Can Structural Change Explain the Decrease in Returns to Technical Analysis?

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Practitioners Abstract:

Returns to managed futures funds and Commodity Trading Advisors (CTAs) have decreased dramatically during the last several years. Since these funds overwhelmingly use technical analysis, this research examines futures prices to determine if there is evidence of a structural change in futures price movements that could explain the reduction in fund returns. Bootstrap tests are used to test significance of a change in statistics related to daily returns, close-to-open changes, breakaway gaps, and serial correlation. Results indicate that several statistics have changed across a broad range of commodities indicating futures price fluctuations have changed. The lower price volatility, decreased price reaction time, and decreased serial correlation may partly explain the lower returns from technical analysis.

Keywords: Structural Change, Bootstrap, Managed Futures, Commodity Trading Advisor, Technical Analysis

Introduction

The managed futures industry has been a quickly growing segment of the financial world. In recent years however, futures fund returns have decreased and the value of assets invested in managed futures has decreased along with returns. Figure 1 shows the Barclay Commodity Trading Advisor Index versus time and shows a steady trend of decreasing returns during the past twenty years. The causes of this decrease in fund performance are not fully known. Two possible explanations for the decrease are a decrease in market volatility (and therefore profit opportunities) and price distortion caused by the growth of the industry. Certainly there must have been changes in the distribution of futures prices in order for returns to have decreased so dramatically[1]. This naturally leads to the research question, "What structural changes have occurred in futures price movements?" Knowing the way futures price distributions have changed will help explain why futures fund returns have decreased.

Most financial participants are at least superficially interested in the return characteristics of managed futures funds and Commodity Trading Advisors. Technically traded managed futures funds rely almost exclusively on past prices to generate buy and sell signals. Accordingly the returns to these funds depend on weak-form inefficiency of the markets. Therefore the return attributes of managed futures funds are of high interest not only to investors but also to regulators, investment advisors, and policy makers. Technical analysis has been advocated as a way for farmers to make buying and selling decisions (e.g. Purcell; Franzmann and Sronce). Many of the farmer advisory services tracked by Irwin et. al. base their recommendations partly on technical analysis. The

[1] Indeed there have been many charges that trading by the funds has distorted prices, including cattle prices in 2002. But the evidence in support of these charges is still inconclusive (Brorsen and Irwin; Holt and Irwin; Commodity Futures Trading Commission).

dramatic decrease in technical profitability indicates that futures markets have become more efficient. Research is needed to determine the ways in which the market has changed, thereby allowing technical traders to adjust trading systems to account for these changes.

Most previous studies of returns to managed futures funds focus on the predictability of returns (e.g. Schwager; Brorsen and Townsend), factors that increase returns (e.g. Irwin and Brorsen 1987), and if an increase in the trading volume of managed futures funds decreases returns (e.g. Brorsen and Irwin 1987; Holt and Irwin). Some authors have examined the profitability of technical trading (e.g. Lukac and Brorsen 1990; Brock, Lakonishok, and LeBaron, Osler and Chang), and Boyd and Brorsen used simulated technical trading profits to see which price statistics are correlated with technical returns, but no authors have compared actual trading profits to price statistics. Furthermore, many authors have examined the distribution (e.g. Mandelbrot; Gordon) and dependence (e.g. Gordon; Mann; Trevino and Martell) of futures price changes. The few studies that have evaluated a possible change in price distributions and dependence are limited in statistical techniques and commodities tested. Using cash prices, Brorsen found that autocorrelations of the Standard and Poor 500 stock index had decreased and the variance of returns had increased over the period 1962 to 1986. Although not backed by formal significance tests, Hudson, Leuthold, and Sarassoro suggest that price changes have become more normal over time. No research has comprehensively studied a change in daily return characteristics. This research will analyze futures prices directly to test the hypothesis that a structural change in price fluctuations has occurred that may have affected the profitability of managed futures and technical analysis. This will be accomplished using bootstrap resampling techniques to test for evidence of a structural change in the dependence and distribution of futures prices.

Economic Theory

Managed futures funds overwhelmingly use technical trading systems to formulate buy and sell decisions (Irwin and Brorsen; Billingsley and Chance). Therefore the ability to generate positive net returns depends on the manner in which prices move. Any development in the futures industry that can change the way prices fluctuate could have changed the returns to technical analysis. If a structural change in price fluctuations has occurred, technical trading systems developed prior to the change may be obsolete, or changes may indicate that the need for technical trading to move the market to equilibrium has decreased.

