TECHNICAL SYSTEM TRADING RETURNS FROM COMMODITY FUTURES MARKETS

By J. Jonathan Weselake

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfilment of the Requirements
for the Degree of

Master of Science

Department of Agricultural Economics
University of Manitoba
Winnipeg, Manitoba, Canada

0-612-41648-8

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

*****

COPYRIGHT PERMISSION PAGE

TECHNICAL SYSTEM TRADING RETURNS FROM COMMODITY FUTURES MARKETS

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University

of Manitoba in partial fulfillment of the requirements of the degree

of

Master of Science

J. Jonathan Weselake ©1999

TECHNICAL SYSTEM TRADING RETURNS FROM COMMODITY FUTURES MARKETS

ABSTRACT

Technical trading systems, also known as system trading or trend following systems, are computerized futures trading methods which use past prices to determine buying and selling signals. System traded monthly returns are computed across 19 commodity futures markets and for a commodity futures portfolio, from 1978-1997. The objective of this study is to analyze the returns from system traded futures markets by testing a cross section of commodities, including agriculturals, metals and financials. This study addresses the level and variability of returns, the possible factors related to returns, the role of commodity returns in investment portfolios and diversification, Capital Asset Pricing Model tests, and portfolio and individual commodity risk-return tradeoffs.

Results indicate that currencies show highest returns, while agriculturals show lowest returns. The 19 commodity portfolio produced positive significant monthly returns. Also, the variability of returns is reduced considerably if commodities are traded in a commodity portfolio, rather than individually. Portfolio returns have significant negative autocorrelation, implying that returns alternate between months of positive and negative returns.

A GARCH econometric model is used to test for possible factors related to returns. Overall, results indicate that time is negatively related to both individual commodity returns and the commodity portfolio returns, which indicates that returns from system trading are decreasing over time. Both price variation and inflation are positively related to individual returns in most cases. This indicates that higher price variation and higher inflation is associated with higher returns. However, in the case of agriculturals, they are found to be negatively related to inflation, which was unexpected. The mean price level was found to be positively related to a number of individual markets. Overall, this information has implications for commodity fund managers since it identifies general conditions under which commodity system trading appears to have the best performance.

Results show that the majority of individual commodity returns had either negative or low positive correlation with each other. This indicates that they may be useful for adding to commodity portfolio diversification. However, commodities from similar groups such as corn and soybeans, or Swiss Franc and Deutsche Mark, are more highly correlated. This indicates that diversification is improved by trading commodities from a number of different groups. Return levels, in relation to risk, were found to be highest for currencies and lowest for agriculturals. Capital Asset Pricing Model tests show that commodity returns were also generally unrelated to returns from the S&P500 and are relatively comparable in return levels. Overall, results indicate that a system traded commodity portfolio may add diversification to a portfolio of equities, T-Bonds, and T-Bills.

ACKNOWLEDGEMENTS

I would like to offer my most sincere appreciation to my advisor Dr. Milton Boyd for his invaluable support, dedication, and knowledge about technical trading systems. His encouragement improved the quality of this study immeasurably. I would also like to thank my other committee members Drs. Gary Johnson and Charles Mossman for their helpful support and assistance.

My family also deserves special recognition for all of their support while I completed this research. Their understanding and compassion are truly appreciated and will never be forgotten. As well, I would like to thank a number of individuals for their help. Tamara Thomson, Patrick Nelson, Scott Farlinger, and Dennis Jackson offered support, suggestions, and counsel that led to the completion of this work.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Appendix Tables

CHAPTER 1

INTRODUCTION

Technical trading systems, also known as system trading or trend following systems, are computerized futures trading methods which use past prices to determine buying and selling signals. The use of technical trading systems for commodity futures trading has grown in popularity over the past 20 years. Some analysts from firms such as investment banks, bank trust departments, and investment management firms judge technical analysis as an important analysis technique (Clyde and Osler, 1997). It has also been found that the addition of public futures funds to a managed portfolio of bills, bonds, and stocks may reduce portfolio risk (Irwin and Brorsen, 1985; Schwager, 1996). The growing popularity of commodity funds and commodity funds reliance on technical analysis makes the analysis of these trading systems important.

Technical analysis may be valuable because fundamental market statistics may reveal some information, but not all information about prices (Blume, 1994). Many technical trading systems have been tested and many have reported significant returns. However, results may not be consistent enough to resolve fully the discussion of whether they are profitable or not (Lukac, Brorsen and Irwin, 1988a). Brock, Lakonishok and LeBaron (1992) also concluded that technical trading rules may have predictive power in forecasting price movements. Lukac, Brorsen and Irwin (1988a) found evidence that technical trading systems may be profitable on a number of futures markets.

The objective of this study is to analyze the returns from system traded futures markets by testing a cross section of various commodities, including agriculturals, metals and financials. Chapter 2 addresses the issues of the level and variability of returns and chapter 3 address the issues of the possible factors related to returns. Chapter 4 investigates the role of commodity returns in investment portfolios and diversification, Capital Asset Pricing Model Tests, and portfolio and individual commodity risk-return tradeoffs.

This study will test 19 commodities across one of the most popular trading systems used by professional traders and individual investors. The nineteen daily nearby futures contracts used are British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. These futures provide a cross-section of agriculturals, metals, and financials. A portfolio of all nineteen commodities is also used to analyze returns. Data will be 1978 through 1997 nearby futures, and replicate the trading methods of large commodity funds by generating monthly and annual percentage returns. S&P500 returns are also included in this paper as a benchmark for comparison.

One of the most popular technical trading systems, the Dual Moving Average Crossover is used to compute trading returns. This trading system was chosen for two reasons. First, it is one of the most popular systems used today and many managers of futures funds use this system. Second, this system is representative of many other trend following systems and returns from it are highly correlated to returns from other systems (Lukac, Brorsen, and Irwin, 1988b). By testing one of the most commonly used technical trading systems across a number of popularly traded futures in an analytical framework, the results will help determine the extent to which technical trading is useful for trading strategies.

In summary, this study will attempt to provide further empirical evidence and analyze the returns and risk of technically traded futures. It will examine such issues as whether the returns are declining over time, what the causes of those returns may be, and the usefulness of commodity returns in investment portfolios.

CHAPTER 2

LEVEL AND VARIABILITY OF RETURNS FROM SYSTEM TRADING

INTRODUCTION

Technical analysis and system trading has grown substantially over the past 20 years. Technical analysis uses historical price data to analyze future price direction. Some analysts from firms such as investment banks, bank trust departments, investment management firms and commodity investment pools judge technical analysis as an important analysis technique (Clyde, 1997). Approximately 80% of public futures funds depend on technical analysis to help calculate buying and selling signals for their portfolios (Irwin and Brorsen, 1985). Technical analysis is also popular with individual investors, and part of its growing popularity may be attributed to the falling prices in computers and analysis software which facilitates system trading.

Technical trading systems, also known as system trading or trend following systems, produce buy and sell signals calculated by rules based on past prices. While some technical trading systems have been tested (Lukac, Brorsen and Irwin, 1988a), results may not be consistent enough to fully resolve the discussion of whether they are profitable or not.

The objective of this paper is to analyze the return levels from system traded futures markets by testing a cross section of various commodities, including agriculturals, metals, currencies, and financials, from 1978 through 1997. The moving average trading system used in this study is representative of a variety of trend following systems and is one of the most popular trading systems used by professional traders (Lukac, Brorsen and Irwin, 1988b). Returns compiled by a dual moving average trading system are used here, since true system traded returns from commodity funds are not available. This is because it is not possible to tell from actual commodity fund returns whether they are truly system traded, since a number of the funds may over-ride their systems or use trade discretion to some extent, despite their intent to fully system trade.

The analysis in this chapter will examine the following issues. First, it will analyze the return levels from system traded futures markets. Second, it will analyze the variability of returns. Third, it will analyze autocorrelation, which is the correlation of returns from the previous period over time. If the returns from system trading are found to have reasonable levels and variability, then system traders may be justified to continue to use these methods for commodity trading decisions.

PAST RESEARCH

If statistically significant returns can be generated from the system trading of futures markets, then futures markets may be in disequilibrium. Equilibrium theory suggests that markets would quickly adjust to equilibrium, so returns from system trading would be equal to zero. However, disequilibrium theory states that markets may not adjust perfectly to new information and therefore not adjust instantaneously to equilibrium (Nawrocki, 1984). As new information is ingested by the market there would be either a price increase or price decrease. Short-run disequilibrium may exist in futures markets as these markets may not adjust to this new information quickly and efficiently. This delay in market reaction may produce profitable trends, caused by factors such as transaction costs, taxes, and the cost of acquiring and acting on new information (Lukac, Brorsen and Irwin, 1988a).

The use of system trading has been tested in the past and some of the results indicate the presence of significant returns. Some past important studies include: Irwin and Uhrig (1984); Bird (1985); Murphy (1986); Elton, Gruber and Rentzler (1987); Lukac, Brorsen and Irwin (1988a, 1988b); Irwin and Brorsen(1985,1987); LeBaron (1991); Taylor (1994); Brock, Lakonishok, and LeBaron (1992); Blume, Easley, and O'Hara (1994); Boyd and Brorsen (1991); Neftci and Policano (1984); Lukac and Brorsen (1990); Peterson and Leuthold (1982); and, Brorsen (1998). A comprehensive study by Lukac and Brorsen (1990) found that all but one of 23 trading systems had significantly positive gross returns trading 11 years with 30 futures markets. The study suggested that there may be disequilibrium in futures markets caused by more than just transaction costs.

Boyd and Brorsen (1991) also found returns in technically traded futures markets. By examining five popular technical systems across seven commodities over a number of years they found that significant returns were possible from futures markets. Peterson and Leuthold (1982) have tested the weak form efficiency market as described by Fama (1970). Their findings indicate that there was failure of the weak form efficiency in hog futures markets, and that significant returns implied the existence of a nonrandom price movement. These results suggest that markets are not as efficient as hypothesized by Fama (1970).

Lukac, Brorsen and Irwin (1988a) found that four technical trading systems had returns above both the cost of transaction and the risk return. These four systems were channel, directional parabolic, MII price channel, and dual moving average crossover. The results indicate market disequilibrium.

PROCEDURE AND DATA

The nineteen daily nearby futures contracts used in this study to compute returns are British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. These futures provide a cross-section of agriculturals, currencies, metals, and financials. Commodities were chosen based on having 20 years or more of historical prices, so they could be analyzed over time. This ruled out commodities such as crude oil, which began trading in 1983. A portfolio of all nineteen commodities is also used to analyze returns. Futures are traded from January 1978 through December 1997, accounting for 20 years of trading. S&P500 returns with dividends reinvested are also included in this paper to use as a benchmark for comparison (Ibbotson, 1998).

One of the most popular technical trading systems, the Dual Moving Average Crossover is used to compute trading returns. This trading system was chosen for two reasons. First, it is one of the most popular systems used today and many managers of futures funds use this system. Second, this system is representative of many other trend following systems and returns from it are highly correlated to returns from other systems (Lukac, Brorsen, and Irwin, 1988b).

Trading rules for the Dual Moving Average Crossover are to buy when the short moving average is greater to or equal to the long moving average, and sell when the short moving average is less than the long moving average. The moving average parameters used are 20 day and 50 day, which are representative of large commodity funds. This system is always in the market and closing prices are used to compute buy/sell signals with trades entered on the next day's open. The trading and computation of returns here attempts to mimic as closely as possible the behavior of large commodity funds. In calculating returns, 25 percent of the total capital is invested in margins, while 75 percent is set aside for margin calls, with returns being calculated from total amount invested. Slippage and commissions are set at $50 per round trade and margin levels are consistent with historical levels. The trading model assumes a position cannot be entered or exited if the market price is limit up or limit down, there is no pyramiding of positions or profits allowed, and any drawdown is replaced with additional trading capital. In order to maintain a conservative estimation of returns no interest is included on margin deposits.

This study tests the hypothesis that returns from technically traded futures markets will be zero. A t-test, also known as the Jensen test, is used to test this hypothesis, which is consistent with previous studies. Various descriptive parametric statistics are calculated to determine the levels and distribution behavior of returns.

RESULTS

Monthly Return Levels

Table 2.1 shows results for mean monthly percent returns for the nineteen commodities, the commodity portfolio and the S&P500. The Swiss Franc had the highest significant mean monthly percent return at 7.77, followed by the Deutsche Mark at 6.65, the Japanese Yen at 6.62, and the British Pound at 5.71. These returns are interesting because they indicate that currencies had the highest return levels, and 4 of the 5 currencies had significant positive returns. The agriculturals were found to have the lowest return levels, with 4 of 11 having negative returns, and livestock futures had an average return of -1.15. These results are consistent with Lukac and Brorsen (1990) who found that returns for currency futures were the highest and that returns from livestock futures were the lowest. Overall, 12 of the 19 commodities show positive returns, with 7 of them statistically significant. Table 2.2 presents results of annual returns.

Table 2.3 presents results for mean monthly returns for commodity groups. Appendix A presents graphs of mean monthly return by commodity group and the commodity portfolio. Results for groups show that the currency portfolio had positive and significant mean monthly returns, indicating that technical system trading may work reasonably well on these markets. Results from agriculturals, metals and financials (T-bonds) also indicate positive returns, but at much lower and not at statistically significant levels. These groups of commodities are likely less suited to technical system trading, due to their low return levels. However, when all commodities are included in the portfolio, returns are positive and the t-value of 2.84 is statistically significant.

A number of factors may explain the relatively high returns of currencies. Compared to agriculturals, it generally takes a longer time for currencies to make a price move. Price movements for currencies usually occur in the same direction in a long trending persistent manner. This is different from the tendency of short term price spikes found in physical commodities, which often quickly move back to equilibrium levels. Many currency prices are determined by long term economic factors such as interest rates, productivity, economic growth, investment climate, and trade balances. These tend to move in slow trends over a number of years. Secondly, equilibrium price levels may be difficult to determine in currency markets, because of disagreement over economic growth, productivity, investment climate, and trade balances. This makes it difficult for fundamental traders to determine when certain currencies are either under or over priced relative to equilibrium levels. As a result, trend followers may hold positions for a long time before reversing back to equilibrium, if they wait for fundamental traders to change the trend back to equilibrium. Therefore, currencies may continue to trend for long periods of time in an under or over priced trend relative to equilibrium, with traders holding some positions for relatively long periods of time.

Returns from agriculturals may be low due to long periods of sideways movement which causes system trading to lose money. Only during strong trends, which are relatively infrequent, such as those brought on by weather or fear of shortage for example, do these systems produce strong returns. However, based on stock/use and other data, equilibrium prices can be computed fairly easily compared to currencies, and traders then may take a position to force the market to quickly trend back to equilibrium, making it difficult for traders to capture a long-term trend, but more likely a short-term large price spike.

System trading of metals had positive returns, with the mean monthly percent return of gold at 2.06 and silver at a statistically significant level of 4.82. However, most of the returns were made in a few years of price spikes, and the other years were losing periods. Returns from these commodities were very high during the period 1979-1982, reflecting price trends that were caused by market activity specific to that time (Appendix A). This is consistent with previous findings which found that public commodity pools had their highest returns in 1979-1980 (Lukac and Brorsen, 1990). Excluding 1979-1982, silver and gold had positive returns in only 6 of the 10 years, and system trading may not be a reliable method to trade these markets, though they may be still useful in a portfolio for diversification purposes.

System Trading

Since system trading shows a statistically significant return across the 19 commodity portfolio, traders may be justified in continuing to use these systems, especially for currencies. Other commodities which show lower returns may be useful for system trading from the standpoint of adding diversification to decrease risk. However, where positive returns were not found, markets may be becoming more efficient as the use of technical trading becomes more widespread. This may be the case for markets such as agriculturals and metals. One result of increased and extensive system trading, brought on by lower cost computing, may be choppy markets with false breakouts. Choppy markets are more difficult for trend following systems to trade. If more system traders continue to enter the market and cause more choppiness and false breakouts, alternative systems may need to be considered as returns to system trading may come closer to disappearing. In the sense that these markets attempt to breakout and are driven back to equilibrium relatively quickly, they may be considered to be mean reverting, and this behavior may be increasing due to system trading.

Commodity Portfolio and S&P500 Returns

Table 2.4 presents an annual comparison of a 19 commodity portfolio returns versus the buy and hold S&P500 returns with dividends reinvested. Appendix B presents a graphical comparison of monthly equity returns for the commodity portfolio and equity returns for the S&P500. These results indicate that equity returns for the commodity portfolio were higher than the S&P500 over the trading period, but equity levels were much more varied for the commodity portfolio.

Appendix C presents annual percent returns of the commodity portfolio and individual commodities. Annual commodity portfolio returns appear to be trending down considerably over time. Implications for commodity funds may be that as more traders are using system trading, returns from it are declining. This raises the question of whether traders will need to develop alternative systems at some point in the future. These results also indicate that year to year return results are relatively variable for the commodity portfolio, compared to the S&P500. The portfolio of nineteen commodities had a mean monthly percent return of 2.31or an annual percent return of 27.74. Both the monthly and annual commodity portfolio returns were significant at the 5 percent level.

Annual Return Levels

Table 2.2 shows mean annual return statistics for the nineteen commodities, the commodity portfolio and the S&P500. When looking at annual mean percent returns, the commodity portfolio was higher than the S&P500 during the period 1978-1997. The S&P500 mean annual percent return was 16.58, which was lower than the 27.74 percent commodity portfolio return by more than 11 percent. However, the annual commodity portfolio minimum return was -27.87 percent, while the S&P500 was -4.26 percent, indicating considerably less annual return risk for equities.

Variability of Monthly Returns

Table 2.1 shows the Sharpe ratio for monthly returns. The Sharpe ratio is calculated as the mean of percent returns divided by the standard deviation of returns (Schwager, 1996). It measures the mean of returns adjusted for risk, and a high positive value indicates a high return to risk ratio. A negative Sharpe ratio indicates negative returns.

