	21, 0.016	6, 0.016	NA	NA	NA
1979	9, 0.014	30, 0.019	36, 0.024	15, 0.022	3, 0.019	39, 0.014	33, 0.018	3, 0.016	9, 0.019	NA	NA	NA
1980	9, 0.014	36, 0.018	27, 0.021	12, 0.015	3, 0.020	39, 0.021	36, 0.019	12, 0.019	27, 0.021	24, 0.021	3, 0.019	3, 0.016
1981	6, 0.018	36, 0.017	27, 0.022	3, 0.015	27, 0.020	33, 0.022	39, 0.020	12, 0.019	12, 0.014	6, 0.023	3, 0.018	6, 0.016
1982	18, 0.023	39, 0.015	18, 0.017	3, 0.015	18, 0.020	39, 0.021	39, 0.021	12, 0.019	9, 0.014	6, 0.024	12, 0.019	6, 0.015
1983	27, 0.023	36, 0.014	6, 0.016	3, 0.015	18, 0.023	9, 0.015	39, 0.016	30, 0.024	3, 0.014	36, 0.017	9, 0.024	12, 0.018
1984	27, 0.016	15, 0.014	9, 0.016	3, 0.014	39, 0.016	9, 0.015	30, 0.017	30, 0.016	3, 0.015	39, 0.017	9, 0.020	9, 0.015
1985	27, 0.016	36, 0.014	6, 0.020	33, 0.014	39, 0.016	9, 0.015	30, 0.017	30, 0.016	3, 0.015	24, 0.024	30, 0.019	18, 0.019
1986	36, 0.018	36, 0.014	39, 0.024	33, 0.014	39, 0.016	9, 0.019	33, 0.017	24, 0.023	6, 0.015	33, 0.021	12, 0.018	30, 0.014
1987	21, 0.016	3, 0.014	6, 0.023	9, 0.020	6, 0.018	18, 0.017	27, 0.017	21, 0.017	6, 0.020	33, 0.020	12, 0.014	27, 0.023
1988	21, 0.024	12, 0.021	36, 0.014	9, 0.020	6, 0.018	39, 0.014	12, 0.017	24, 0.024	33, 0.019	33, 0.020	9, 0.016	6, 0.020
1989	21, 0.024	12, 0.014	3, 0.015	27, 0.024	36, 0.015	27, 0.017	6, 0.017	6, 0.024	39, 0.014	30, 0.014	9, 0.016	3, 0.016
1990	9, 0.014	24, 0.022	9, 0.015	15, 0.014	3, 0.023	12, 0.019	6, 0.016	6, 0.021	39, 0.014	12, 0.015	33, 0.014	3, 0.017
1991	39, 0.016	3, 0.014	6, 0.015	12, 0.014	3, 0.024	6, 0.018	3, 0.014	6, 0.021	39, 0.014	6, 0.015	27, 0.018	3, 0.017
1992	27, 0.018	39, 0.014	18, 0.019	12, 0.018	27, 0.015	39, 0.021	3, 0.014	9, 0.018	36, 0.014	6, 0.015	24, 0.014	3, 0.022
1993	30, 0.018	18, 0.014	39, 0.024	6, 0.018	27, 0.017	21, 0.018	36, 0.016	9, 0.024	12, 0.023	12, 0.015	12, 0.017	3, 0.021
1994	21, 0.018	3, 0.014	39, 0.024	6, 0.023	21, 0.024	21, 0.024	24, 0.016	18, 0.024	6, 0.014	39, 0.016	21, 0.023	3, 0.021
1995	30, 0.020	6, 0.021	39, 0.024	6, 0.018	6, 0.024	30, 0.019	21, 0.016	18, 0.014	15, 0.024	30, 0.016	21, 0.023	6, 0.015
1996	30, 0.016	12, 0.021	39, 0.024	15, 0.022	6, 0.024	3, 0.014	21, 0.015	15, 0.024	18, 0.023	30, 0.018	33, 0.023	6, 0.015
1997	33, 0.017	39, 0.024	36, 0.022	15, 0.015	3, 0.022	6, 0.014	33, 0.015	30, 0.021	18, 0.023	27, 0.019	24, 0.024	NA
1998	9, 0.016	39, 0.018	33, 0.017	6, 0.014	3, 0.022	15, 0.021	33, 0.014	30, 0.023	21, 0.019	3, 0.021	18, 0.024	NA
1999	9, 0.016	6, 0.019	33, 0.017	6, 0.017	3, 0.022	15, 0.022	24, 0.014	39, 0.023	3, 0.016	24, 0.017	NA	NA
2000	9, 0.016	9, 0.015	33, 0.017	39, 0.019	3, 0.022	39, 0.023	9, 0.014	6, 0.020	3, 0.015	15, 0.018	NA	NA
2001	9, 0.016	3, 0.014	33, 0.017	39, 0.019	6, 0.023	39, 0.022	9, 0.014	3, 0.023	3, 0.016	3, 0.021	NA	NA
2002	33, 0.019	24, 0.014	33, 0.018	39, 0.014	33, 0.015	3, 0.021	12, 0.014	6, 0.020	3, 0.019	3, 0.017	NA	NA
2003	30, 0.023	24, 0.024	33, 0.019	33, 0.014	6, 0.021	3, 0.021	6, 0.023	3, 0.021	3, 0.019	39, 0.014	NA	NA

[a] The 2 parameters of the Directional Parabolic (DRP) system are the number of days used to calculate the directional indicator in the Directional Movement system and the incremental constant in the Parabolic Time/Price (PAR) system. For example, the optimal parameters (33, 0.019) for corn in 1978 indicate that a rule with a 33-day directional indicator window and an incremental constant of 0.017 produced the highest mean net return over the previous three years, 1975-1977.