The most popular forms of technical analysis are trend-following methods (e.g. Billingsley and Chance; Kaufmann; Commodity Futures Trading Commission). While some economists have placed technical analysis in the same category as astrology, there are sound theoretical explanations for the profitability of trend-following systems. Disequilibrium models such as those developed by Beja and Goldman and Grossman and Stiglitz are based on the assumption that prices do not instantaneously fully react to an information shock. Fundamental traders start moving the price toward equilibrium, but are unable to fully move the market due to risk aversion, capital constraints, or position limits. The result is price trends that technical analysts can detect and trade. The trending periods would be reflected in positive autocorrelation. Thus any reduction in the autocorrelation of futures prices will decrease the profitability of trend-following systems. Empirical research, however, has only been able to detect a small amount of autocorrelation beyond what would be expected in an uncorrelated series (Irwin and Uhrig). The theoretical arguments for trend-following systems are based on a delayed movement toward equilibrium after new information enters the marketplace. The increased speed of news dissemination and market transactions and the increased use of trend-following systems likely have decreased the duration of market trends.

A structural change in futures markets could be caused by many developments. Fundamental changes in markets have the possibility of modifying the way and speed in which traders react. A decrease in the cost of information, increase in the speed of financial transactions, decrease in computing cost, and an increase in the relative use of technical analysis, all have the potential to change the way prices fluctuate by increasing the reaction to new information and driving the market to equilibrium faster. These developments will have decreased the cost of using technical analysis and therefore may have decreased its profitability. In addition to these developments directly related to the futures industry, there are many economy wide changes that may have affected futures prices. Freer trade, better economic predictions, and fewer major shocks to the economy all may have lowered price volatility and therefore lowered the need for technical speculators to move the markets to equilibrium. Previous research by Boyd and Brorsen supports this theory as they found a strong relationship between market volatility and technical trading profits.

Developments in the past several years may have allowed markets to react faster to new information. If new information becomes available overnight, the change in prices between the close and open would be large. If price movements occur overnight then funds will either miss trading opportunities or will have to trade in the overnight markets that have higher liquidity costs. It is expected that advancements in markets such as increased news and transaction speed have caused the variance and kurtosis of close-to-open gaps to increase; however, the expected increase in the variance of gaps may be offset by a decrease in overall market volatility.

These possible changes in prices leads to the first hypothesis of structural change in daily futures prices:

1) There is a decreased demand for technical trading due to market developments and macroeconomic change. These changes will be shown through reduced price volatility and decreased market reaction time.

Another possible explanation for the reduced technical trading profitability is that large increase in the managed futures industry has distorted prices. Lukac, Brorsen, and Irwin found that different simulated technical trading systems signaled trades on the same day a significant number of days, which may allow for price distortion. In a recent Commodity Futures Trading Commission Report (page 7), the market surveillance staff reported:

> Over many years of observing the activity of commodity funds, the Surveillance staff has observed that, although a large number of funds may hold positions in a market, most of them do not trade on any given day. When funds do trade, however, they tend to trade in the same directions. Since many funds use technical, trend-following, trading systems, it is not clear whether fund activity contributes to the magnitude or direction of the price change or whether they are reacting to the price change.

Empirical research is inconsistent as to whether an increase in the size of managed futures increases price volatility (e.g. Brorsen and Irwin; Holt and Irwin; Irwin and Brorsen). Increased technical trading should speed price adjustments (i.e. reduce inefficiency), but it would also increase the variance and kurtosis of price movements (Brorsen, Oellermann, and Farris).

The possibility of price distortion leads to the second hypothesis of structural change in daily futures prices:

2) The increase in the size of the managed futures industry has increased price volatility, increased price kurtosis, and decreased autocorrelations, by either increasing market efficiency or price distortion through similarity of trading.

These two hypotheses represent two possible ways that a change in daily futures price behavior may be reflected in reduced technical profitability.

Data

Daily futures prices from seventeen commodities were used to test hypotheses regarding a structural change in daily price movements. A diverse set of commodities was selected representing four sectors: agricultural, financial, foreign exchange rates, and precious metals. The data were collected from the Bridge/CRB commodity database. The tests of structural change separate the data into two distinct time periods. Time period one begins on January 1, 1975 or the first date on which data were available, and ends on December 31, 1990. Time period two begins on January 1, 1991 and ends on December 31, 2001. The split date was selected to coincide with the drop in technical trading returns as shown in Figure 1.

In order to analyze the contracts typically traded by managed futures funds, a continuous series of prices was constructed utilizing a contract until thirty trading days prior to the expiration of a contract, then the price series uses the next subsequent contract month. The changes in variables were calculated before splicing the data so that no outliers are created when contracts are rolled over.

Three market related variables were analyzed: daily returns, close-to-open price changes, and daily trading gaps. Percent daily returns are defined as:

(1) $$r_t = 100 * (\ln s_t - \ln s_{t-1})$$

where r_t is the daily return for day *t*, and s_t is the futures settlement price for day *t*. Close-to-open price changes are the gaps between the settlement price of a futures contract and the opening price on the following day. Therefore,

(2) $$c_t = \ln o_t - \ln s_{t-1}$$

where c_t is the logarithmic close-to-open change, o_t is the opening price on day *t*, and s_{t-1} is the previous day's settlement price. The final statistic, breakaway trading gaps, is

(3) $$g_t = \begin{cases} \ln h_t - \ln l_{t-1}, & \text{if } h_t \le l_{t-1} \\ \ln l_t - \ln h_{t-1}, & \text{if } l_t \ge h_{t-1} \\ \text{"missing"}, & \text{otherwise} \end{cases}$$

where g_t is the trading gap, h_t is the highest price attained on day *t*, and l_t is the lowest price attained on day *t*.