Individual commodities had relatively low Sharpe ratios, indicating a relatively high variance of returns for individual commodities and an indication of their risk as investments. This would be expected from trend following systems, due to periods of non trending markets, in which they spend the majority of their time in until a large profitable trend appears. Positive Sharpe ratios for individual commodities ranged in values between .02 and .17 and the average Sharpe ratio was .095. These results indicate that the returns from individual commodities have a relatively high variability which is consistent with Lukac and Brorsen (1990) and Murphy (1986).

The commodity portfolio had a Sharpe ratio of .18 which was higher than any of the individual commodities, as expected. As individually traded markets are combined into a commodity portfolio account, risk drops to a level which is more acceptable for investors. However, the S&P500 had a Sharpe ratio of .32, indicating a higher return to risk level than for the commodity portfolio.

Minimum and Maximum Monthly Returns

Table 2.1 presents maximum and minimum monthly percent returns for the 19 commodities, the commodity portfolio, and the S&P500. Maximum monthly percent returns are 142.00

for the Swiss Franc, 138.75 for the Deutsche mark, 114.80 for the Japanese Yen, and 152.60 for the British Pound. The portfolio had a maximum monthly percent return of 37.94 and a minimum monthly percent return of -47.23. The largest difference between maximum and minimum (largest range) was found in Coffee at 467.77% and the smallest difference was found in the Portfolio at 85.17%. The reduction in the difference between maximum and minimum returns existed because of the diversification of the portfolio across a number of futures markets. Individual markets were subject to very large swings in mean monthly returns, which was not as prevalent in the portfolio returns. By comparison, the S&P500 had a difference of maximum and minimum monthly returns of only 34.95%, making it the investment with the smallest difference in maximum and minimum return levels.

Commodity Fund Portfolio Versus Individual Investor

High variance in individual markets and lower variance in the commodity portfolio has important implications. It may sometimes be prohibitively expensive for individual investors to achieve the same level of diversification that commodity funds can deliver. The capital requirement of diversifying across a number of commodities can be very high for individual investors. For example, if an individual investor wanted to trade twenty-five commodities, each with a margin deposit of $1,000 and $3,000 deposited for margin calls, the total investment would be $100,000. This relatively high capital requirement of diversification may be a significant barrier for the individual to trade in these markets, which keeps the small direct investor out.

Commodity funds, which operate in a manner similar to equity market funds, allow individual investors access to these futures markets without large capital outlays. Commodity funds allow investment at a risk level that is below that of individual futures markets and with an investment amount, such as $10,000, which is lower than if they were to diversify on their own, using $100,000. This may partially explain the high growth in commodity funds popularity over the past number of years. These funds provide a service by providing individual investors a lower risk access to futures market returns, and providing a way around the traditional barriers of size for the small investor to enter the commodity markets.

Another important finding is that compared to the commodity portfolio, individual markets show considerably lower risk adjusted returns as measured by the Sharpe ratio. This finding may be consistent with the efficient market hypothesis. Relatively efficient markets, as measured by relatively small risk adjusted returns, appear likely to exist for individual system traded commodities. However, when measured in a portfolio, returns become higher related to risk indicating a less efficient market. This indicates that markets may be too efficient to be profitable for the individual investor. Yet, they may remain inefficient enough in the portfolio sense for the larger investor or large fund to be profitable.

Distribution Statistics of Returns

Table 2.5 presents monthly skewness and kurtosis levels are calculated and presented for 19 commodities, the commodity portfolio, and the S&P500. Skewness, or lack of symmetry, is referred to as the third moment of a distribution around its mean value. Skewness shows whether the distribution leans to the left (negative returns) or to the right (positive returns). The results of this paper show that the skewness results are very small and close to zero for all cases. The only exception to this result is silver which has a skewness value of 1.15. The commodity portfolio's skewness is -.28, showing a slightly left leaning distribution of mean monthly returns. Skewness results indicate that 10 of the 19 individual commodities had positive skewness values. The majority of commodities showed positive skewness, and Lukac and Brorsen (1990) found similar results.

Kurtosis is referred to as the fourth moment of a distribution around its mean. This statistic shows the amount of the distribution that rests in the tails. A large negative kurtosis statistic indicates that the distribution has less weight in the tails than a normal distribution. A positive kurtosis value would indicate that there is more weight in the tails than in a normal distribution, and it is referred to as a leptokurtic distribution. This would indicate a large number of large positive and negative returns. A zero value would indicate tail weights consistent with normal distributions. All of the nineteen commodities have positive kurtosis values, with silver the largest at 3.89 and the British Pound at 3.73. The high values indicate that these markets have more large positive returns and negative returns, compared to a normal distribution.

The commodity portfolio had a kurtosis value of 1.66 which also indicates a leptokurtic distribution of mean monthly returns. The presence of leptokurtic distributions in commodity portfolio returns is consistent with Brorsen's (1998) finding. The S&P500 had a kurtosis value of 3.37, which was higher than all but two of the individual commodities and the commodity portfolio.

Using kurtosis to estimate risk levels should be done cautiously. Kurtosis is the fourth moment around the mean of a distribution and any month with an extreme return level is extremely amplified through the fourth moment. While Sharpe ratios were high for the benchmark S&P500, indicating low risk levels, kurtosis levels were found to be higher in the S&P500 than in the majority of the commodity markets. This situation may result largely from the few days of extreme price movements that affected the equity market in October, 1987, which became greatly amplified due to the exponential effect in computation of the kurtosis statistic. This caused a high kurtosis statistic for the S&P500 over the period 1978-97.

The indication of leptokurtic distributions may imply higher risk for traders. This indicates that there may be more levels of risk for commodity funds than in a normal distribution of returns. Although much of this risk has been diversified away in the commodity portfolio, there remains more risk than in a typical normal distribution of returns.

Autocorrelation

Table 2.6 shows the results of monthly autocorrelation tests or correlation over time (persistence). S&P500 results are also shown in each table for comparison. The autocorrelation statistic indicates whether or not returns from this period are correlated with returns from last period. The commodity portfolio had a significant negative autocorrelation coefficient and this can be partially attributed to the fact that 4 of the 5 significant autocorrelation coefficients were negative. The finding of significant negative autocorrelation for the commodity portfolio indicates that returns from last period are negatively correlated to the returns from this period. High returns may be followed by lower returns, and vice versa. These results are consistent with previous findings of Brorsen (1998), and Schwager

(1996) who argued that CTA/fund returns are negatively correlated over time in the short run. These negative autocorrelation results indicate that investors may be better off to invest following a low monthly return, because a higher return would be expected the next month. For fund managers, this means they are more likely to have months which alternate between positive and negative returns. This is in contrast to positive autocorrelation or runs of positive returns followed by runs of negative returns, leading to a large loss of capital.

For individual monthly returns, 11 of the 19 commodities indicate positive autocorrelation, but only 5 of the 19 commodities and the commodity portfolio indicated autocorrelation at the statistically significant level, and only 1 was positive. Autocorrelation coefficients were all quite small with the average of the significant negative autocorrelation coefficients being -.125 and the single significant positive autocorrelation coefficient being .03. Since so few of the autocorrelation coefficients were statistically significant, general conclusions about individual markets cannot be reached.

Autocorrelation coefficients were not similar for the markets with the highest returns or the lowest returns. The five markets with the highest returns had 3 negative and 2 positive autocorrelation coefficients, with two being statistically significant. The five commodities with the lowest returns had 4 negative and 1 positive autocorrelation coefficients, with none being statistically significant.

SUMMARY

System trading returns of nineteen commodities over a twenty year (1978-1997) period using the Dual Moving Average Crossover system were computed. The commodity futures traded were British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. Transaction and slippage costs were assumed to be $50 per round trade. In calculating returns 25 percent was invested in the market, while 75 percent was held in reserve for margin calls. Returns are calculated from the total investment, and trading methods used attempted to mimic those of large commodity funds.

There are a number of important findings that this paper has presented. First, results of this study indicate that some system trading of futures markets can produce positive statistically significant returns in some futures markets. Overall the 19 commodity portfolio showed an annual return of 27.74 percent over the 1978-1997 period, compared to 16.58 for the S&P500. The British Pound, cotton, Deutsche Mark, Japanese Yen, Swiss Franc, silver, sugar, and the commodity portfolio were found to have positive statistically significant monthly returns. However, metals, agriculturals, and financials (T-bonds) were found to have considerably smaller returns. These results suggest that currencies may be well suited to technical system trading, and that physical commodities may be less suited, though they may still be traded for diversification purposes. The profitability of currencies may be due to their long trends created by long-term factors such as interest rates, economic growth, investment climate, and trade balances. The increased use of technical system trading may also lead to choppiness in physical markets and false breakouts, with fewer substantial profitable trends.

Second, the relatively high risk associated with individual commodities can be reduced considerably if they are traded as a portfolio. By using the monthly Sharpe ratio as a measure of risk, the commodity portfolio was found to have a much lower risk level than any of the nineteen commodities. Commodity funds allow the individual investor access to this risk diversification, as diversification may be prohibitively expensive for an individual investor to achieve, since they may need to trade as many as 15 commodities to lower risk. When compared to the return from the S&P500, the commodity portfolio was found to have a higher mean monthly return but a higher risk. The mean monthly percent return from the commodity portfolio was .93 higher than the S&P500. However, its Sharpe ratio was .14 lower, indicating that commodity returns were more risky relative to those of stocks.

Third, relatively high levels of kurtosis were found in the distribution for individual commodity returns and in the commodity portfolio returns. This indicates the presence of leptokurtic distributions and that traders can expect more returns to be in either of the tails than in a normal distribution of returns. The high kurtosis values for the S&P500 likely occurred because of the stock market crash of October 1987.

Fourth, the mean monthly percent return from the commodity portfolio was found to display significant negative autocorrelation, which suggests that a month of high returns is followed by a month of low returns, and vice versa. Investors may be better off to invest following a low monthly return, because a higher return would be expected the next month. For the fund manager, this means they are more likely to have monthly returns alternate from positive to negative, rather than a number of runs of positive months followed by runs of negative months, which may cause substantial losses of capital.

Fifth, commodity fund returns appear to be declining over time. This may be due to the lower cost of computing and the large number of traders who now have access to system trading. If this situation continues, system trading may become less profitable to the point where traders may find it necessary to develop alternative trading methods. Finally, returns in this study are based on specific commodities and specific past time periods and results reported here may not necessarily hold in the future.

Table 2.1

Monthly Return Statistics for Nineteen Commodities and Commodity Portfolio Using System Trading, 1978-97 [a,b,c,d,e].

Commodity	Mean Monthly % Return	Sharpe Ratio	Coefficient of Variation	Minimum Monthly Return	Maximum Monthly Return	T-Ratio
British Pound	5.71	0.13	773.51	-222.60	152.60	2.00*
Canadian Dollar	-0.75	-0.04	-2352.15	-61.53	58.38	-0.66
Coffee	1.30	0.02	4255.23	-268.13	199.64	0.36
Corn	1.64	0.04	2298.91	-144.07	191.55	0.67
Cotton	5.55	0.17	578.11	-76.25	136.23	2.68*
Deutsche Mark	6.65	0.15	654.32	-166.14	138.75	2.37*
Gold	2.06	0.06	1737.98	-118.96	147.04	0.89
Japanese Yen	6.62	0.16	623.18	-160.59	114.80	2.49*
Live Cattle	-1.08	-0.02	-3504.38	-160.02	101.16	-0.44
Live Hogs	-1.21	-0.03	-3295.91	-165.32	119.62	-0.47
Orange Juice	0.62	0.03	3599.02	-81.75	92.27	0.43
Swiss Franc	7.77	0.07	588.65	-175.79	142.00	2.63*
Silver	4.82	0.12	836.54	-99.77	182.93	1.85**
Soybeans	-0.10	-0.01	-27637.89	-114.56	86.39	-0.06
Soybean Oil	-0.31	-0.01	-17465.72	-189.73	258.76	-0.09
Soybean Meal	-0.93	-0.03	-3141.79	-99.89	92.43	-0.49
Sugar	6.79	0.12	807.94	-165.40	229.90	1.92**
T Bonds	2.05	0.07	1345.89	-87.90	109.57	1.15
Wheat	-3.28	-0.11	-889.90	-158.33	82.16	-1.74
Portfolio	2.31	0.18	545.00	-47.23	37.94	2.84*
S&P 500	1.38	0.32	306.75	-21.52	13.43	5.05*

[a] * indicates significance at 5% level
[b] ** indicates significance at 10% level
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 dollars from the futures market, his return would be 10% or $100/$1000.
[e] Portfolio consists of all nineteen commodities

Table 2.2

Annual Return Statistics for Nineteen Commodities and Commodity Portfolio Using System Trading, 1978-97.[a,b,c,d,e]

Commodity	Annual % Return	Sharpe Ratio	Coefficient of Variation	Minimum Annual Return	Maximum Annual Return	T-Ratio
British Pound	68.60	0.53	189.83	-171.05	319.82	1.82**
Canadian Dollar	-8.97	-0.20	-508.79	-113.91	81.17	-0.68
Coffee	15.56	0.08	1220.18	-474.53	380.53	0.28
Corn	19.67	0.19	538.71	-165.12	251.11	0.64
Cotton	66.64	0.56	179.50	-118.91	277.64	1.93**
Deutsche Mark	79.74	0.73	136.66	-161.13	298.13	2.53*
Gold	24.75	0.19	527.77	-228.82	381.57	0.66
Japanese Yen	79.43	0.62	162.36	-100.36	298.29	2.13*
Live Cattle	-12.92	-0.15	-680.06	-213.48	146.01	-0.51
Live Hogs	-14.62	-0.11	-943.06	-258.72	266.52	-0.37
Orange Juice	7.46	0.07	1414.44	-256.77	153.40	0.24
Swiss Franc	93.29	0.91	110.01	-72.63	346.08	3.15*
Silver	57.83	0.35	282.15	-87.15	503.61	1.23
Soybeans	-1.21	-0.02	-6084.11	-153.67	174.78	-0.06
Soybean Oil	-3.69	-0.02	-5655.82	-413.16	425.11	-0.06
Soybean Meal	-11.21	-0.14	-692.71	-161.64	148.36	-0.50
Sugar	81.47	0.42	235.68	-281.20	485.05	1.47
T Bonds	24.66	0.35	282.80	-67.02	196.54	1.22
Wheat	-39.45	-0.47	-213.97	-244.82	58.49	-1.62
Portfolio	27.74	0.84	118.70	-27.87	104.77	2.92*
S&P 500	16.58	1.46	68.32	-4.26	32.34	6.55*

[a] *indicates significance at 5% level.
[b] **indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 dollars from the futures market, his return would be 10% or $100/$1000.
[e] Portfolio consists of all nineteen commodities.

Table 2.3

Monthly Return Statistics for Commodity Groups and Commodity Portfolio Using System Trading, 1978-97 [a,b,c,d,e]

Commodity Group	Mean Monthly % Return	Sharpe Ratio	Coefficient of Variation	Minimum Monthly Return	Maximum Monthly Return	T-Ratio
Agriculturals	0.91	0.06	1573.00	-45.51	38.96	0.98
Currencies	5.20	0.19	506.00	-131.65	92.06	3.06*
Metals	3.44	0.10	955.00	-99.86	162.46	1.62
Financials	2.05	0.07	1345.00	-87.90	109.57	1.15
Portfolio	2.31	0.18	545.00	-47.23	37.94	2.84*
S&P 500	1.38	0.32	307.00	-21.52	13.43	5.05*

[a] * indicates significance at 5% level
[b] Financials are represented by United States T-Bonds.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 dollars from the futures market, his return would be 10% or $100/$1000.
[e] Portfolio consists of all nineteen commodities

Table 2.4

Annual Returns from a Portfolio of Nineteen Commodities Using System Trading and Annual Returns form S&P500, 1978-97.[a,b,c]

Year	Portfolio Return (%)	S&P500 Return (%)
1978	-17.44	7.66
1979	53.36	17.86
1980	77.90	29.96
1981	104.77	-4.26
1982	31.48	21.16
1983	17.13	20.92
1984	14.77	6.96
1985	40.44	28.87
1986	54.52	18.55
1987	43.91	9.72
1988	22.96	16.10
1989	-13.31	28.37
1990	66.35	-1.67
1991	7.18	28.07
1992	14.48	7.66
1993	25.91	9.73
1994	19.51	1.81
1995	-4.37	32.34
1996	-27.87	21.48
1997	23.04	30.30

[a] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[b] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 dollars from the futures market, his return would be 10% or $100/$1000.
[c] Portfolio consists of all nineteen commodities

Table 2.5

Monthly Return Distribution Statistics for Nineteen Commodities and Commodity Portfolio, 1978-97 Using System Trading. [a,b,c]

Commodity	Skewness	Kurtosis
British Pound	-0.81	3.73
Canadian Dollar	-0.01	0.80
Coffee	0.14	3.19
Corn	0.22	3.10
Cotton	0.34	0.93
Deutsche Mark	-0.39	1.54
Gold	0.44	2.76
Japanese Yen	-0.28	1.50
Live Cattle	-0.35	1.25
Live Hogs	-0.34	1.53
Orange Juice	0.10	2.07
Swiss Franc	-0.37	0.89
Silver	1.15	3.89
Soybeans	0.10	1.40
Soybean Oil	0.42	2.50
Soybean Meal	-0.04	1.42
Sugar	0.07	1.70
T Bonds	0.24	1.18
Wheat	-0.50	2.85
Portfolio	-0.28	1.66
S&P 500	-0.61	3.37

[a] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[b] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 dollars from the futures market, his return would be 10% or $100/$1000.
[c] Portfolio consists of all nineteen commodities

Table 2.6

Autocorrelation Coefficients of Mean Monthly Returns for Nineteen Commodities and Commodity Portfolio, 1978-97 Using System Trading [a,b,c,d]

Commodity	Autocorrelation Coefficient	T-Ratio
British Pound	-0.10	-1.62**
Canadian Dollar	-0.07	-1.00
Coffee	-0.11	-1.67**
Corn	-0.12	-1.82**
Cotton	0.08	1.15
Deutsche Mark	0.01	0.01
Gold	0.02	0.34
Japanese Yen	-0.02	-0.27
Live Cattle	0.04	0.59
Live Hogs	0.09	1.36
Orange Juice	0.08	1.16
Swiss Franc	-0.04	-0.58
Silver	0.02	0.23
Soybeans	-0.17	-2.73*
Soybean Oil	-0.05	-0.68
Soybean Meal	0.05	0.71
Sugar	0.03	1.85**
T Bonds	0.09	1.44
Wheat	0.01	0.13
Portfolio	-0.14	-2.26*
S&P 500	-0.03	-0.41

[a] * indicates autocorrelation value significant at the 5% level and ** at the 10% level.
[B]Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[C] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 dollars from the futures market, his return would be 10% or $100/$1000.
[D]Portfolio consists of all nineteen commodities

CHAPTER 3

FACTORS RELATED TO RETURNS FROM SYSTEM TRADED FUTURES MARKETS

INTRODUCTION

Technical trading systems, also known as system trading or trend following systems, are computerized futures trading methods which use past prices to determine buying and selling signals. Past research has investigated the levels and variability of commodity futures returns from these systems, but limited research has been devoted to the factors explaining these returns.

The main objective of this study is to analyse a number of factors related to returns from system traded commodity funds. This will provide fund managers and traders with more information regarding the conditions under which their trading systems are best suited. The commodity futures returns used in this study are computed by a moving average trading system that is representative of trading systems used by a typical large commodity fund. This study will compute system traded commodity futures returns across 19 commodity futures over a 20 year period, and mimic the returns of large commodity funds.

The factors related to commodity futures returns may help to explain the levels of returns in futures markets and some of the conditions under which system trading performs best. As technical trading system returns have varied considerably over time, this paper may also help fund managers and investors understand the factors related to this variation in return levels (Irwin and Brorsen, 1987). If some of the causes of technical system trading returns can be identified, fund managers and traders may be able to incorporate some of this information into their trading methods and make more skilled trades.

BACKGROUND

While the traditional market efficiency theory suggests that returns from trading strategies such as system trading should not be possible, short-run market disequilibrium may partially help explain why returns from technical system trading are possible. Short-run disequilibrium theory states that markets may not adjust perfectly and instantaneously to new information (Nawrocki, 1984). As new information is ingested by the market there would be either a price increase or price decrease, and so short-run disequilibrium may exist in futures markets because they may not adjust to information shocks quickly.

The delay of the markets reaction to new information may be caused by transaction costs, taxes, the cost of acquiring and acting on new information and lags in obtaining new information (Lukac, Brorsen and Irwin, 1988a). The time between when investors receive new information and until the time the market fully reacts, may cause a trend in prices. This trending of prices may lead to positive returns for system trading as markets trend back to equilibrium levels, from levels either above or below equilibrium.

If there are positive returns from system trading of commodity futures, it may be possible to identify some of the factors related to these returns, or short-run disequilibrium. Some causes of this short-run disequilibrium may be inaccurate or untimely information flows, information arriving in uneven doses, transaction costs, taxes, interest rates, inflation, and risk premiums (Boyd and Brorsen, 1991). This paper will analyze four factors which may be related to technical system trading returns.

First, inflation (consumer price index) may be positively related to returns from technical system trading. Measured as a change in consumer price index, CPI data is used as a proxy for inflation levels and general uncertainty of economy wide price levels. Uncertainty may be a cause of short-run disequilibrium in futures markets. If traders and investors are uncertain of the true price level, they may act on improper information, and at improper price levels. This may cause prices to move slowly back to equilibrium levels, because traders and investors may be unsure of the relation between perceived and real price levels. They may be slow to react to futures market price changes, and short-run disequilibrium in markets may exist. Consumer price level changes may also lead to unexpected futures price level changes. Traders may either overestimate or underestimate the effect of consumer price levels on futures price levels, possibly leading to short-run disequilibrium. Therefore, as inflation increases, commodity returns would be expected to increase.

Second, returns from technical trading systems may be negatively related to time. Time may represent a number of possible factors explaining returns, and it will be theorized that as time increases, commodity returns should decrease. Time may represent an increase in the number of system trading market participants. As the number of these participants increases over time, returns from using these systems may be expected to decrease through competition. The increasing number of system traders in the markets may be caused by the introduction, low cost, and widespread use of the personal computer, software, and data. Therefore, as the number of technical system traders increases, markets may become more efficient and returns may be decreasing. Markets may be forced back to equilibrium levels faster when more participants are involved in price determination. Time may also represent the increased prevalence of choppy markets and false breakouts, which may be characteristic of increased system trading. Brorsen (1998) found that CTA returns were decreasing over time, and many of these CTA's use technical analysis and system trading to trade futures markets.

Third, the mean futures price level may be a factor positively related to returns. This could mean higher price levels would be positively related to return levels. Part of this may be due to price asymmetry in futures markets, as price trends may increase slower than they decrease. As prices move in a slow, somewhat persistent manner to higher price levels, away from equilibrium levels, trend following systems may be an appropriate way to trade these markets. But as prices move quickly back to perceived equilibrium levels, trend following systems may not be able to reverse their positions fast enough, and systems may "give back" previous returns. In this case, trend following systems may be somewhat inappropriate for trading these relatively fast moving markets. Therefore, system trading returns may be explained by higher returns at higher commodity price levels since lower price levels may have fewer persistent trends.

Fourth, individual commodity price variation is theorized to be positively related to returns. This study measures price variation as the change in the coefficient of variation of price. This may be thought of as a risk premium. This risk premium may be a cause of market disequilibrium in the sense that if an investment is considered risky, it may have a higher level of return. Investors may expect a higher level of return from a futures market that has high levels of price variation. As variation levels increase, returns from these system traded markets may also increase.

In summary, four variables will be tested in this study to examine if they are related to the returns from technical system trading. The variables used in this study are inflation, time, mean price, and price variation. Testing these variables may help explain some of the causes of returns, whether these relationships will continue into the future, and their implications for fund managers and investors.

PROCEDURE AND DATA

Data

The nineteen daily nearby futures contracts used to compute returns are British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. These futures provide a cross-section of agriculturals, metals, and financials. A single portfolio of these nineteen commodities is also used in this study. Futures are traded from January 1978 through December 1997, totaling 20 years of trading. U.S. Consumer Price Index data is obtained from the CANSIM database. Futures market price data is obtained from Technical Tools.

Trading Model

One of the most popular technical trading systems, the Dual Moving Average Crossover, is used to compute the trading returns. Trading rules for the Dual Moving

Average Crossover are to buy when the short moving average is greater to or equal to the long moving average, and sell when the short moving average is less than the long moving average. This trading system is chosen for two reasons. First, it is one of the most popular systems used by managers of futures funds. Second, this system is representative of many other trend following systems and returns from it are highly correlated to returns from other systems (Lukac, Brorsen, and Irwin, 1988b). Details of the trading model can be found in Chapter 2.

Tests of Factors Related to Disequilibrium

Possible factors related to returns are tested to see if they are related to short-run disequilibrium or commodity futures returns. Independent variables tested include inflation (monthly consumer price index), time, mean price level, and price variation (coefficient of variation of individual commodity price). All variables used are changes from the previous months, since monthly percentage returns (dependent variable) is also a change variable because it is a change in equity from the previous month. However, changes are not used for the price level variable and the time variable, because the levels of them rather than changes in them would be expected to be most closely related to returns. Monthly data is used in this study, since it allows for more degrees of freedom than annual data.

The hypothesized monthly regression equation in time t is therefore:

$$MMR = \beta_0 + \beta_1 CV + B_2 Time + B_3 CPI + B_4 MP + \varepsilon \qquad (3.1)$$

where,

MMR = mean monthly percentage return for each commodity

CV = coefficient of variation of price (volatility)

Time = linear representation of time

CPI = U.S. consumer price index for each month

MP = mean price level

ε = error term

GARCH Econometric Estimation

A generalized autoregressive conditional heteroskedasticity (GARCH) regression model is used in the econometric estimation of the possible factors related to returns. This model is used because it accommodates the two assumptions of non-constant variance and correlated variance over time. First, as the mean return of an investment increases, the variance of that return would be expected to be non-constant and increase. This is because as returns levels rise, the risk would also be expected to rise (Sharpe, 1964). Second, the variance of the regression model returns may be correlated over time or have serial correlation, just as commodity mean returns have been found to have serial correlation (Lukac, Brorsen, and Irwin, 1988b). Regression variance that is assumed to be a moving average process and an autoregressive process can then be modeled with a GARCH model.

The GARCH model specified in this study is one which uses the standard one period moving average process and one period autoregressive process. This is specified as a

GARCH (1,1) model. This process has been used in many studies which estimate non-constant or heteroskedastic returns. The econometric model with GARCH process (p,q) is explained by Najand and Yung (1991), and has been used in many recent studies as an adequate way to estimate time series return data.

RESULTS

Factors Related to Monthly Returns for Individual Commodities

Table 3.1 shows GARCH (1,1) results of possible factors related to individual commodity returns, using a four variable model. The variables include individual commodity price variation, time, inflation, and individual commodity price level, as explanatory independent variables. However, results in general show less explanatory power, compared to the commodity portfolio results which follow. (Appendix D shows GARCH(1,1) economic results of the above four factors related to returns, except as single variable models rather than a four variable model.)

Table 3.1 shows price variation, as measured by coefficient of price variation, is positively related to returns in 15 of the 19 cases, and statistically significant in 7 of them. This generally shows that as price variation increases, so do returns generated from system trading. This is consistent with expectations because variation in market price is required for trend following systems to compute buy and sell signals. This is also consistent with basic finance theory which argues that as asset price risk (price variation) increases, returns to investors should also increase. Returns from agriculturals are positively related to price variation in 9 of the 11 cases, with soybean oil being statistically significant. The relationship between price variation and returns for currencies is interesting, as 3 currency markets indicated a positive relationship, and all 3 statistically significant. The other 2 cases indicated a negative relationship, with one of them being statistically significant. Single variable results for price variation in Appendix Table D.4 show that in 16 of the 19 cases, price variation is positively related to returns, further emphasizing its importance. In order to best take advantage of this information, system traders would need to be able to adequately anticipate or forecast price variation, and then scale back trading during periods of low price variation.

Time is negatively related to the returns from system trading of futures markets in 10 of the 19 cases, and is significant in 3 of those 10 cases. This negative relationship is expected and is consistent with Brorsen (1998). Results also indicate that four of the five currencies have negative coefficients. This result is important because many currency traders use system trading. However, it should be noted that return levels have been relatively higher for currencies and appear to be decreasing. Since agricultural returns have been relatively low and somewhat unprofitable, they are less likely to continue to decrease much over time. It should also be noted that the currency returns are estimated conservatively, since many large system traders may use larger position sizes and the interbank market, which may lower their actual transaction cost below the futures transaction cost of $50 assumed in this study. However, currency returns here should be viewed with caution, since many of them are European currencies and will be replaced with the Euro, for which historical returns are not available.

Results for the commodity portfolio in a later section of this study show a more general and stronger negative relationship with time. This result is supported by the single variable model for time found in Appendix D.1, which shows that in 11 of the 19 cases, time in negatively related to returns. One possible explanation for decreasing returns over time may be that as technical trading systems become more popular, their effectiveness may decrease. The increased use of personal computing, the decreased cost of market data, and the increased availability of technical analysis software, which in turn encourages more system traders, may be responsible for decreased returns to system trading. If system trading is becoming less effective over time, traders may wish to develop improved or alternative trading systems. For example, this may cause an increased interest in discretionary trading, which some had abandoned in favor of system trading in past years.

Inflation, as measured by a change in the consumer price index, is positively related to 10 of the 19 returns, as expected, with 3 being statistically significant. An increase in inflation may cause short-term disequilibrium in some commodity futures markets, as traders and investors attempt to analyze equilibrium price levels. For most individual commodities, results are too statistically insignificant to make any general conclusions. These results are consistent with Boyd and Brorsen (1991). However, most of the commodity group results shown in the next section indicate a positive and statistically significant relationship with inflation. As well, 12 of the 19 cases for the single variable models in Appendix D.2 show a positive relationship with inflation. This is further supported by the portfolio returns in the next section which show a positive and statistically significant relationship with inflation.

Inflation is negatively related to returns for 7 of the 11 individual agricultural commodities. This may mean that agricultural prices do not trend well during times of high inflation. This result may be surprising to investors who normally assume that returns from investments in agriculturals would be higher during periods of high inflation and that system trading does not necessarily perform well for agriculturals during periods of high inflation. Some causes of low inflation may be deregulation and increased competition which puts downward pressure on prices. As well, conservative monetary policy is also associated with low inflation. If these policies continue, there may be increased likelihood of future low inflation periods, and in turn generally lower system traded returns.

Commodity price level, as measured by mean monthly price, is positively related to individual monthly returns in 9 of the 19 cases in Table 3.1, with only one of those being statistically significant. This positive relationship is expected. This is also supported by the single variable model in Appendix Table D.3. This table shows that commodity price levels are positively related to returns in 12 of the 19 cases, again with only one statistically significant. These results generally indicate that when commodity futures prices are at higher levels, system trading has higher returns. When markets are at lower price levels, they may have less trends and system trading returns may be lower during these periods. This is important for fund managers and traders, because it indicates that lower price markets may not provide the same level of returns as higher priced markets. Therefore, system traders may wish to attempt to anticipate or forecast times of generally low price levels, and scale back their positions during these periods.

The R^2, which measures explanatory power, was quite low for most of the cases, as expected. In Table 3.1, only 5 of the 19 cases had an R^2 of .05 and above, and some results were close to zero. This indicates that monthly returns may be relatively variable, and it is relatively difficult to fully explain the factors related to returns from system trading of futures markets.

Multicollinearity, or correlation between the four independent explanatory variables, may influence the estimation of some of the factors related to returns, in the four variable model in Table 3.1. Therefore, estimation of some of the impacts of these factors related to returns may be unreliable if multicollinearity exists. In order to provide alternative results, single variable models for factors related to returns are presented in Appendix D. These single variable equations avoid possible multicollinearity problems, but they may suffer from some bias associated with omitted variables, and so should be interpreted with some caution.

Factors Related to Monthly Returns for Commodity Portfolio

Time and its relationship to the commodity portfolio is shown in Figure 3.2. Figure 3.1 shows annual commodity portfolio returns, and indicates they are decreasing considerably over time. Results indicate that monthly commodity portfolio returns are negatively related to time at a statistically significant level. This means that the returns from the portfolio of 19 commodities are decreasing over time. The coefficient of -.01 means that the monthly return is decreasing by .01 percent each month. This important result is shown graphically in Figure 3.1, where commodity portfolio returns have some peaks indicating a cyclical pattern, but the overall pattern shows a decreasing trend in returns. If this linear trend of decreasing returns continues, returns from system traded commodities would disappear by about the year 2013. However, returns may never actually go to zero over time, instead, they would more likely come relatively close to zero and then flatten out. The most unprofitable system traders would leave the industry, and the most profitable would remain, but earning a relatively smaller return than in previous years. This study assumes a $50 transaction cost per round turn trade, however, if transaction costs continue to drop, system trading returns may not decrease as fast as projected here. As well, many firms may change to alternative, improved, or discretionary trading systems and lower transaction costs in order to remain competitive.

One interesting implication of this is that system traders will likely force continued downward pressure on transaction costs, such as brokerage fees. This could occur because increased system trading competition may cause lower gross returns. In order to maintain net returns at sufficient levels for investors, system traders would then need lower brokerage fees. The increased use of technical trading systems, decreased computing and data costs, and the growing popularity of commodity funds, may be some causes of decreasing returns over time. As returns in these markets continue to fall, alternative and improved systems may have to be considered by traders and commodity funds, and likely some renewed interest in discretionary trading. Another impact of lower returns may be increased equity draw downs. If this is the case, then system traders may need to reduce their leverage levels in order to reduce the impact of individual market draw downs.

Results of inflation related to the monthly return for a portfolio of 19 commodities are shown in Table 3.3. These results indicate that inflation is positively and significantly related to commodity portfolio returns, and that a 1 per cent monthly (12 percent annual) change in the consumer price index would lead to a 5.03 percent rise in the monthly return (60 percent annual) for a commodity portfolio. Alternatively, this can be roughly interpreted that a one percent increase in annual inflation would give approximately a five percent increase in annual portfolio returns. Although inflation was not necessarily closely related to individual market returns, it is strongly related to commodity portfolio returns. The results support the investors expectation of commodity fund returns being higher during times of high inflation. This result is consistent with Irwin and Brorsen (1987).

SUMMARY

The system trading returns of nineteen commodities over a twenty year period using the Dual Moving Average Crossover system were computed. The commodity futures traded were British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. Transaction and slippage costs were assumed to be $50 per round trade. In calculating returns 25% was invested in the market, while 75% was held in reserve for margin calls. Returns were calculated from the total investment. A regression approach was used to analyze if price variation, time, inflation, and price level are related to trading returns, and if portfolio returns are changing over time.

There are a number of important findings from this study. First, time was found to be generally negatively related to returns, meaning that returns from system trading are decreasing over time, as expected. The coefficient for time was found to be negative in the majority of individual markets, and significantly negative for the commodity portfolio. Currency returns indicated the largest decreases in returns over time. Other commodities such as agriculturals and metals have always had relatively low or negative system traded returns, so they are less likely to decrease much further. Results indicate that returns for the commodity portfolio will be considerably lower and closer to zero by about the year 2013. However, returns would be unlikely to reach zero, since the least profitable funds would leave the industry or change trading methods, leaving the more profitable and most efficient funds in the industry. Since returns from system trading appear to be decreasing with time, system traders may wish to consider improved or alternative methods to trade these markets. System trading returns may be declining due to the increase number of system traders and competition, brought on by the availability, lower cost, increased use of the personal computer, software, and data. These declining system traded returns may also in turn bring increased pressure on brokers for lower transaction costs.