Statistics Tested

Daily Return Statistics. More statistics are calculated for the daily returns than for other variables. Both short-term and long-term statistics are generated. There are three distributional statistics that are calculated for daily returns: sample variance, skewness, and kurtosis.

The *p*-day logarithmic return was calculated by summing daily returns. Long-run returns are calculated for lengths of 5 (weekly), 10 (biweekly), and 20 (approximately monthly) days. The long-run returns are overlapping in order to allow for greater power of bootstrap statistical tests (Harri and Brorsen). The variance of weekly, biweekly, and monthly returns is calculated and analyzed for changes in long-run volatility.

The multi-day returns also allow comparing short-run and long-run effects. In order to compare daily returns to returns of longer time horizons, ratios of daily variance to 5, 10, and 20 day variances were calculated. Variance ratios have been used in market efficiency tests (Poterba and Summers; Lo and Mackinlay). With independent and identically distributed normal random variables, the variance of *p*-day returns is *p* times that of daily returns. Positive autocorrelation would cause variance ratios to be less than 1/*p*. The variance ratios of Lo and MacKinlay also use overlapping data.

Daily Breakaway Gap and Close-to-Open Change Statistics. The same statistics will be calculated for both gaps and close-to-open changes. These statistics are intended to summarize the size and distribution of these variables. Four sample statistics will be calculated for each variable: mean, variance, relative skewness, and relative kurtosis.

Bootstrap tests were used to determine if any of the first four moments of gaps or close-to-open changes have significantly changed.

Autocorrelation Statistics. In addition to distributional measures of returns and gaps, structural change in autocorrelation of daily returns was also tested. Four statistics were calculated: the sum of the first 5 and first 10 autoregressive coefficients, and the sum of the first-5 and first-10 squared autoregressive coefficients. The sum of the squared coefficients is linearly related to the Box-Pierce and Ljung-Box Q.[2] A p-lag autoregressive coefficient ρ_p is defined as

(4) $$\rho_p = \frac{\text{cov}(r_t, r_{t-p})}{\text{var}(r_t)}$$

where $\text{cov}(r_t, r_{t-p})$ is the covariance of r_t and r_{t-p}, and $\text{var}(r_t)$ is the variance of daily returns. If $E(r_t)=0$ then equation (4) is algebraically equivalent to

(5) $$\rho_p = \frac{\sum_{t=p+1}^{N} (r_t * r_{t-p})}{(N-1)(Var(r_t))}$$

where N is the sample size.

Procedures

Formal tests of structural change were performed using bootstrap procedures. Due to the serial dependence of returns and gaps, both parametric tests and standard bootstrap procedures developed by Efron are not appropriate since they assume independence. The unique nature of the data and statistics requires the type of bootstrap procedure being used to be carefully selected. Two different bootstrap procedures were used to approximate the sampling distributions of the statistics. Non-autocorrelation statistics must be analyzed with a bootstrap that both accounts for serial dependency and also preserves the stationarity of the time series. The bootstrap procedure used for serial correlation statistics must maintain the long-term dependency in the data. Therefore the data must be resampled in a way that preserves the dependency in the original time series.

Bootstrap Method for Daily Returns, Close-to-Open Changes and Gaps

For all statistics other than autocorrelation statistics, the stationary bootstrap (Politis and Romano) is used to construct confidence intervals for the statistics during the first time

[2] Under the null hypothesis of no autocorrelation for the Ljung-Box and Box-Pierce tests, the Q statistics are asymptotically pivotal (Ljung and Box; Box and Pierce). An asymptotically pivotal statistic is one whose distribution does not depend on any unknown parameters. For example, if a statistic converges in distribution to a chi-squared distribution, then the statistic is asymptotically pivotal. Horowitz argues that the bootstrap procedure has greater power with asymptotically pivotal statistics. In practice, however, the asymptotic pivotalness property has proven unimportant (Maausoumi), and therefore no attempt is made here to ensure that test statistics are asymptotically pivotal.

period. This type of bootstrap is applicable to weakly dependent stationary time series and has been used in financial studies such as White, Sullivan, and Timmerman, and White.

The formation of the pseudo time series involves many steps. Let N_1 be the sample size of the first time period and N_2 be the sample size of the second time period. First the length of the block, l, is determined. This random length varies according to a geometric (.10) variable. Next the starting observation, s, is chosen by randomly selecting a number according to a discrete uniform distribution. The starting block is generated by $x_1^* = [x_S, x_{S+1}, \ldots x_{S+l-1}]$. This process is repeated by selecting a new l and s to generate x_2^*. This process is continued and the vector **X*** is generated by concatenating the $\mathbf{x_i}^*$ vectors until the pseudo series is greater in length than N_1. The generated series is then truncated such that the number of observations in **X*** equals N_1, the number of elements in the first time period. This process is repeated to form another pseudo-series **Y***, which is a 1 x N_2 vector generated from stochastic length blocks of data from the first time period.