Second, individual commodity price variation was found to be generally related to commodity return levels, as expected. This implies that traders may wish to remain as market participants during volatile price changes, assuming that their return is reasonable, and may wish to scale back their positions during periods of lower price variation. If price variation is somewhat predictable then this may be possible to some extent.

Third, inflation levels were positively related to portfolio return levels, as expected. A very important result is that inflation was significantly and positively related to return levels for the commodity portfolio. Given this result, system traders should benefit most during times of high inflation. However, agricultural returns were negatively related to inflation in the majority of cases. This may mean that agricultural prices do not trend well during times of high inflation. The positive correlation between inflation and some returns implies that system traders will be more successful during periods of higher inflation. However, more recent economic policy has encouraged deregulation and increased competition, resulting in lower inflation. Lower inflation has also been encouraged by conservative monetary policy. If these trends continue, system traders may face continued lower returns.

Fourth, the mean price level was found to be positively related to some individual markets, which was expected. These results indicate that as commodity futures markets move to higher price levels, system trading may be an appropriate way to trade these markets. This result also implies that lower priced individual markets may be less suited for system trading. However, this result was not highly consistent across commodities, so should not be weighted too highly by traders. Finally, returns in this study are based on assumptions of historical data over specific commodities and specific past time periods. Therefore, past trends, assumptions, and results may change in the future.

Table 3.1

Monthly Econometric Results GARCH(1,1) Explaining Factors Related to System Trading Returns for Nineteen Commodities, 1978-97.[a,b,c,d,e,f]

Dependent Variable	Independent Variable					
Mean Percent Return	Intercept	Price Variation	Time	Inflation	Commodity Price Level	R^2
British Pound	17.05	-8.39	-.09	-1.51	-.01	0.06
	(.75)	(-2.63)*	(-1.96)*	(-.14)	(-.05)	
Canadian Dollar	-7.74	7.53	-.01	-1.40	.12	0.02
	(-.38)	(2.50)*	(-.55)	(-.35)	(.48)	
Coffee	17.50	3.54	-.10	-14.84	.01	0.01
	(1.03)	(3.30)*	(-1.76)*	(-1.48)	(.07)	
Corn	-4.85	.92	-.01	2.09	.02	0.01
	(-.35)	(.98)	(-.03)	(.27)	(.38)	
Cotton	4.59	-1.03	.01	5.86	-.04	0.01
	(.33)	(-1.92)**	(.02)	(.83)	(-.20)	
Deutsche Mark	-9.91	9.18	.11	29.27	-.18	0.05
	(-.64)	(2.85)*	(1.68)**	(2.75)*	(-.47)	
Gold	5.34	1.16	-.01	5.28	-.01	0.05
	(.36)	(.75)	(-.39)	(.71)	(-.31)	
Japanese Yen	-4.05	-.39	-.02	6.66	.16	0.01
	(-.36)	(-.15)	(-.21)	(.71)	(.61)	
Live Cattle	-18.99	1.10	-.02	-10.40	.34	0.01
	(-.84)	(1.01)	(-.41)	(-1.29)	(.97)	
Live Hogs	24.63	.25	-.03	-20.02	-.29	0.02
	(1.39)	(.22)	(-.67)	(-2.21)*	(-.88)	
Orange Juice	-10.35	.42	.04	-3.09	.06	0.03
	(-1.21)	(.80)	(1.58)	(-.61)	(1.16)	
Swiss Franc	-3.59	6.10	.10	31.15	-.22	0.04
	(-.23)	(2.40)*	(1.40)	(2.86)*	(-.64)	
Silver	-16.75	3.52	.01	12.05	.02	0.14
	(-1.58)	(3.56)*	(.11)	(1.41)	(2.70)*	
Soybeans	-17.37	.83	.01	1.04	.03	0.01
	(-1.39)	(.91)	(.21)	(.17)	(1.38)	
Soybean Oil	29.62	3.06	.03	-9.99	-1.56	0.03
	(1.48)	(1.71)**	(.75)	(-.92)	(-1.77)**	

Soybean Meal	-6.71	.42	-.02	-3.47	.05	0.03
	(-.57)	(.39)	(-.64)	(-.51)	(.81)	
Sugar	18.50	.70	-.10	-3.91	-.04	0.02
	(1.46)	(.61)	(-1.83)**	(-.32)	(-.05)	
T Bonds	-1.49	7.27	.05	11.16	-.08	0.05
	(-.12)	(3.57)*	(1.28)	(1.86)*	(-.51)	
Wheat	1.43	-.51	.05	2.60	-.03	0.01
	(.13)	(-.60)	(1.39)	(.37)	(-.98)	

[a] T-Ratio appears in parenthesis.
[b] * Indicates statistically significant coefficient at 5% level and **Indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then the return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH (1,1) is a Generalized Autoregressive Conditional Heteroskedasticity econometric model

Table 3.2

Monthly Econometric Results GARCH (1,1) Explaining Factors Related to Returns for Commodity Portfolio Using System Trading, 1978-1997, Independent Variable: Time [a,b,c,d,e,f]

Dependent Variable	Independent Variable		
Mean Percent Return	Intercept	Time	R^2
Portfolio	4.21 (2.56)*	-.01 (-1.70)**	0.01

[a] T-Ratio appears in parenthesis.
[b] * Indicates statistically significant coefficient at 5% level and **Indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then the return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH (1,1) is a Generalized Autoregressive Conditional Heteroskedasticity econometric model

Table 3.3

Monthly Econometric Results GARCH (1,1) Explaining Factors Related to Returns for Commodity Portfolio Using System Trading, 1978-1997, Independent Variable: Inflation [a,b,c,d,e,f]

Dependent Variable	Independent Variable		
Mean Percent Return	Intercept	Inflation	R^2
Portfolio	.08 (.07)	5.03 (2.11)*	0.01

[a] T-Ratio appears in parenthesis.
[b] * Indicates statistically significant coefficient at 5% level and **Indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then the return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH (1,1) is a Generalized Autoregressive Conditional Heteroskedasticity econometric model

Figure 3.1
Mean Annual Return for Commodity Portfolio Using System Trading, 1978-1997

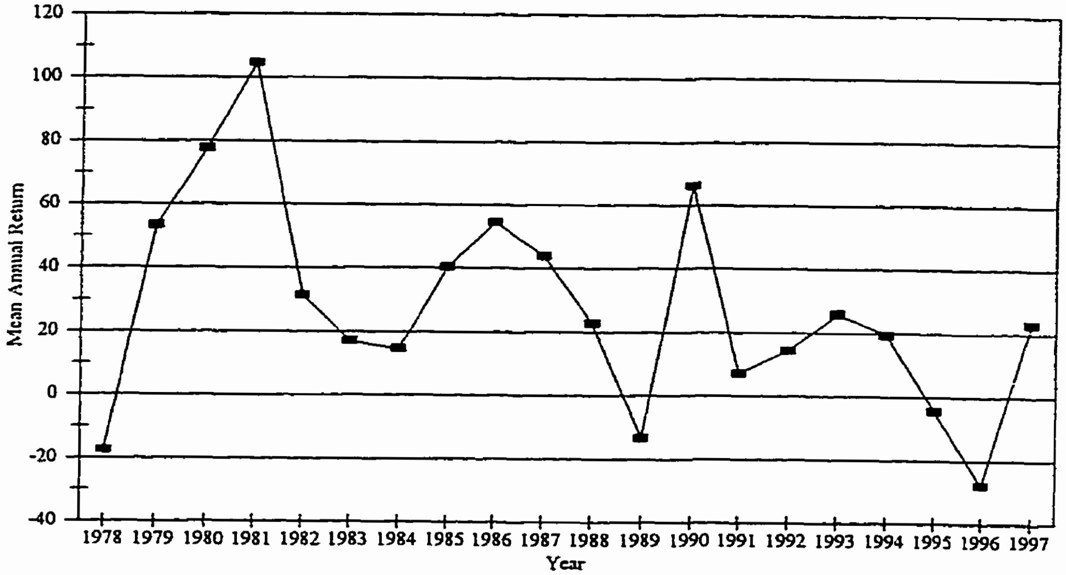
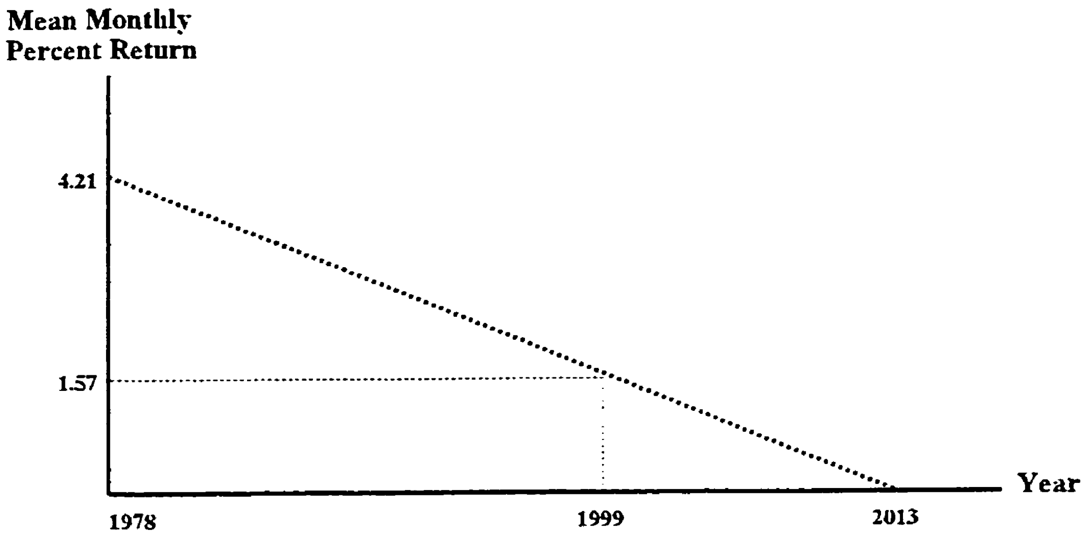


Figure 3.2
Estimation and Forecast of Commodity Portfolio Returns Over Time from System Trading, 1978-97



CHAPTER 4

SYSTEM TRADED COMMODITY FUTURES, DIVERSIFICATION, AND THEIR ROLE IN INVESTMENT PORTFOLIOS

INTRODUCTION

System trading uses past price trends in a computer model to compute buy and sell signals for futures markets, and is a popular form of managed futures. Managed futures have grown by more than 28% a year from 1980 to 1995 (Edwards and Park, 1996), and understanding the portfolio behavior of system traded commodity returns used in managed futures funds is becoming increasingly important. Pension and endowment funds are also turning to managed futures in an attempt to reduce portfolio risk (Billingsley and Chance, 1996). Therefore, the relationship between commodity portfolio returns and more traditional portfolio returns, such as T-Bonds, T-Bills, and equity markets needs to be examined in more depth.

This chapter analyzes the returns from system trading of futures markets in four ways. First, the correlation across commodity returns is examined to determine the extent to which various commodities contribute to commodity portfolio diversification. Second, individual commodity risk-return tradeoffs are examined. Third, the relationship between commodity portfolio returns and S&P500 returns is examined by using the Capital Asset Pricing Model to determine the extent to which individual commodities and the commodity portfolio add to equity portfolio diversification.

Fourth, the risk-return tradeoff and correlation coefficients between a commodity portfolio, T-Bills, T-Bonds, and the S&P500 is examined. These results will help explain the relationship between various risk and return relationships involving commodities and other investments. This is important for fund managers attempting to diversify or design a portfolio of individual commodity returns, or include them in a portfolio of stocks, T-Bonds, or T-Bills. These results are also important because of he growing popularity of investors using non-traditional investing to diversify more broadly (Jacob, 1995).

Managed futures are increasingly becoming more important as a member of a portfolio of T-Bonds, T-Bills and equities. Their addition to a portfolio may increase portfolio performance, by providing diversification benefits (Edwards and Park, 1996). Adding a new asset to an existing portfolio of assets will enhance portfolio performance if the correlation between the existing portfolio and the commodity portfolio is sufficiently low or negative. If this is the case with returns from the commodity portfolio and returns from other markets, then the addition of the commodity portfolio to a more general existing portfolio will enhance its performance, in terms of increasing diversification.

Elton, Gruber and Rentzler (1987) and Brorsen and Lukac (1990) have also determined the suitability of adding a commodity portfolio to an existing portfolio of assets. Previous studies have also determined that commodity futures trading returns have little or no correlation with other assets (Brorsen and Irwin, 1985), and that their addition to an existing portfolio may enhance diversification.

The commodity futures returns used in this study are computed by a moving average trading system that is representative of trading systems used by a typical large commodity fund. Returns are computed in this manner because true actual system traded returns from commodity funds are not available, because it is not possible to tell from actual commodity fund returns whether they are truly system traded. For example, a number of funds may over-ride their systems or use trade discretion to some extent, despite their intent to fully system trade. This study will use returns from a 20 year period, from 1978 to 1997, across nineteen commodity markets.

DATA AND PROCEDURE

Data

The nineteen daily nearby futures contracts used to compute returns are British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. These futures provide a cross-section of agriculturals, metals, and financials. A single portfolio of these nineteen commodities is also used in this study. Futures are traded from January 1978 through December 1997, totaling 20 years of trading. S&P500 returns with dividends reinvested, T-Bill return data, and T-Bond return data is obtained from Ibbotson and Associates Inc. (1998), and are used for comparison with the commodity returns. T-Bill and T-Bond data are total returns, which is comprised of income return, reinvestment of income return and capital appreciation return. Futures market price data is obtained from Technical Tools.

Trading Model

One of the most popular technical trading systems, the Dual Moving Average

Crossover, is used to compute the trading returns. Trading rules for the Dual Moving Average Crossover are to buy when the short moving average is greater to or equal to the long moving average, and sell when the short moving average is less than the long moving average. This trading system is chosen for two reasons. First, it is one of the most popular systems used by managers of futures funds. Second, this system is representative of many other trend following systems and returns from it are highly correlated to returns from other systems (Lukac, Brorsen, and Irwin, 1988a). Details of the trading model can be found in Chapter 2.

Correlation Coefficients

Correlation coefficients of commodity returns are used to determine the extent to which individual monthly returns are related. Correlation coefficients may be used to provide information regarding which commodities to include in order to diversify a portfolio of futures markets. High positive correlations between returns indicates similarity between returns, and limited diversification. Returns which show little correlation to one another or negative correlation are useful for diversification as they reduce portfolio risk.

The correlation coefficient used here is:

$$\rho_{x,y} = \frac{Cov(x,y)}{\sigma_x \cdot \sigma_y} \tag{4.1}$$

where $\rho_{x,y}$ is the correlation coefficient of commodity return (x) and commodity return (y), Cov(x,y) is the covariance between return (x) and return (y), σ_x is the variance of commodity return (x), and σ_y is the variance of commodity return (y).

Capital Asset Pricing Model Tests

The Capital Asset Pricing Model (CAPM) is also used in this study to adjust returns to risk. The CAPM in this study is used to evaluate whether system traded futures markets have a beta that corresponds negatively to the S&P500. If the Beta is negative, or small positive, this means the commodity futures returns are relatively unrelated to S&P500 equity returns and may be suitable for diversifying an equity portfolio.

The CAPM was developed by Sharpe (1964) and can be expressed as:

$$E(R_i) = \alpha_i + [E(R_m)]B_i \tag{4.2}$$

where $E(R_i)$ is the expected return from asset i, $E(R_m)$ is the expected rate of return on the market portfolio, α_i is the difference in return between $E(R_i)$ and $E(R_m)$, and B_i is the Beta, or relative risk of i given as:

$$B_i = \frac{COV(R_i, R_m)}{\sigma^2_{R_m}} \tag{4.3}$$

where σ^2_{Rm} is the variance of the market portfolio, and cov (R_i, R_m) is the covariance between the return from asset i and the return from the market portfolio. Normally a risk-free rate of return is subtracted from the market portfolio (R_m), but since the capital invested in margins and the capital held back for margin calls could have been invested in T-Bills, the risk free rate does not have to be subtracted.

For an example of the CAPM, the mean monthly percent returns for corn may be used as the dependent variable and mean monthly percent returns from the S&P500 as the independent variable. The results of the CAPM test would provide an Alpha coefficient which would help explain if return levels for corn are significantly different from the S&P500, and a Beta coefficient which would help explain the relationship between the returns for corn and the S&P500.

The Capital Asset Pricing Model asserts that over the long run it is not possible to achieve returns above the return to risk. Following CAPM, the risk variable will be linearly related to its Beta, the measure of relative volatility, or systematic risk (Malkiel and Yexiao, 1997). As the Beta gets higher, so does the expectation for higher returns because of increased risk in the investment.

The CAPM is employed on many empirical studies investigating the relationship between risk and return, and the existence of returns (Levy, 1997). Levy also found that it is being used by numerous institutional investors, such as Value Line, Standard and Poors, and Merrill Lynch, and that the use of Beta analysis was often accepted as a useful risk measure.

A generalized autoregressive conditional heteroskedasticity (GARCH) regression model is used in the econometric estimation of the capital asset pricing model. This model is used because it accommodates the two assumptions of non-constant variance and correlated variance over time. First, as the mean return of an investment increases, the variance of that return would be expected to be non-constant and increase. This is because as returns levels rise, the risk would also be expected to rise (Sharpe, 1964). Second, the variance of the regression model returns may be correlated over time or have serial correlation, just as commodity mean returns have been found to have serial correlation (Lukac, Brorsen, and Irwin, 1988b). Regression variance that is assumed to be a moving average process and an autoregressive process can then be modeled with a GARCH model.