Once the pseudo time series sample is generated, the statistics of interest are calculated on **X*** and **Y***. For a test of a change in the mean, the difference in the mean of the elements of **X*** and **Y*** is found:

(6) $$\hat{\Theta}_1 = \frac{1}{N_1}\sum_{i=1}^{N_1} X_i - \frac{1}{N_2}\sum_{i=1}^{N_2} Y_i$$

Following Good, a test in the change of the variance is performed by calculating the ratio of the variance of **X*** to the variance of **Y***

(7) $$\hat{\Theta}_2 = \frac{\frac{1}{N_1 - 1}\sum_{i=1}^{N_1}(X_i - \bar{X})^2}{\frac{1}{N_2 - 1}\sum_{i=1}^{N_2}(Y_i - \bar{Y})^2}$$

Equation (7) is used for daily, 5-day, 10-day, and 20-day returns. Tests of a change in relative skewness and relative kurtosis use the difference in the sample relative skewness and relative kurtosis in **X*** and **Y***. In contrast Dufour and Farhat use the absolute value of the change in skewness and relative kurtosis. The statistics used are thus:

(8) $$\hat{\Theta}_3 = \frac{N_1}{(N_1-1)(N_1-2)}\frac{\sum_{i=1}^{N_1}(X_i - \bar{X})^3}{s_x^{\,3}} - \frac{N_2}{(N_2-1)(N_2-2)}\frac{\sum_{i=1}^{N_2}(Y_i - \bar{Y})^3}{s_y^{\,3}}$$

and

$$\hat{\Theta}_4 = \left[\frac{N_1(N_1+1)}{(N_1-1)(N_1-2)(N_1-3)} \frac{\sum_{i=1}^{N_1} (X_i - \overline{X})^4}{s_x^{\ 4}} - \frac{3(N_1-1)^2}{(N_1-2)(N_1-3)} \right] - \tag{9}$$

$$\left[\frac{N_2(N_2+1)}{(N_2-1)(N_2-2)(N_2-3)} \frac{\sum_{i=1}^{N_1} (Y_i - \overline{Y})^4}{s_y^{\ 4}} - \frac{3(N_2-1)}{(N_2-2)(N_2-3)} \right]$$

where s_x and s_y are the sample standard deviations of **X*** and **Y***, respectively.

The process is repeated until 1,000 new pseudo-series have been generated and the $\hat{\Theta}_m$ $(m = 1, 2, 3, 4)$ statistics calculated. The actual change in the statistic, Θ_m, is then calculated. Θ_m is the value of Equations (6) to (9) when the actual data from time period one is the vector **X** and the actual data from time period two is the vector **Y**. The null hypothesis of no change (i.e. Θ_m=0) is rejected if Θ_m is less than the $\alpha/2$ percentile of $\hat{\Theta}_m$ or greater than the 1-$\alpha/2$ percentiles of $\hat{\Theta}_m$. The levels of α selected for this study are .05 and .10.

Bootstrap Methods for Daily Autocorrelations

Any bootstrap autocorrelation test must maintain the dependence between observations. The block bootstrap methods maintain dependence asymptotically as the size of the block increases to infinity (Horowitz). However, in finite samples, block bootstrap methods alone produce autocovariance estimates that are biased toward zero. In order to fully maintain the dependence, a new type of bootstrap procedure was developed.

Let N_2 be the sample size of the second sub-period, and let p={5,10} be the length of autoregressive lag tested. Then form **C** to be a $(N_1 - p)$ x $(p + 1)$ matrix comprised of row vectors $\mathbf{c_t}$ where the jth element of $\mathbf{c_t}$ is the return for day $t - j + 1$ from the first subperiod, such that $\mathbf{c_t}=[r_t, r_{t-1},\ldots,r_{t-j+1},\ldots, r_{t-p}]$ for all $t>p$. Bootstrap confidence intervals were formed by resampling blocks of row vectors (with replacement) from the matrix **C** to form a N_1 x p+1 matrix **C*** and a N_2 x p + 1 matrix **D***. The number of vectors in a block is a geometric (.10) random variable. Therefore, **C*** and **D*** are similar to the pseudo-time series generated by the stationary bootstrap used for returns and gaps. Equation (5) can then be rewritten as

$$\rho_{p,\tau} = \frac{\sum_{i=1}^{T-p} (\tau_{i,1} * \tau_{i,k})}{\text{var}(\tau_{i,1})} \quad \text{for } \tau = \{c, d\} \tag{10}$$

where var($\tau_{i,1}$) is the variance of the first column vector of **T***, (**T**={**C**,**D**}).

The statistics of interest are the differences in the autocorrelation coefficients from **C*** and **D*** adjusted by the degrees of freedom. These statistics are then calculated from the simulated ρ_p 's (10) by the equation

$$(11) \qquad \hat{\Theta}_5 = \left(N_1 * \sum_{i=1}^{p} \rho_{i,c}^{w} - N_2 * \sum_{i=1}^{p} \rho_{i,d}^{w} \right) \text{ for } w = \{1,2\}, \text{ and } p = \{5,10\}$$

where p is the lag and w is the power to which the autoregressive coefficient is raised. This process is repeated 1,000 times to form an empirical bootstrap distribution of the $\hat{\Theta}_5$. Let **D** be a $(N_2 - p)$ x $(p + 1)$ matrix formed in the same manner as **C**, but using data from the second time period. Then Θ_5 is the difference in the autocorrelations from the first time period and the second time period (i.e. using the matrices **C** and **D** in Equations 10 and 11). The null hypothesis of no change (i.e. Θ_5 =0) was reject if Θ_5 was less than the α/2 percentile of $\hat{\Theta}_5$ or greater than the 1-α/2 percentiles of $\hat{\Theta}_5$.

Since it is unlikely that a statistic will significantly change across all commodities, a rule to determine how many commodities represent enough to conclude a change has occurred is desired. However, a rule such as this is difficult to formulate. This is due in large part to prices of many commodities being correlated with prices of other commodities. Furthermore, this dependency is not constant between commodities. Therefore any rule devised using standard statistical methods has been ruled out as inappropriate and an ad hoc rule was formulated. In order to save space in this paper and prevent reporting several pages of insignificant statistics, only those statistics that have changed in one half or more of the commodities or have substantial theoretical explanations will be presented and explained. This will allow more emphasis on statistics that have more evidence of change than discussing all commodity-statistic pairs that have changed.

Results

The tests of structural change are presented in Table 1 through Table 8.[3] There is definite evidence of a structural change in futures price returns, gaps, and autocorrelations.

The volatility of futures prices has decreased. Table 1 shows that the variance of one and twenty-day returns has decreased in 8 of the 17 commodities. Furthermore Table 2 shows the frequency of gaps has decreased in 16 commodities and the variance of gaps has decreased in 9 commodities. The variance of close-to-open changes has decreased in 14 commodities as shown in Table 6. A reduction in volatility translates into less trading opportunities for technical funds (Boyd and Brorsen); thereby, reducing profit prospects. Technical trading systems profit by moving a market to equilibrium. If price

[3] Coffee and wheat consistently change different than the other commodities. This is likely due to the breakup of the International Coffee Organization in 1989 (Indahsari) and the decrease in wheat subsidies by the federal government (United States Department of Agriculture).

equilibriums do not move as much, there are fewer opportunities for technical systems to profitably trade. Therefore, the decreased volatility in short and long-run returns is consistent with the hypothesis that a structural change in futures markets caused a decrease in technical trading returns.

Although the variance of several of the variables decreased, the kurtosis of daily returns (Table 2), breakaway gaps (Table 5), and close-to-open changes (Table 6) all increased in several commodities. The increased kurtosis suggests that when new information is released during non-trading hours, the market reacts quickly to this information and has already moved toward equilibrium by the open. The quicker jump to an equilibrium price may cause technical systems to not be able to execute a trade until prices have already moved toward equilibrium.

The nature of price autocorrelations has changed. Tables 7 and 8 show the four autocorrelation measures. In 6 of the 17 commodities, at least one of the sums of autocorrelation changed significantly. All but two of the significant changes was a decrease in autocorrelation. In addition the variance ratios in Table 3 show weak evidence of decreased autocorrelation. Under the assumption of independent and normally distributed changes, these ratios should be near $1/p$. Eight of the commodities showed a significant increase in the ratios and almost all of the ratios moved closer to $1/p$, which indicates less autocorrelation. A majority of the technical trading systems are trend following, and a decrease in the autocorrelation of daily returns would likely decrease the profitability of trend following systems. While the change in price serial correlation is not pronounced, it is in a direction consistent with technical trading being less profitable.

Although many market variables show evidence of change, there are still a few statistics that did not significantly change.[4] The average size of close-to-open price changes and breakaway gaps did not consistently change. The skewness of returns, gaps, and close-to-open changes changed in only a few commodities.

Conclusions

The returns to managed futures have decreased steadily during the past two decades; since these funds are overwhelmingly technically traded, futures prices were examined for evidence of a structural change that could explain the reduction in fund profitability. The results show there is evidence of a structural change in prices that may have caused a reduction in the returns to managed futures funds. The two dominant changes are a decrease in price volatility and increase in large price changes occurring while markets are closed. There was also a slight indication of reduced autocorrelation. These changes are consistent with the reduced profitability of technical trading being due to changes in the overall economy. If prices were to again become more volatile, then presumably returns to technical trading would likely increase again. The reduced profitability is a signal to traders that less technical trading is now needed and presumably as technical

[4] Five-minute intraday prices of six commodities were also examined, but no clear pattern of change was found (Kidd).

traders exit the market, profits will return to normal levels but not likely to the abnormal levels of the early 1980s.