The GARCH model specified in this study is one which uses the standard one period moving average process and one period autoregressive process. This is specified as a GARCH (1,1) model. This process has been used in many studies which estimate non-constant or heteroskedastic returns. The econometric model with GARCH process (p,q) is explained by Najand and Yung (1991), and has been used in many recent studies as an adequate way to estimate time series return data.

RESULTS

Correlation of Monthly Returns Across Commodities

Table 4.1 shows correlation coefficients for nineteen commodity returns in the commodity portfolio. Correlation coefficients are important because they indicate the degree to which individual returns are related to one another. Of the 171 correlations shown, 110 are positive, 57 are negative and 4 show no correlation. Only 35 of the 171 correlation coefficients are both positive and statistically significant. Results also show that while the majority of individual commodity returns are positively related to other individual commodity returns, overall they are not highly related in terms of statistical significance. In terms of the positive correlation coefficients, 70 of 110 (about 64 percent) of the positive correlation coefficients are very low (less than .10). Overall, since the bulk of the commodity return correlations have either negative or low positive correlation with each other, they are useful in the portfolio in terms of adding diversification.

Results show that the highest correlation between individual commodities is between the Deutsche Mark, Swiss Franc, and British Pound. Corn is also highly correlated with soybeans, soybean oil, and soybean meal. Silver and gold returns are also highly correlated. These results are not surprising, as return results within similar commodity groups would be expected to be somewhat correlated, because they have similar prices.

The currency returns are positively correlated to other currencies in 8 of 10 cases. The agricultural returns are positively related to other agriculturals in 26 of 46 cases. Again, these results are interesting because they show that returns have some tendency to be correlated with each other if they are from the same commodity group. However, extremely high diversification of commodities may be difficult to achieve because a number of commodities have some similarity. For example, currency returns appear to have similar behavior, as do agriculturals. Therefore, correlation coefficients indicate that portfolio diversification is best achieved by including returns from as many different commodity groups as possible, subject to desired return levels.

Individual Commodity Risk-Return Tradeoffs

Figure 4.1 shows the risk-return tradeoff for the nineteen individual commodities.

Results indicate that a number of commodities have similar return levels, as measured by the mean monthly percent return, but that risk levels vary relatively widely across individual commodities. Commodity returns can be broken up into three groups, as indicated by Figure 4.1.

First, "Group A" returns consist of seven commodities, mostly agriculturals, and these returns are the lowest of the three groups. The mean monthly percent returns are between -3.28 and -0.10, and the standard deviation ranging from 17.59 to 53.78. Six of these seven negative returns are agriculturals, with the other the Canadian Dollar. Second, "Group B" returns consist of five commodities, with three agriculturals and, gold, and T-Bonds, and with medium level returns compared to the other two groups. The mean monthly percent returns range between .62 and 2.06, and the standard deviation ranging from 22.37 to 55.17.

Third, "Group C" returns contain seven commodities and is dominated by currencies, cotton, sugar, and silver. This group contains the highest returns of the three groups. The mean monthly percent returns range between 4.82 and 7.77, and the standard deviation ranges from 32.10 to 54.85. This higher return group consists of four currencies, cotton, sugar, and silver. Overall, these results are consistent with Billingsley and Chance (1996) who found that CTA monthly returns were highest for currencies and lowest for agriculturals. They also found that the standard deviation of monthly returns for CTA's by market specialization was highest for currencies and lowest for agriculturals

Results also indicate that, in general, as mean monthly percent returns increase, the level of risk associated with returns also increases. This is indicated by the regression estimated trend line in Figure 4.1. There appears to be a general increase in the level of standard deviation associated with higher return levels. Higher return commodities tended to have higher standard deviations, and lower return commodities tended to have lower standard deviations, as expected. This result is consistent with finance theory and with investors expectations.

Figure 4.1 also shows that often individual commodities with similar return levels within each of the three groups have a fairly wide range of standard deviations. First, the range of standard deviations for the "lower returns" Group A, which contains primarily agriculturals, is 36.19. Second, the range of standard deviations for the "medium returns" Group B, which is a combination of agriculturals, gold and T-Bonds, is 39.79. Third, the range of standard deviations for the "higher returns" Group C, which is primarily currencies, is 22.75. Therefore, results indicate that there is a varying degree of risk associated with individual markets that have similar monthly returns. This result is important for investors because it indicates that some commodities with similar return levels can sometimes have different risk levels, even though overall results indicate that the higher the return level is the higher the risk will be, according to the trend line (Figure 4.1).

Monthly Results of Capital Asset Pricing Model

Table 4.2 presents results of Capital Asset Pricing Model Tests. CAPM tests are important for two reasons. First, the intercept of this regression, or its Alpha, may be generally interpreted as an indication if commodity returns differ from S&P500 returns. Second, the correlation between the returns of system traded commodities and the commodity portfolio versus S&P500 returns is analyzed, as indicated by its Beta.

Commodity returns are above the S&P500 normal returns to risk in 11 of the 19 cases, as indicated by a positive intercept in the CAPM, using S&P500 market data. The bottom of Table 4.2 shows that the portfolio of 19 commodities has a significant positive intercept coefficient, indicating commodity returns may exceed equity returns. These findings are consistent with Lukac, Brorsen and Irwin (1988b).

Individual commodity returns show low correlation with the returns from equity markets such as the S&P500. Only 2 of the 19 beta coefficients were positive and significant, which would indicate only 2 cases of undesirable strong positive correlation with returns from the S&P500. These coefficients were found in returns from the Canadian Dollar and T-bonds. The T-Bond coefficient may be somewhat expected to be positive, as equity and bond market prices may often have similar price movements, but the positive coefficient for the Canadian Dollar is surprising.

The bottom of Table 4.2 shows that the beta coefficient for the portfolio is negative, indicating no correlation between portfolio returns and equity returns. This is very important because it shows that a portfolio of system traded commodities would add to diversification of an equity portfolio.

Commodity Portfolio Risk-Return Tradeoff and Portfolio Asset

Figure 4.2 presents the risk-return tradeoff curve for returns from the commodity portfolio, the S&P500, T-Bonds, and T-Bills. Results indicate that T-Bills, with a mean monthly percent return of .59 and a standard deviation of .24, is the minimum risk-return point of the four categories of returns. Risk levels are higher for T-Bonds and the S&P500 and both have higher corresponding mean monthly percent returns. The maximum risk-return point is the commodity portfolio which has a monthly standard deviation of 12.61 and a mean monthly percent return of 2.31. These results are consistent with general finance theory where investments with higher returns are associated with higher levels of risk. As the return levels increase investors would expect that the risk levels associated with those investments would also increase.

Table 4.3 presents monthly correlation coefficients for the commodity portfolio, T-Bonds, T-Bills, and the S&P500. Again, results indicate that the commodity portfolio may be a useful investment in term of adding diversification to a portfolio of stocks, T-Bonds, and T-Bills. This is because commodity portfolio returns appear to be generally uncorrelated with returns from other markets. Results indicate that the commodity portfolio is negatively related with returns from the S&P500, but at a very low level of -.05. The correlation coefficient between the commodity portfolio and T-Bills is .08, and for T-Bonds is .03, both of which are very small. This shows that the commodity portfolio returns are generally unrelated to T-Bill and T-Bonds returns. These results are important because they demonstrate again that a commodity portfolio may enhance the performance of an existing portfolio of assets, in terms of adding diversification.

Table 4.3 also shows that the correlations between other traditional investments is also very low. The correlation between returns on the S&P500 and T-Bonds is .38, and between the S&P500 and T-Bills is -.08. These results support earlier findings that indicate that the correlation between returns on equity markets and T-Bonds and T-Bills is relatively low

(Edwards and Park, 1996). Results also indicate that the correlation between T-Bills and T-Bonds is .05, also very small and positive. Overall, these results generally indicate that an addition of commodity returns to a portfolio of the S&P500, T-Bonds, and T-Bills may enhance the diversification of the portfolio.

SUMMARY

Returns from the system trading of nineteen commodities over a twenty year period using the Dual Moving Average Crossover system were computed. The commodity futures traded were British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. Transaction and slippage costs were assumed to be $50 per round trade. In calculating returns 25% was invested in the market, while 75% was held in reserve for margin calls. Returns are calculated from the total investment.

This study proceeded in four steps. First, correlations were computed to determine the extent to which returns are related to one another. Second, the risk-return tradeoff for the nineteen individual commodities was analyzed. Third, the CAPM was used to test for return levels and the extent to which system traded commodity returns are related to equity returns. Fourth, the risk-return tradeoff for the commodity portfolio, T-Bills, T-Bonds, and the S&P500 was analyzed.

There are a number of important findings that this paper has presented. First, correlation coefficients indicate that returns from individual commodities displayed either negative or low positive correlation, unless the commodities were from similar commodity groups. This result is as expected, and it emphasizes the need for investors to diversify portfolios across a number of individual commodities and different commodity groups. The use of system traded commodity funds may be an appropriate manner for investors to achieve diversification within futures markets, assuming that these funds trade a number of unrelated commodities.

Second, this study has illustrated the relationship between risk and return for individual commodities. Although the risk levels associated with individual commodity returns were quite variable, results generally show that as individual commodity returns increase, the standard deviation associated with that return also increases. This result is consistent with standard finance theory, which suggests that as the risk of an investment increases, the expected return should also increase.

Third, the Capital Asset Pricing Model was used to test return levels and test for correlation between commodity returns and equity returns. Results indicate that the commodity portfolio returns are unrelated to S&P500 returns, as shown by its negative beta coefficient. This is important because it shows that commodity funds can be a useful investment in terms of adding diversification to an equity portfolio. Given the diversification benefits of system traded commodity returns and their historical return levels competitive to the S&P500, they have likely been a suitable investment for a number of investors. It was found that some of the individual commodities and the portfolio of commodities appear to have returns that exceed the S&P500 returns. Results also indicate that many individual markets had either a negative or low positive beta coefficient, suggesting that system traded returns are unrelated to returns from the S&P500.

Fourth, the risk-return tradeoff curve and correlations for the S&P500, T-Bonds, T-Bills, and the commodity portfolio were analyzed. Results of the risk-return tradeoff curve indicate that T-Bills had the minimum risk-return point while the portfolio had the maximum risk-return point. Results indicate that investments with higher monthly returns were found to have higher levels of risk. Correlation results show that the commodity portfolio is relatively uncorrelated with returns from other markets, such as equities, T-Bills, and T-Bonds, so may be included in an investors portfolio to help diversify.

Finally, caution should be used in extrapolating these results to the future. With the increased competition from the use of computers and system trading, commodity returns may not maintain past levels. As well, past returns from equities, T-Bonds, T-Bills, may change, resulting in different portfolio risk and return levels for investors.

Table 4.1
Correlations of Monthly System Trading Returns Across Commodities [a,b,c]

	British Pound	Canadian Dollar	Coffee	Corn	Cotton	Deutsche Mark	Gold	Japanese Yen	Live Cattle	Live Hogs	Orange Juice	Swiss Franc	Silver	Soybeans	Soybean Oil	Soybean Meal	Sugar	T Bonds
Canadian Dollar	-0.11**																	
Coffee	-0.02	0.01																
Corn	0.09	-0.09	-0.08															
Cotton	0.04	-0.11	-0.06	-0.06														
Deutsche Mark	.44*	-0.02	0.03	.13*	-0.07													
Gold	0.12	0.03	-0.04	0.01	.13*	.24*												
Japanese Yen	.22*	0.10	-.18*	0.04	-0.06	.34*	.12*											
Live Cattle	0.08	0.02	0.05	0.03	-0.01	0.07	-0.08	0.03										
Live Hogs	0.05	-0.04	.11**	0.01	0.05	.14*	-0.02	0.01	.16*									
Orange Juice	0.03	-0.07	0.02	0.06	0.11	-0.03	-0.05	0.01	-0.02	0.06								
Swiss Franc	.36*	0.09	0.04	.11**	-0.07	.72*	.26*	.34*	0.06	0.09	0.02							
Silver	.11**	-0.02	0.01	-0.01	.16*	.16*	.49*	0.06	-0.04	0.01	-0.03	0.16						
Soybeans	.16*	-.13*	-0.02	.27*	-0.02	.15*	0.08	0.04	-0.05	-.13*	-0.01	.11**	.11**					
Soybean Oil	0.00	-0.06	0.01	.25*	0.03	0.07	0.06	0.08	0.08	-0.04	-0.03	0.08	0.07	.47*				
Soybean Meal	.14*	-0.02	-0.02	.23*	-0.01	.25*	0.01	0.05	-0.04	0.00	-0.05	.11**	0.03	.52*	.21*			
Sugar	0.06	-0.03	-0.06	-0.01	0.07	-0.02	0.05	-0.01	-.13**	-0.01	0.03	-0.02	0.06	-0.06	-.12**	0.05		
T Bonds	0.02	0.02	-0.09	0.01	0.05	0.03	-0.10	0.06	0.05	-0.04	-0.09	0.00	0.04	0.09	0.06	0.09	0.05	
Wheat	-0.07	0.09	0.09	.19*	0.10	0.01	0.06	0.09	-0.04	.16*	0.05	-0.04	0.01	0.08	.16*	0.07	-0.08	0.00

[a] * Indicates significance at 5% level and ** Indicates significance at 10% level.
[b] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[c] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market the return would be 10% or $100/$1000.

Table 4.2

Econometric CAPM Results GARCH(1,1) for System Trading Returns of Nineteen Commodities and Commodity Portfolio Versus S&P500, 1978-97 [a,b,c,d,e,f,g]

Dependent Variable	Independent Variable		
Mean Percent Return	Alpha (Intercept)	Beta (S&P500)	R^2
British Pound	3.86 (1.35)	-.54 (-.85)	0.01
Canadian Dollar	-1.55 (-1.32)	.52 (1.94)*	0.01
Coffee	2.69 (.85)	-.08 (-.12)	0.01
Corn	-.18 (-.08)	.65 (1.25)	0.01
Cotton	5.42 (2.55)*	-.49 (-1.02)	0.01
Deutsche Mark	7.76 (2.69)*	-.59 (-.93)	0.01
Gold	1.69 (.98)	-.31 (-.77)	0.01
Japanese Yen	8.02 (2.97)*	.19 (.31)	0.01
Live Cattle	-.98 (-.51)	.12 (.26)	0.01
Live Hogs	-1.17 (-.43)	.01 (.01)	0.01
Orange Juice	.69 (.46)	-.06 (-.18)	0.01
Swiss Franc	8.40 (2.70)*	-.45 (-.64)	0.01
Silver	-.41 (-.20)	-.18 (-.39)	0.01
Soybeans	.99 (.55)	-.63 (-1.55)	0.01
Soybean Oil	-5.12 (-1.62)**	.56 (.79)	0.01

Soybean Meal	-.80 (-.41)	-.35 (-.82)	0.01
Sugar	9.07 (2.92)*	-.92 (-1.28)	0.01
T Bonds	.92 (.50)	.83 (1.97)*	0.02
Wheat	-2.87 (-1.46)	-.19 (-.43)	0.01
Portfolio	2.07 (2.75)*	-.26 (-1.46)	0.01

[a] T-Ratio appears in parenthesis.
[b] *Indicates statistically significant coefficient at 5% level and **Indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then the return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH (1,1) is a Generalized Autoregressive Conditional Heteroskedasticity econometric model.
[g] S&P500 returns include dividends reinvested.

Table 4.3

Monthly Correlations Between Commodity Portfolio and Other Investment Returns, 1987-1997 [a,b,c]

	Market Return Correlations		
	Commodity Portfolio	S&P500	T-Bonds
S&P500	-0.05		
T-Bonds	0.03	0.38	
T-Bills	0.08	-0.07	0.05

[a] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters
[b] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then the return would be 10% or $100/$1000.
[c] T-Bonds, T-Bills, and S&P500 returns assume a buy and hold strategy with income/dividends reinvested.

Figure 4.1

Risk-Return Tradeoff and Trend-Line for Individual Commodities, 1978-1997

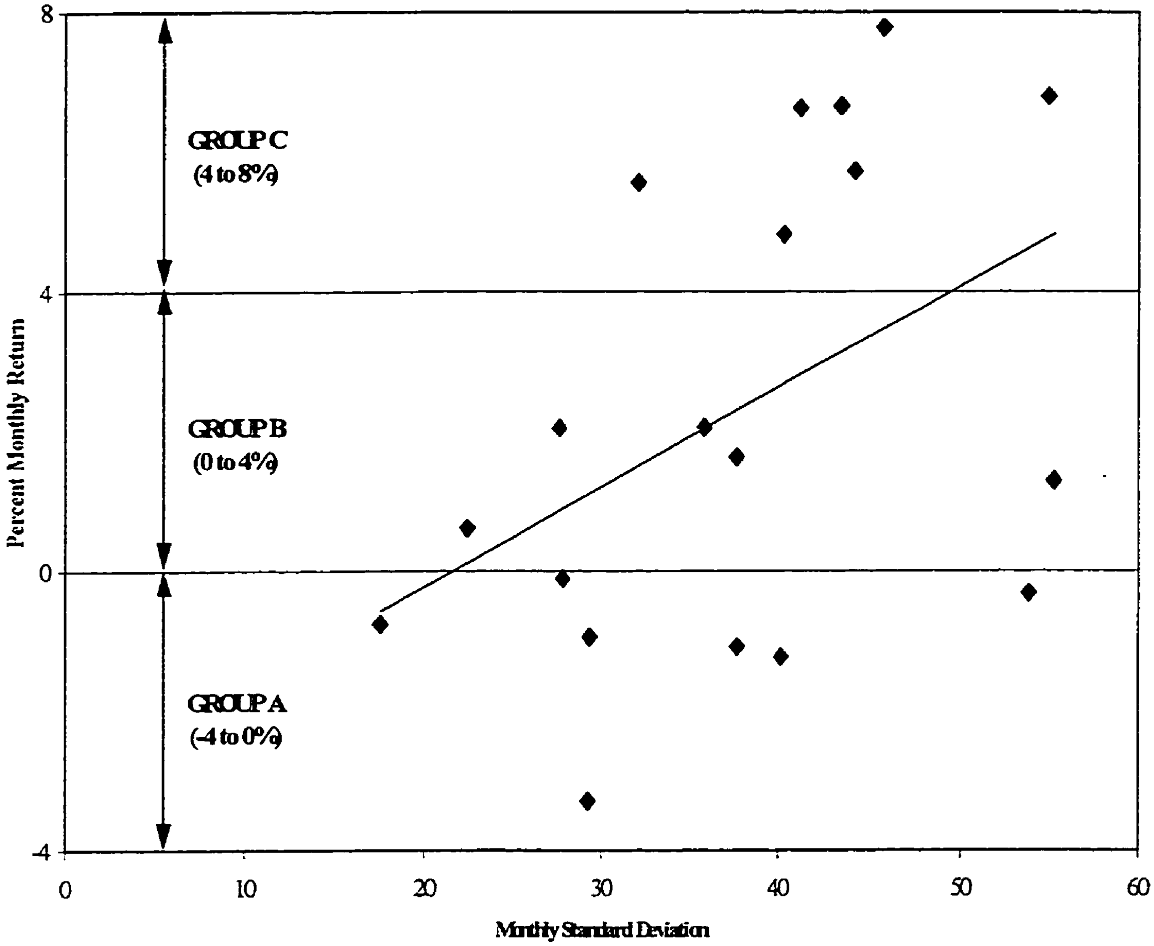
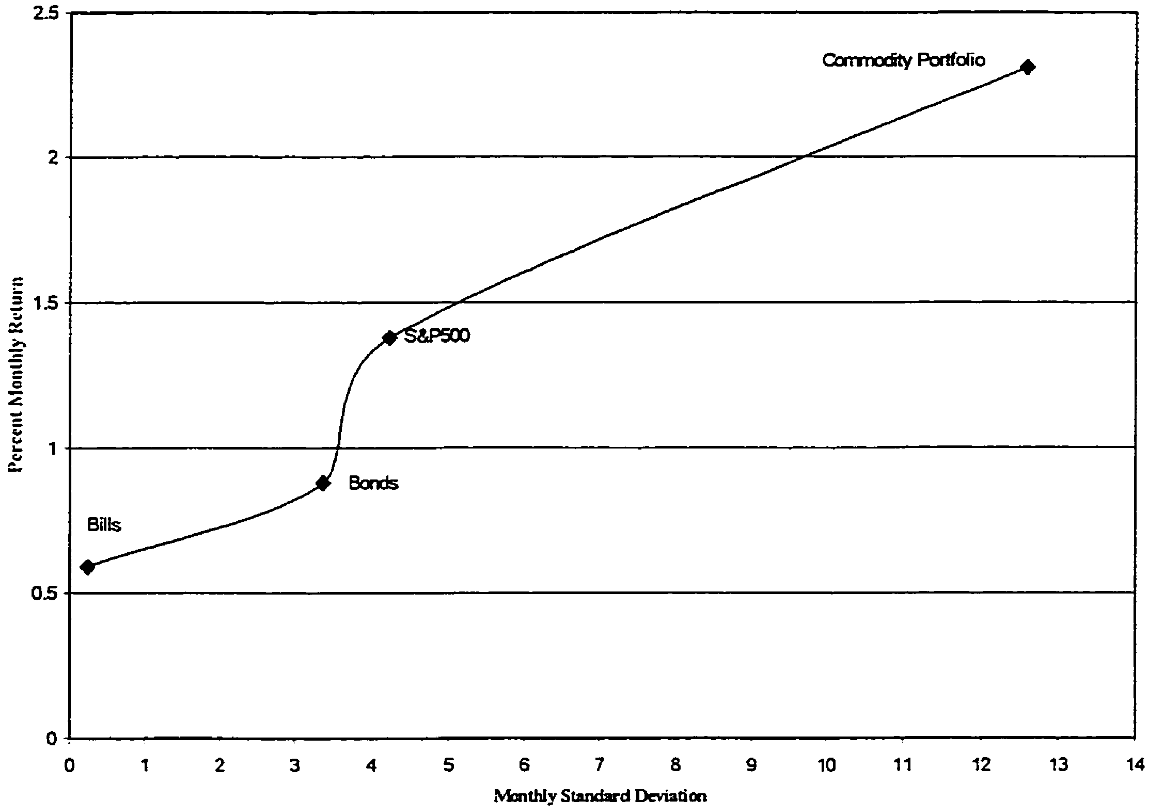


Figure 4.2

Risk-return Tradeoff Curve for Commodity Portfolio and Other Investments



CHAPTER 5

SUMMARY

Technical trading systems, also known as system trading or trend following systems, are computerized futures trading methods which use past prices to determine buying and selling signals. The objective of this study was to examine the returns from technical system trading of futures markets. This study addressed the level and variability of returns, the possible factors related to returns, the role of commodity returns in investment portfolios and diversification, Capital Asset Pricing model tests, and portfolio and individual commodity risk-return tradeoffs.

System trading returns of nineteen commodities over a twenty year (1978-1997) period using the Dual Moving Average Crossover system were computed. This trading system was chosen for two reasons. First, it is one of the most popular systems used today and many managers of futures funds use this system. Second, this system is representative of many other trend following systems and returns from it are highly correlated to returns from other systems (Lukac, Brorsen, and Irwin, 1988b).

The commodity futures traded were British Pound, Canadian Dollar, coffee, corn, cotton, Deutsche Mark, gold, Japanese Yen, live cattle, live hogs, orange juice, Swiss Franc, silver, soybeans, soybean oil, soybean meal, sugar, United States T-bonds, and wheat. Transaction and slippage costs were assumed to be $50 per round trade. In calculating returns 25 percent was invested in the market, while 75 percent was held in reserve for margin calls. Returns are calculated from the total investment, and trading methods used attempted to mimic those of large commodity funds.

Level and Variability of Returns

There are a number of important findings that Chapter 2 presented. First, results of this chapter indicate that some system trading of futures markets produced positive statistically significant returns in some futures markets. Overall the 19 commodity portfolio showed an annual return of 27.74 percent over the 1978-1997 period, compared to 16.58 for the S&P500. The British Pound, cotton, Deutsche Mark, Japanese Yen, Swiss Franc, and the commodity portfolio were found to have positive statistically significant monthly returns. However, metals, agriculturals, and financials (T-bonds) were found to have considerably smaller returns. These results suggest that currencies may be well suited to technical system trading, and that physical commodities may be less suited, though they may still be traded for diversification purposes. The profitability of currencies may be due to their long trends created by long-term factors such as interest rates, economic growth, investment climate, and trade balances. The increased use of technical system trading may also lead to choppiness in physical markets and false breakouts, with fewer substantial profitable trends.

Second, the relatively high risk associated with individual commodities can be reduced considerably if they are traded as a portfolio. By using the monthly Sharpe ratio as a measure of risk, the commodity portfolio was found to have a much lower risk level than any of the nineteen commodities. Commodity funds allow the individual investor access to this risk diversification, as diversification may be prohibitively expensive for an individual investor to achieve, since they may need to trade as many as 15 commodities to lower risk. When compared to the return from the S&P500, the commodity portfolio was found to have a higher mean monthly return but a higher risk. The mean monthly percent return from the commodity portfolio was .93 higher than the S&P500. However, its Sharpe ratio was .14 lower, indicating that commodity returns were more risky relative to those of stocks.

Third, relatively high levels of kurtosis were found in the distribution for individual commodity returns and in the commodity portfolio returns. This indicates the presence of leptokurtic distributions and that traders can expect more returns to be in either of the tails than in a normal distribution of returns. The high kurtosis values for the S&P500 likely occurred because of the stock market crash of October 1987.

Fourth, the mean monthly percent return from the commodity portfolio was found to display significant negative autocorrelation, which suggests that a month of high returns is followed by a month of low returns, and vice versa. Investors may be better off to invest following a low monthly return, because a higher return would be expected the next month. For the fund manager, this means they are more likely to have monthly returns alternate from positive to negative, rather than a number of runs of positive months followed by runs of negative months, which may cause substantial losses of capital.

Factors Related to Returns from System Traded Futures Markets

Chapter 3 presented a number of important findings. First, time was found to be generally negatively related to returns, meaning that returns from system trading are decreasing over time, as expected. The coefficient for time was found to be negative in the majority of individual markets, and significantly negative for the commodity portfolio. Currencies returns indicated the largest decreases in returns over time. Other commodities such as agriculturals and metals have always had relatively low or negative system traded returns, so they are less likely to decrease much further. Results indicate that returns for the commodity portfolio will be considerably lower and closer to zero by about the year 2013. However, returns would be unlikely to reach zero, since the least profitable funds would leave the industry or change trading methods, leaving the more profitable and most efficient funds in the industry. Since returns from system trading appear to be decreasing with time, system traders may wish to consider improved or alternative methods to trade these markets. System trading returns may be declining due to the increase number of system traders and competition, brought on by the availability, lower cost, increased use of the personal computer, software, and data. These declining system traded returns may also in turn bring increased pressure on brokers for lower transaction costs.

Second, individual commodity price variation was found to be generally related to commodity return levels, as expected. This implies that traders may wish to remain as market participants during volatile price changes, assuming that their return is reasonable, and may wish to scale back their scale back positions during periods of lower price variation. If price variation is somewhat predictable then this may be possible to some extent.

Third, inflation levels were positively related to portfolio return levels, as expected. A very important result is that inflation was significantly and positively related to return levels for the commodity portfolio. Given this result, system traders should benefit most during times of high inflation. However, agricultural returns were negatively related to inflation in the majority of cases. This may mean that agricultural prices do not trend well during times of high inflation. The positive correlation between inflation and some returns implies that system traders will be more successful during periods of higher inflation. However, more recent economic policy has encouraged deregulation and increased competition, resulting in lower inflation. Lower inflation has also been encouraged by conservative monetary policy. If these trends continue, system traders may face continued lower returns.

Fourth, the mean price level was found to be positively related to some individual markets, which was expected. These results indicate that as commodity futures markets move to higher price levels, system trading may be an appropriate way to trading these markets. This result also implies that lower priced individual markets may be less suited for system trading. However, this result was not highly consistent across commodities, so should not be weighted too highly by traders.

System Traded Commodity Futures, Diversification, and Their Role in Investment Portfolios

Chapter 4 presents results related to commodity return correlation, diversification, and risk-return tradeoffs. First, correlation coefficients indicate that returns from individual commodities displayed either negative or low positive correlation, unless the commodities were from similar commodity groups. This result is as expected, and it emphasizes the need for investors to diversify portfolios across a number of individual commodities and different commodity groups. The use of system traded commodity funds may be an appropriate manner for investors to achieve diversification within futures markets, assuming that these funds trade a number of unrelated commodities.

Second, this study has illustrated the relationship between risk and return for individual commodities. Although the risk levels associated with individual commodity returns were quite variable, results generally show that as individual commodity returns increase, the standard deviation associated with that return also increases. This result is consistent with standard finance theory, which suggests that as the risk of an investment increases, the expected return should also increase.

Third, the Capital Asset Pricing Model was used to test return levels and test for correlation between commodity returns and equity returns. Results indicate that the commodity portfolio returns are unrelated to S&P500 returns, as shown by its negative beta coefficient. This is important because it shows that commodity funds can be a useful investment in terms of adding diversification to an equity portfolio. Given the diversification benefits of system traded commodity returns and their historical return levels competitive to the S&P500, they have likely been a suitable investment for a number of investors. It was found that some of the individual commodities and the portfolio of commodities appear to have returns that exceed the S&P500 returns. Results also indicate that many individual markets had either a negative or low positive beta coefficient, suggesting that system traded returns are unrelated to returns from the S&P500.

Fourth, the risk-return tradeoff curve and correlations for the S&P500, T-Bonds, T-Bills, and the commodity portfolio were analyzed. Results of the risk-return tradeoff curve indicate that T-Bills had the minimum risk-return point while the portfolio had the maximum risk-return point. Results indicate that investments with higher monthly returns were found to have higher levels of risk. Correlation results show that the commodity portfolio is relatively uncorrelated with returns from other markets, such as equities, T-Bills, and T-Bonds, so may be included in an investors portfolio to help diversify.

Limitations and Suggestions for Further Research

Returns in this study are based on assumptions and historical data over specific commodities and past trends. Therefore, caution should be used in extrapolating these results to the future. With the increased competition from the use of computers and system trading, commodity returns may not maintain past levels. As well, past returns from equities, T-Bonds, and T-Bills may change, resulting in different portfolio risk and return levels for future investors. Assuming trend following systems may be less effective in the future because of their increased use, caused by the lower cost of computing and data, there may be an increase in the number of false break-outs, and whipsaw losses to traders. If this occurs, new systems may need to be designed and tested to trade these markets.

REFERENCES

Billingsley, Randall S. and Don M. Chance. "Benefits and Limitations of Diversification Among Commodity Trading Advisors," The Journal of Portfolio Management 23(1996): 65-80

Bird, P.J.W.N. "Dependency and Efficiency in the London Terminal Markets," Journal of Futures Markets 3(1985):433-446

Blume, L. and D. Easley and M. O'Hara. "Market Statistics and Technical Analysis: The Role of Volume," Journal of Finance 1(1994):153-181

Boyd, M.S. and B.W. Brorsen. "Factors related to Futures Market Disequilibrium," Canadian Journal of Agricultural Economics 39(1991): 769-778

Brock, W. A. and J. Lakonishok and B. LeBaron. "Simple Technical Trading Rules and the Stochastic Properties of Stock Returns," Journal of Finance 5(1992):1731-1764

Brorsen, B.Wade. "Performance Persistence for Managed Futures," Foundation for Managed Derivatives research, Washington, D.C., 1998

Brorsen, B.Wade and Scott H. Irwin "Examination of Commodity Fund Performance," Review of Research in the Futures Markets 4(1985):84-94

Brorsen, B. Wade and Louis Lukac "Optimal Portfolios for Commodity Futures Funds," Journal of Futures Markets 3(1990):247-258

Clyde, W.C. and C.L. Osler. "Charting: Chaos Theory in Disguise?," The Journal of Futures Markets 5(1997):502-514

Edwards, Franklin and James Park "Do Managed Futures make Good Investments?," Journal of Futures Markets 5(1996):475-517

Elton, E. and M.J. Gruber and J.C. Rentzler, "Professionally Managed, Publicly Traded Commodity Funds," Journal of Business 2(1987):175-199

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

Ibbotson Associates, Stocks, Bonds, Bills and Inflation: 1998 Yearbook, Ibbotson Associates, Inc., Chicago, 1998

Irwin, S.H. and B.W. Brorsen. "A Note on the Factors Affecting Technical Trading System

Returns," Journal of Futures Markets 5(1987):591-595

Irwin, S.H. and B.W. Brorsen. "Public Futures Funds," Journal of Futures Markets 2(1985):149-171

Irwin, S.H. and J.W. Uhrig. "Do Technical Analysts have holes in their shoes?" Review of Research in Futures Markets 3(1984):264-277

Jacob, Nancy L. "Portfolio Management and Non-Traditional Investing," Trusts and Estates 6(1995):14-32)

LeBaron, B. "Technical Trading Rules and Regime Shifts in Foreign Exchange," University of Wisconsin, Social Systems Research Institute Working Paper, 1991

Levy, H. "Risk and Return: An Experimental Analysis," International Economic Review 1(1997):119-149

Lukac, L.P. and B.W. Brorsen. "A Comprehensive Test of Futures Market Disequilibrium," The Financial Review 4(1990):593-622

Lukac, L.P. and B.W. Brorsen and S.H. Irwin. "Similarity of Computer Guided Technical Trading Systems," Journal of Futures Markets 1(1988a):1-13

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

Malkiel, B.G. and X. Yexiao. "Risk and Return Revisited: The Volatility of Individual Stocks and the Predictability of Returns-Some Surprising Patterns," Journal of Portfolio Management Spring(1997):9-14

Murphy, J.A. "Futures Fund Performance: A Test of the Effectiveness of Technical Analysis," Journal of Futures Markets 2(1986):175-185

Najand, Mohammad and Yung, Kenneth. "A GARCH Examination of the Relationship between Volume and Price Variability in Futures Markets," Journal of Futures Markets 5(1991):613-621

Nawrocki, D. "Adaptive Trading Rules and Dynamic Market Disequilibrium," Applied Economics 16(1984):1-14

Neftci, S.N. and A.J. Policano. "Can Chartists Outperform the Market? Market Efficiency Tests for Technical Analysis," Journal of Futures Markets 4(1984):465-478

Peterson, P.E. and R.M. Leuthold. "Using Mechanical Trading Systems to Evaluate the Weak Form Efficiency of Futures Markets," Southern Journal of Agricultural Economics July(1982):147-151

Schwager, J. "Managed Trading: Myths and Truths," Wiley, New York, 1996

Sharpe, W.F. "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk," Journal of Finance 19(1964):425-442

Taylor, S.J. "Trading Futures Using a Channel Rule: A Study of the Predictive Power of Technical Analysis with Currency Examples," Journal of Futures Markets 2(1994):215-235