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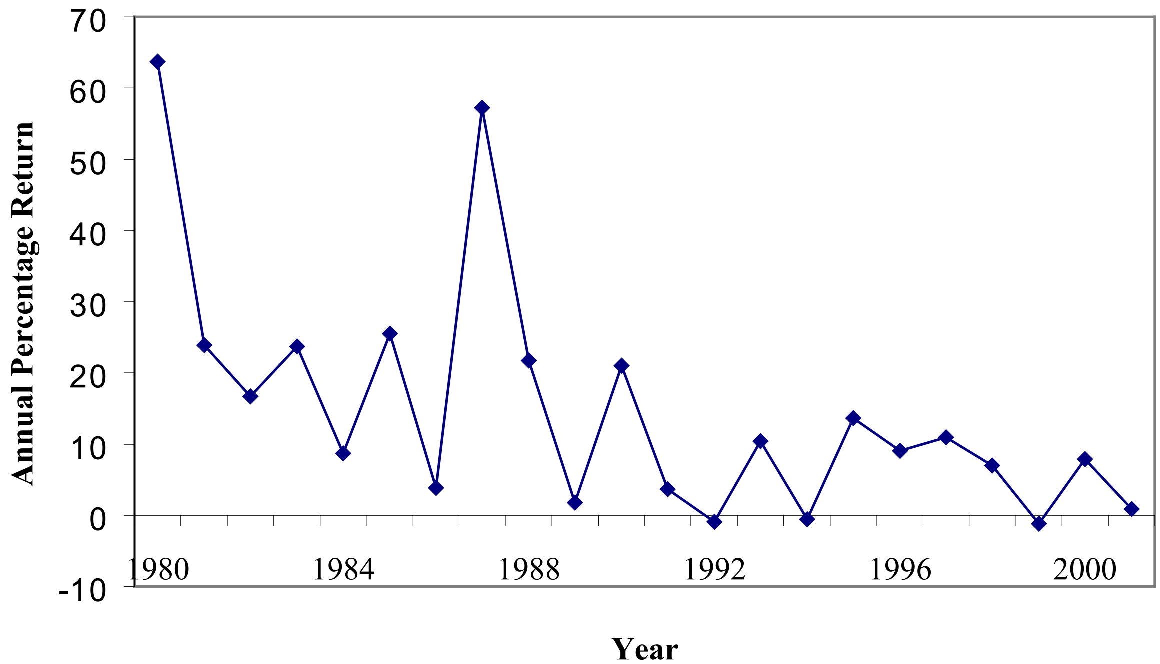

Figure 1. Barclay CTA index annual percentage returns by year
Source: The Barclay Group

Table 1. Variance of Daily and 5-Day Returns for Futures Prices.

Commodity	Variance of Daily Returns 1975[a]-1990	Variance of Daily Returns 1991-2001	Variance of 20-Day Returns 1975[a]-1990	Variance of 20-Day Returns 1991-2001
Coffee	3.38	7.10++	99.9	162.4++
Cocoa	3.57	3.16**	77.5	60.9**
Corn	1.41	1.52	35.5	36.9
Crude Oil	3.83	3.60	105.4	67.2
Deutsche Marks	0.44	0.48	10.2	10.6
Eurodollars	0.02	<0.01**	0.5	0.1**
Feeder Cattle	1.14	0.53**	27.0	11.1**
Gold	2.15	0.60**	45.5	12.8**
Heating Oil	2.99	3.14	84.6	67.0
Japanese Yen	0.43	0.58++	11.1	12.6
Live Cattle	1.33	0.60**	28.2	11.0**
Pork Bellies	4.52	5.08+	116.3	114.5
Soybeans	2.25	1.48**	51.0	29.4**
Standard and Poor's 500	2.02	1.09	25.8	17.9
Sugar	7.42	3.29**	160.2	66.2**
Treasury Bonds	0.71	0.37**	16.9	7.3**
Wheat	1.28	1.52	26.2	40.9++

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions.
Statistically significant increases are denoted by + at .10 level and ++ at .05 level.
Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 2. Skewness and Kurtosis of Daily Returns for Futures Prices.

	Skewness of Daily Returns		Kurtosis of Daily Returns	
Commodity	1975[a]-1990	1991-2001	1975[a]-1990	1991-2001
Coffee	-0.28	0.47++	4.05	8.08++
Cocoa	0.05	0.37++	0.64	2.27++
Corn	-0.01	-0.02	1.90	1.86
Crude Oil	-0.14	-2.14**	4.85	36.11++
Deutsche Marks	0.20	0.01	2.44	1.90
Eurodollars	0.62	0.33	10.19	6.55
Feeder Cattle	-0.08	-0.07	0.46	1.04++
Gold	-0.10	0.63++	4.00	18.11++
Heating Oil	-0.06	0.10	2.44	3.37
Japanese Yen	0.32	0.84++	3.13	8.62++
Live Cattle	-0.10	-0.02	0.26	0.75++
Pork Bellies	-0.01	0.01	-0.59	0.02++
Soybeans	-0.11	-0.05	0.96	2.99++
Standard and Poor's 500	-5.52	-0.28	158.43	5.11
Sugar	-0.04	-0.05	1.85	2.46
Treasury Bonds	0.21	-0.36	5.80	2.06**
Wheat	0.32	0.15	5.94	1.32**

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions.
Statistically significant increases are denoted by + at .10 level and ++ at .05 level.
Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 3. Ratio of Daily Variance to 5-Day and 20-Day Variance for Futures Prices.

	Ratio of Daily Variance to 5-Day Variance		Ratio of Daily Variance to 20-Day Variance	
Commodity	1975[a]-1990	1991-2001	1975[a]-1990	1991-2001
Coffee	0.17	0.19^{+}	0.033	0.043^{++}
Cocoa	0.18	0.21^{++}	0.046	0.051
Corn	0.18	0.18	0.039	0.041
Crude Oil	0.16	0.22^{++}	0.036	0.053^{++}
Deutsche Marks	0.19	0.19	0.043	0.045
Eurodollars	0.17	0.17	0.039	0.034
Feeder Cattle	0.17	0.18	0.042	0.048
Gold	0.19	0.20	0.047	0.046
Heating Oil	0.16	0.21^{++}	0.035	0.046^{+}
Japanese Yen	0.19	0.20	0.038	0.046^{+}
Live Cattle	0.18	0.19	0.047	0.055^{++}
Pork Bellies	0.17	0.19^{++}	0.038	0.044
Soybeans	0.19	0.20	0.044	0.050
Standard and Poor's 500	0.25	0.22	0.078	0.061
Sugar	0.20	0.20	0.046	0.049
Treasury Bonds	0.18	0.20	0.042	0.051^{+}
Wheat	0.20	0.17**	0.048	0.037**

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions.
Statistically significant increases are denoted by $^{+}$ at .10 level and $^{++}$ at .05 level.
Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 4. Frequency and Mean of Breakaway Gaps in Futures Prices.

	Frequency of Breakaway Gaps		Variance of Breakaway Gaps	
Commodity	1975[a]-1990	1991-2001	1975[a]-1990	1991-2001
Coffee	0.19	0.09**	1.73	3.12++
Cocoa	0.20	0.12**	1.14	0.41**
Corn	0.16	0.10**	0.74	0.42
Crude Oil	0.22	0.06**	1.65	1.43
Deutsche Marks	0.26	0.15**	0.18	0.21
Eurodollars	0.17	0.03**	0.01	<0.01**
Feeder Cattle	0.15	0.09**	0.36	0.15**
Gold	0.18	0.07**	1.05	0.19**
Heating Oil	0.26	0.08**	1.49	0.81**
Japanese Yen	0.39	0.09**	0.15	0.10**
Live Cattle	0.13	0.06**	0.45	0.11**
Pork Bellies	0.15	0.11**	2.02	2.06
Soybeans	0.14	0.07**	1.02	0.84
Standard and Poor's 500	0.07	0.03**	0.28	0.34
Sugar	0.19	0.09**	2.14	0.56**
Treasury Bonds	0.17	0.07**	0.38	0.14**
Wheat	0.16	0.15	0.28	0.40

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions.
Statistically significant increases are denoted by + at .10 level and ++ at .05 level.
Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 5. Variance and Skewness of Breakaway Gaps in Futures Prices.

	Skewness of Breakaway Gaps		Kurtosis of Breakaway Gaps	
Commodity	1975[a]-1990	1991-2001	1975[a]-1990	1991-2001
Coffee	0.33	3.77[++]	7.34	33.27[++]
Cocoa	0.39	0.37	2.33	2.40
Corn	0.86	1.06	11.25	8.79
Crude Oil	0.15	-3.94*	25.31	42.95
Deutsche Marks	-0.07	-0.48	11.26	5.10
Eurodollars	1.73	0.60	22.91	11.55
Feeder Cattle	-0.26	1.01[++]	3.65	7.71[++]
Gold	-0.09	-3.46**	9.01	30.84[++]
Heating Oil	-0.17	4.38[++]	6.85	42.02[++]
Japanese Yen	0.54	0.73	4.96	5.30
Live Cattle	-0.30	1.05[++]	3.55	9.53[++]
Pork Bellies	0.09	-0.16	2.21	2.62
Soybeans	0.15	-0.25	6.50	7.84
Standard and Poor's 500	-0.91	-1.98	6.56	13.17
Sugar	-0.65	1.09[++]	7.23	6.44
Treasury Bonds	1.41	-1.19	23.34	14.42
Wheat	-0.33	2.15	28.12	13.95

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions. Statistically significant increases are denoted by [+] at .10 level and [++] at .05 level. Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 6. Mean and Variance of Close-to-Open Changes in Futures Prices.