Technical Tools, Futures Data, Los Altos, CA., USA

APPENDIX A

Graphs of Mean Monthly Return by Commodity Group and Commodity Portfolio

Figure A.1

Mean Monthly Percent Return for Agriculturals

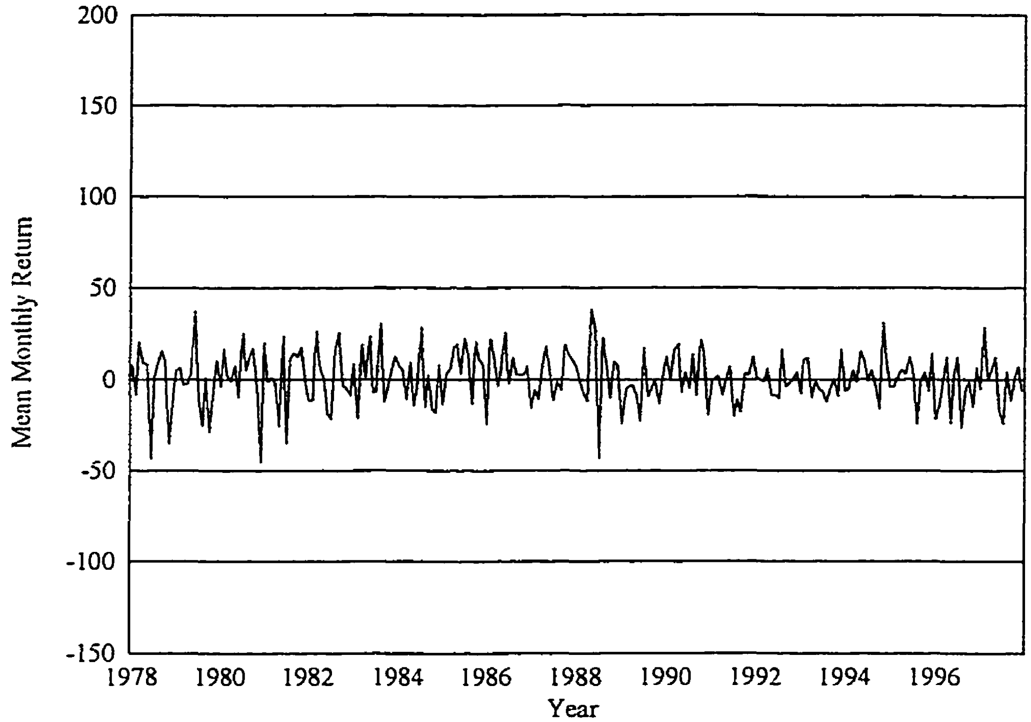


Figure A.2

Mean Monthly Percent Return for Metals

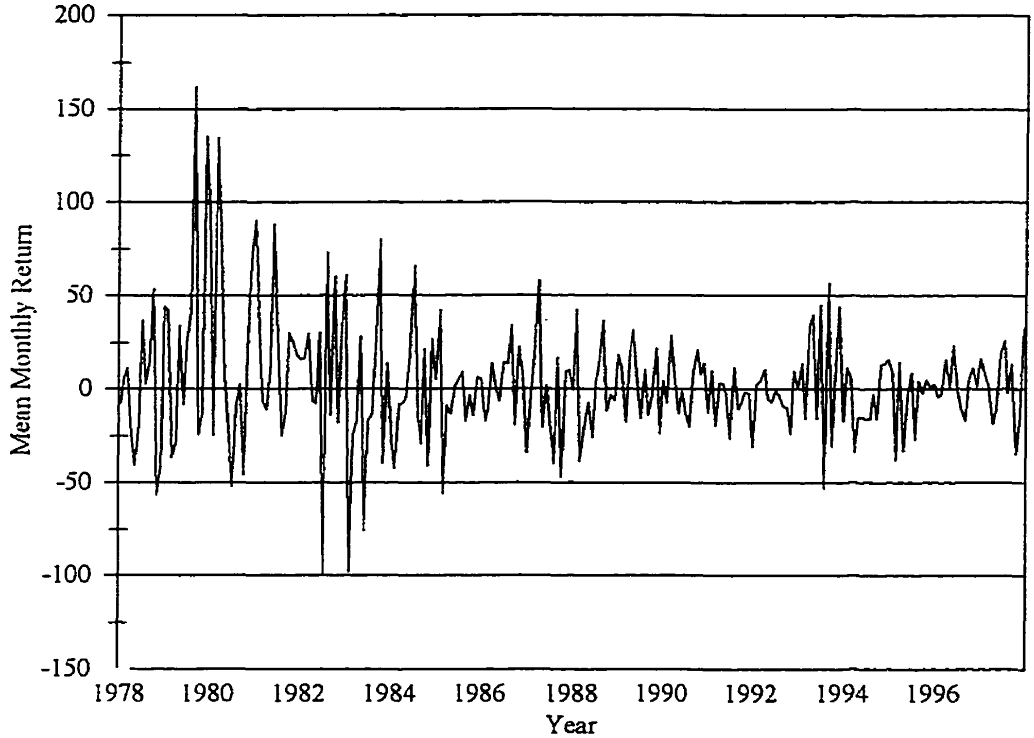


Figure A.3

Mean Monthly Percent Return for Currencies

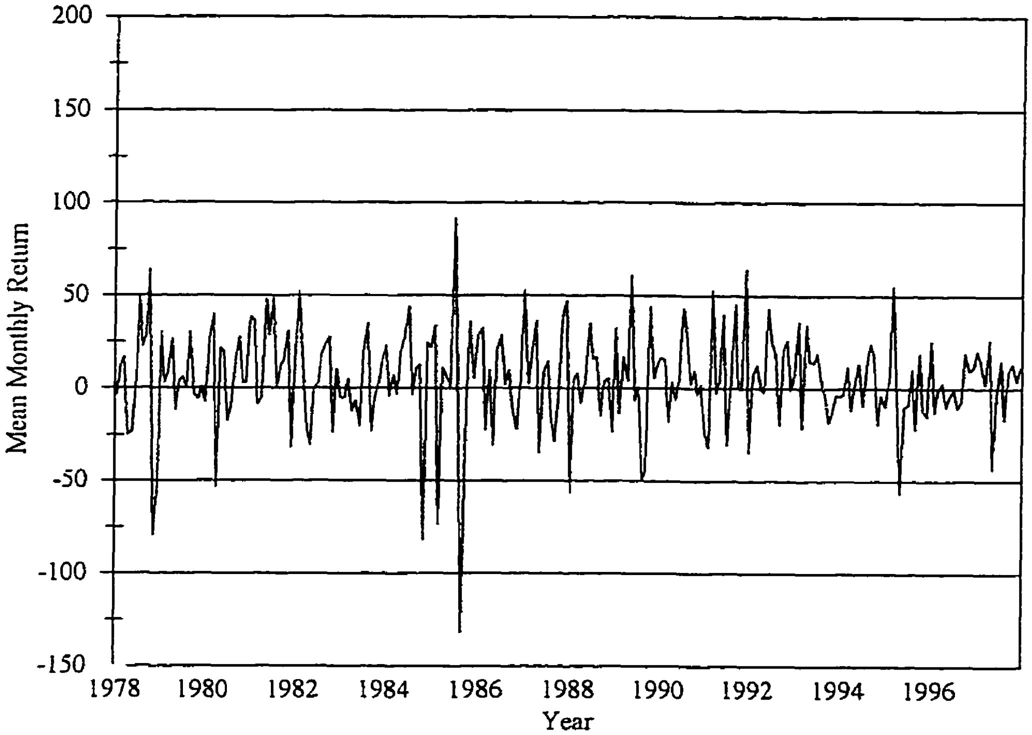


Figure A.4

Mean Monthly Percent Return for Financials

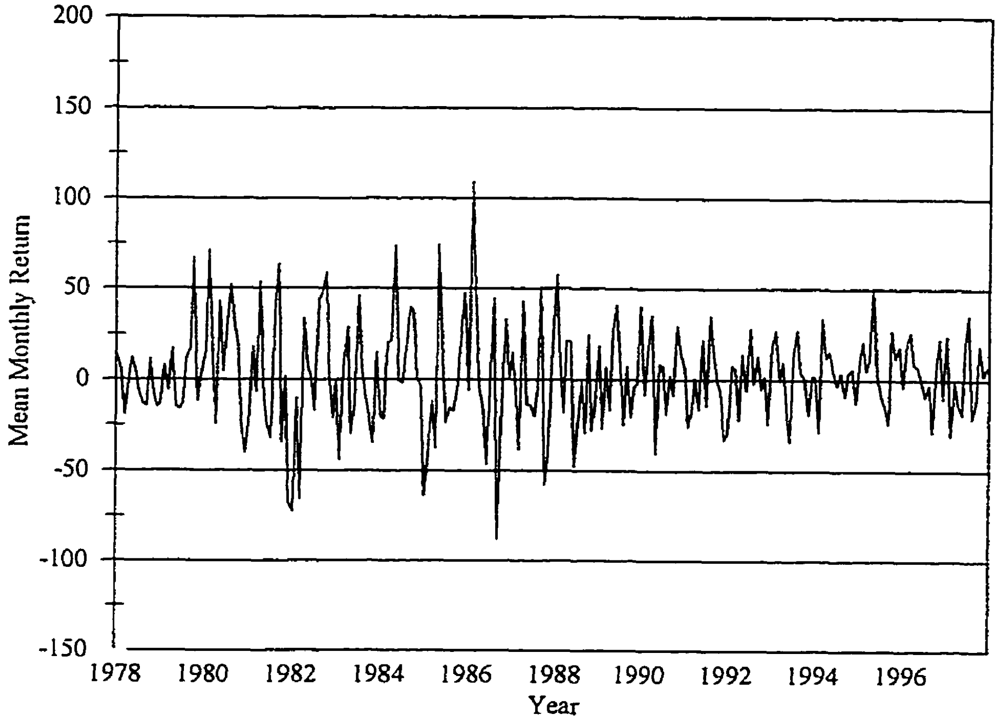
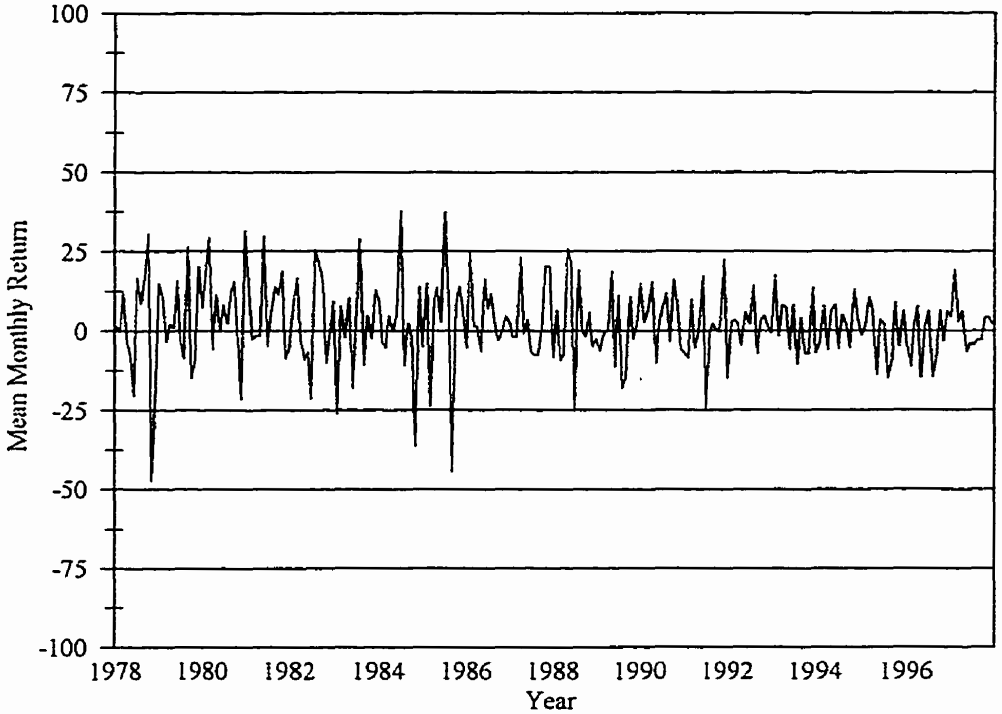


Figure A.5

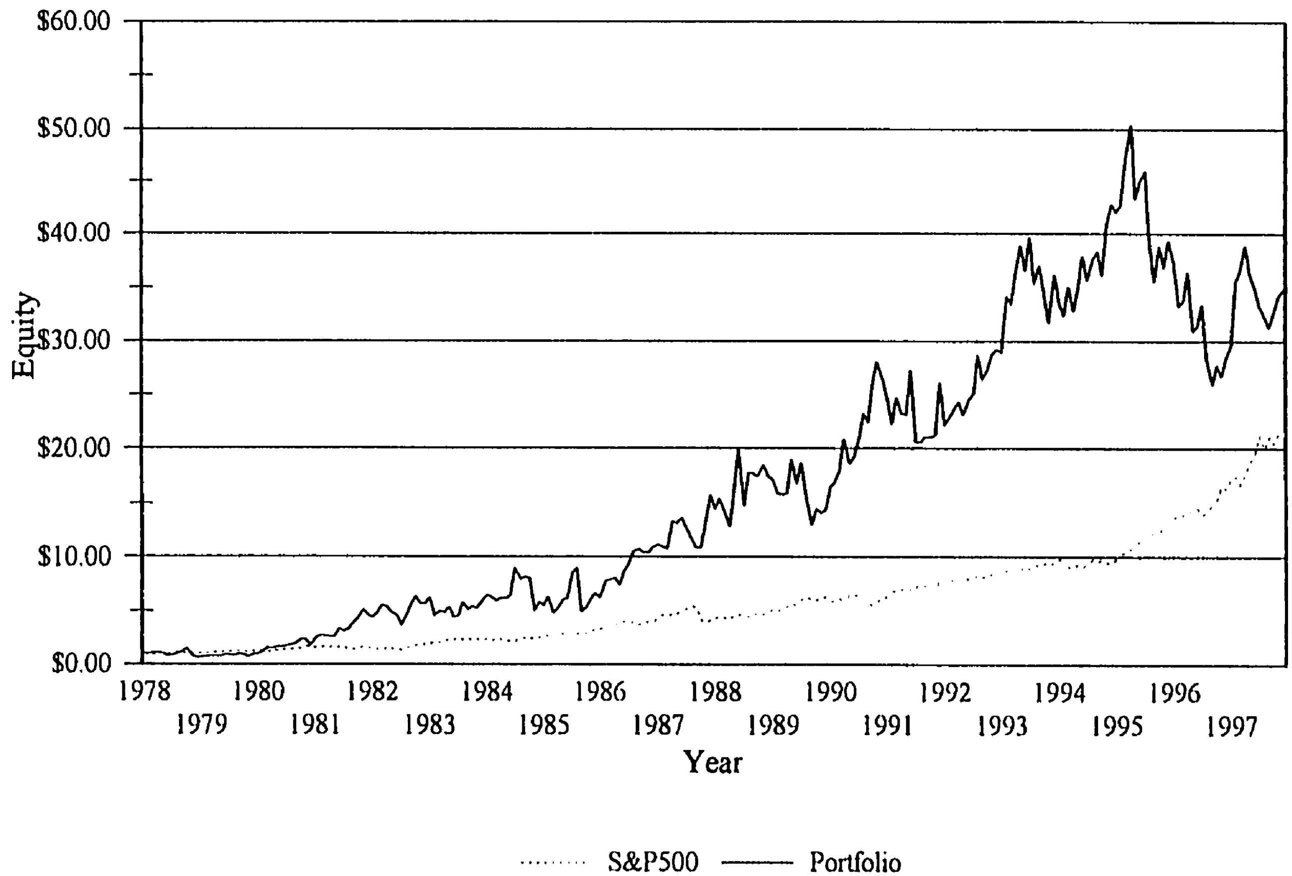
Mean Monthly Percent Return for Portfolio



APPENDIX B

Equity for Commodity Portfolio versus Buy and Hold Equity for S&P500

Figure B.1
System Traded Portfolio Returns Versus Buy and Hold Strategy for S&P500, 1978-1997