Commodity	Variance of Close-to-Open Changes 1975[a]-1990	Variance of Close-to-Open Changes 1991-2001	Kurtosis of Close-to-Open Changes 1975[a]-1990	Kurtosis of Close-to-Open Changes 1991-2001
Coffee	1.35	1.93^{++}	8.64	67.33^{++}
Cocoa	1.37	0.73**	2.58	2.74
Corn	0.45	0.28**	13.44	17.85
Crude Oil	1.82	0.68**	11.12	25.41^{++}
Deutsche Marks	0.23	0.14**	5.83	7.26
Eurodollars	<0.01	<0.01**	89.94	32.56
Feeder Cattle	0.31	0.11**	7.90	12.29
Gold	1.03	0.15**	9.36	86.64^{++}
Heating Oil	1.57	0.86**	6.83	32.02^{++}
Japanese Yen	0.26	0.09**	3.44	8.21^{++}
Live Cattle	0.36	0.09**	4.01	7.96^{++}
Pork Bellies	1.17	1.28	3.80	6.42^{++}
Soybeans	0.66	0.32**	9.16	30.39^{++}
Standard and Poor's 500	0.66	0.11*	410.12	42.18
Sugar	2.35	0.61**	6.61	7.25
Treasury Bonds	0.37	0.06**	12.65	16.10
Wheat	0.29	0.43^{+}	25.96	12.98

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions.
Statistically significant increases are denoted by $^{+}$ at .10 level and $^{++}$ at .05 level.
Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 7. Sums of First 5 and First 10 Autoregressive Coefficients Times the Number of Observations for Futures Prices.

Commodity	Sum of First Five Autoregressive Coefficients		Sum of First 10 Autoregressive Coefficients	
	1975[a]-1990	1991-2001	1975[a]-1990	1991-2001
Coffee	463.4	-61.6*	780.1	88.3*
Cocoa	14.2	-57.3	53.5	-48.1
Corn	76.3	20.1	395.5	257.1
Crude Oil	199.7	-247.7	526.6	-291.4
Deutsche Marks	54.9	25.5	286.5	47.9
Eurodollars	167.2	288.2	375.2	644.5
Feeder Cattle	459.2	79.4**	284.8	-188.0
Gold	-61.5	204.0	-38.0	111.4
Heating Oil	309.1	-113.2	402.4	-91.8
Japanese Yen	144.9	-61.5	503.1	53.6
Live Cattle	241.0	-19.5	56.0	-375.5*
Pork Bellies	349.4	-9.2**	484.5	257.4
Soybeans	68.9	-256.4	183.3	-94.8
Standard and Poor's 500	-436.4	-344.8	-599.0	-438.5
Sugar	-6.1	76.6	102.9	-136.5
Treasury Bonds	157.1	-260.2**	252.6	-229.3
Wheat	-187.5	174.3+	101.2	397.0

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions. Statistically significant increases are denoted by + at .10 level and ++ at .05 level. Statistically significant decreases are denoted by * at .10 level and ** at .05 level.

Table 8. Sums of First 5 and First 10 Squared Autoregressive Coefficients Times the Number of Observations for Futures Prices.

	Sum of First Five Squared Autoregressive Coefficients		Sum of First 10 Squared Autoregressive Coefficients	
Commodity	1975[a]-1990	1991-2001	1975[a]-1990	1991-2001
Coffee	26.0	16.4	34.8	21.6
Cocoa	9.5	7.6	15.4	10.9
Corn	10.9	14.3	29.1	25.0
Crude Oil	53.7	36.7	72.9	40.2
Deutsche Marks	4.1	4.8	9.8	13.3
Eurodollars	26.9	47.6	30.6	64.5
Feeder Cattle	17.2	10.2	20.6	28.7
Gold	21.3	26.7	25.6	31.2
Heating Oil	54.0	8.8	59.2	18.2
Japanese Yen	4.3	5.5	15.8	9.6
Live Cattle	7.5	7.1	21.2	22.9
Pork Bellies	14.6	10.3	17.9	22.0
Soybeans	2.7	13.8	8.9	20.9
Standard and Poor's 500	54.7	12.6	61.7	19.1
Sugar	7.6	17.7	12.1	25.0
Treasury Bonds	6.0	15.2	8.0	35.4^{+}
Wheat	14.6	33.3	25.7	37.3

[a] 1975 or the first date in the time series.

Notes: Hypothesis tests were performed using the two sample stationary bootstrap with 1,000 repetitions. Statistically significant increases are denoted by $^{+}$ at .10 level and $^{++}$ at .05 level. Statistically significant decreases are denoted by * at .10 level and ** at .05 level.