APPENDIX C

Graphs of Commodity Annual Percent Returns

Figure C.1

Annual Percent Return for British Pound

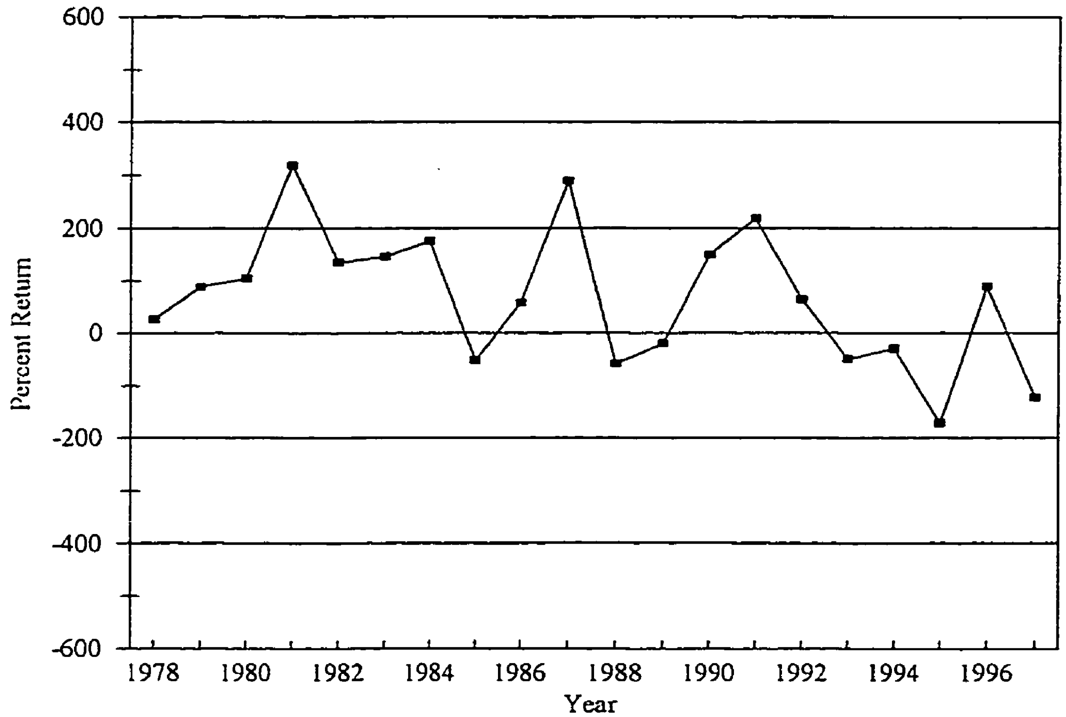


Figure C.2

Annual Percent Return for Canadian Dollar

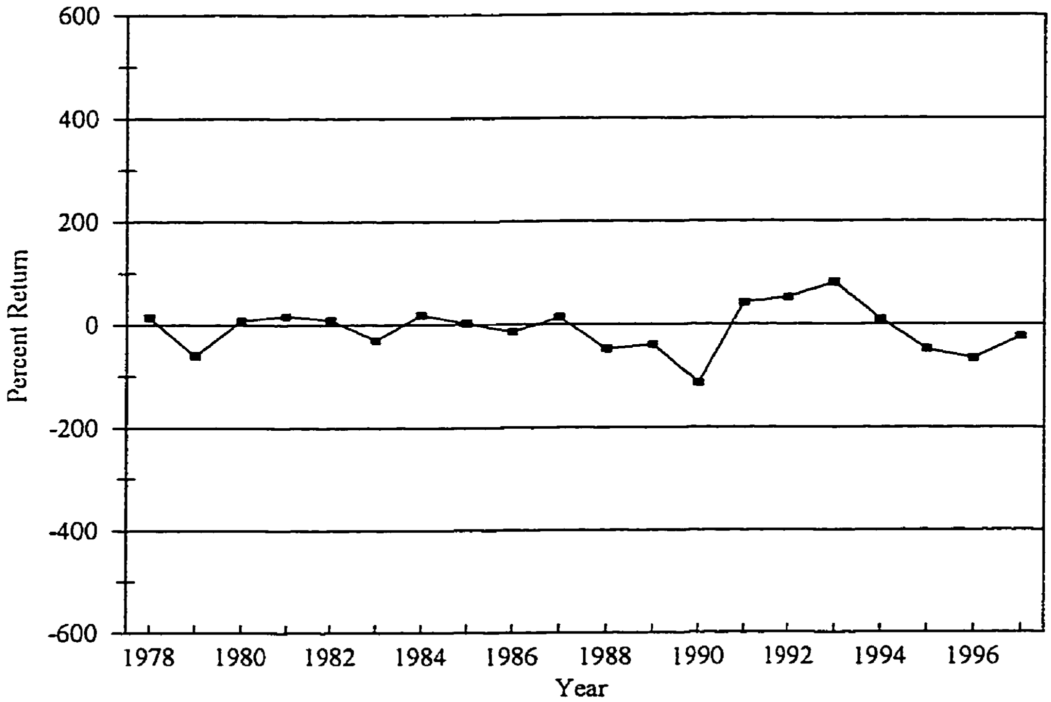


Figure C.3

Annual Percent Return for Coffee

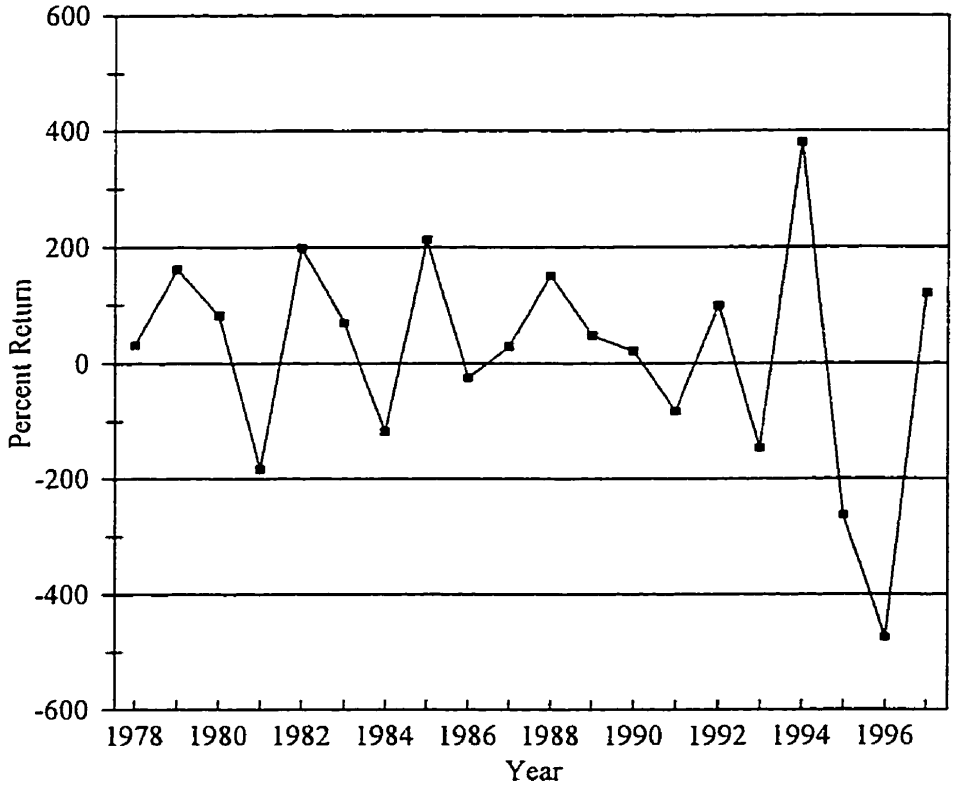


Figure C.4

Annual Percent Return for Corn

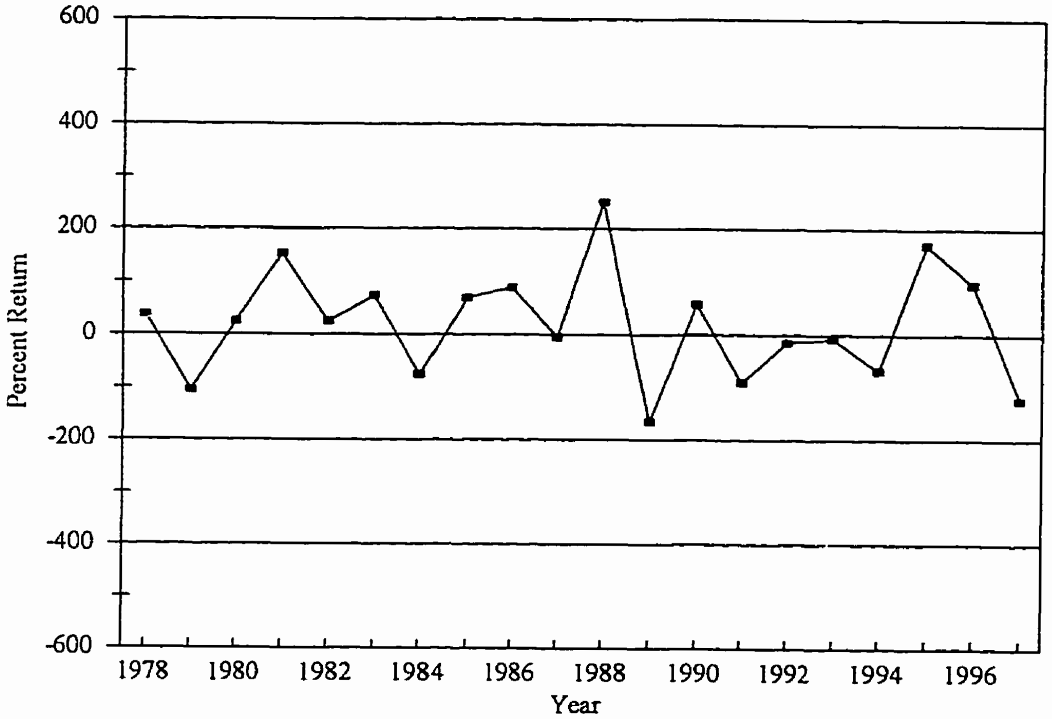


Figure C.5

Annual Percent Return for Cotton

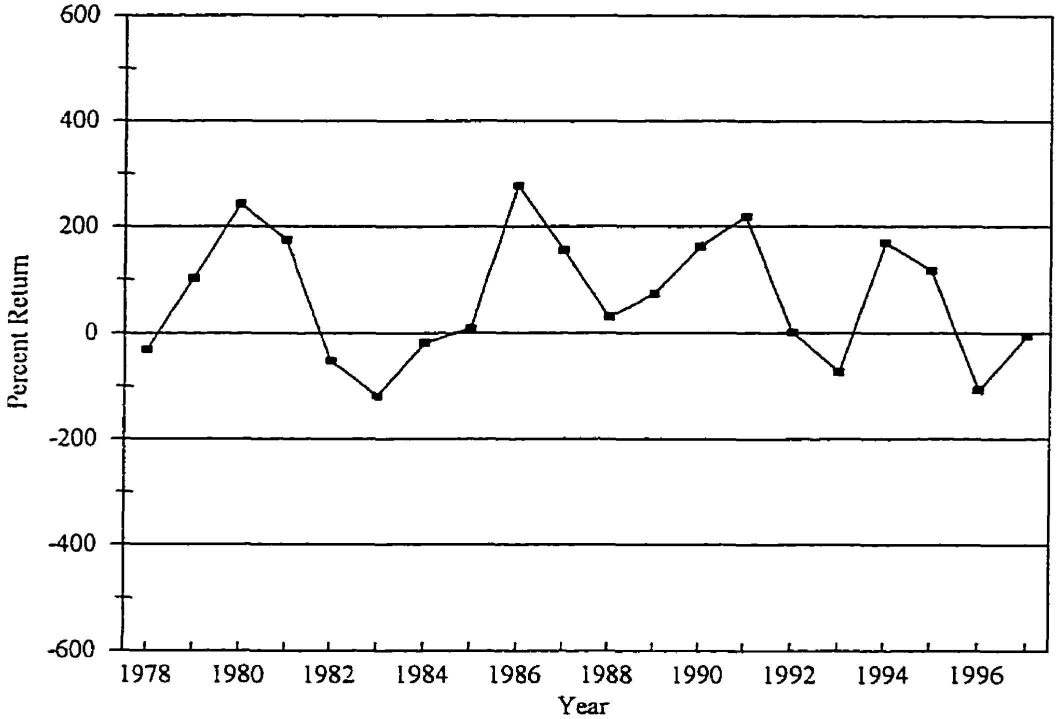


Figure C.6

Annual Percent Return for Deutsche Mark

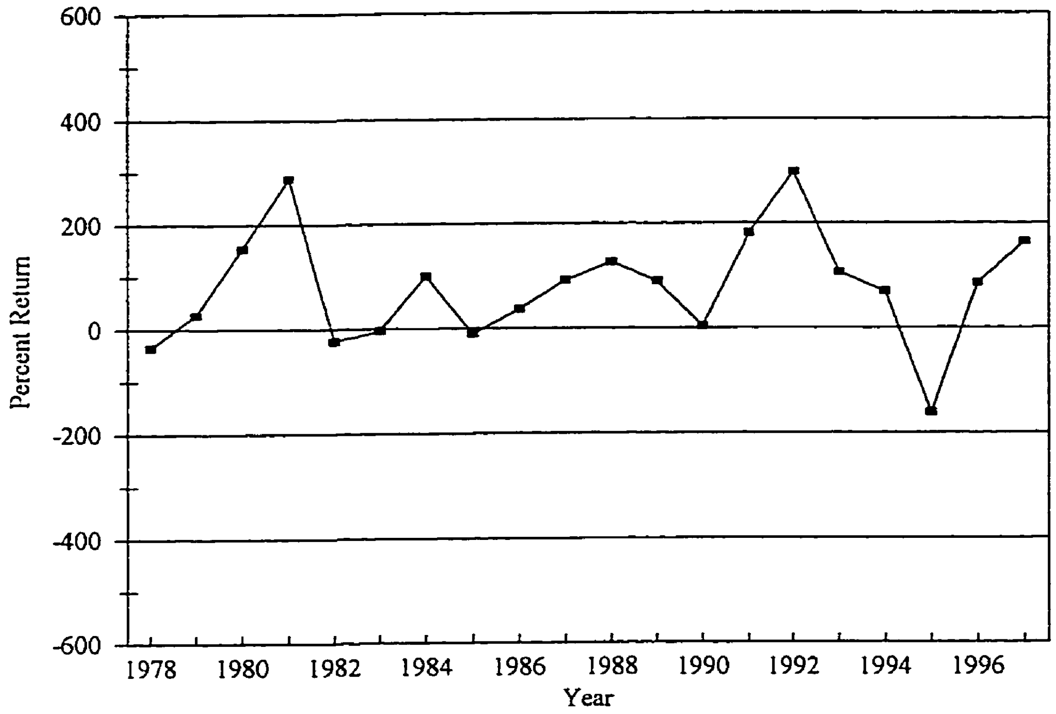


Figure C.7

Annual Percent Return for Gold

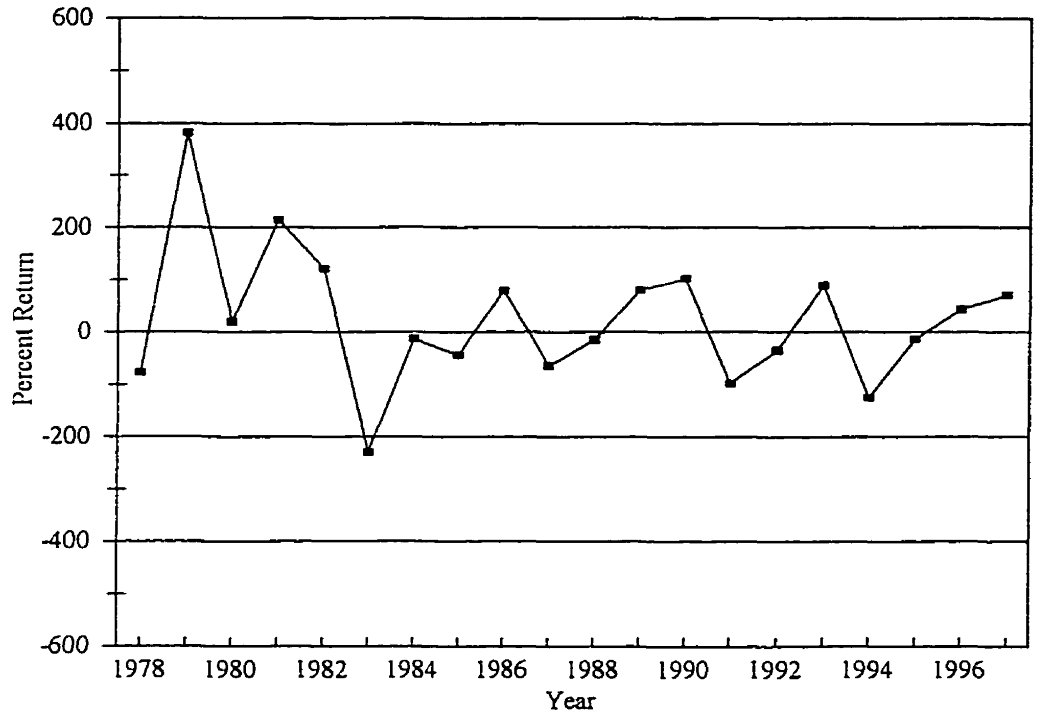


Figure C.8

Annual Percent Return for Japanese Yen

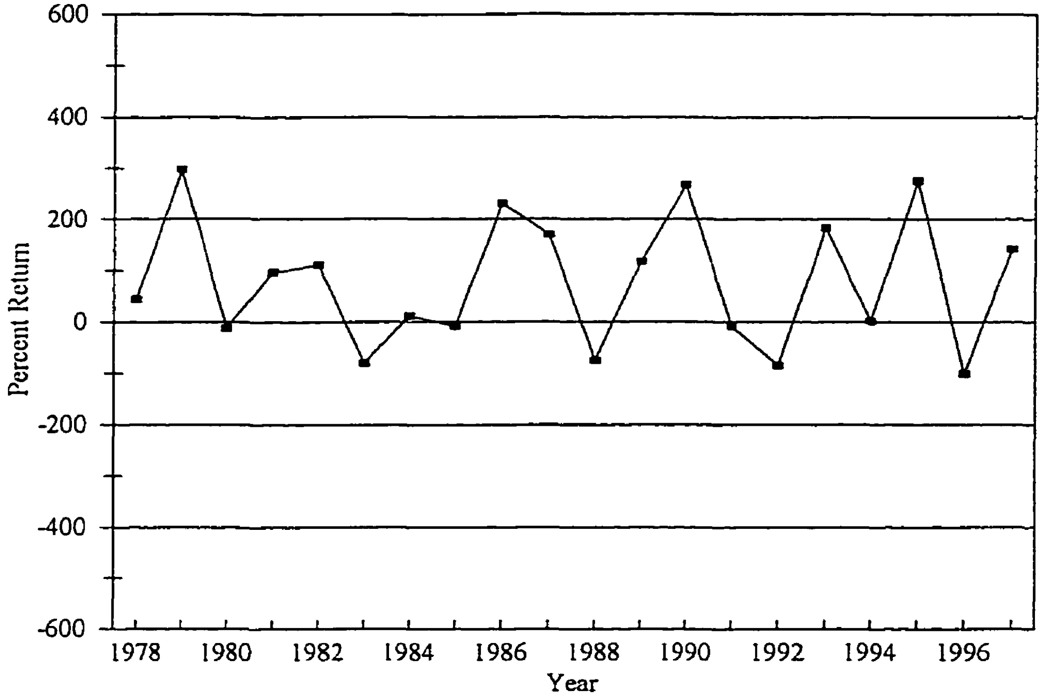


Figure C.9

Annual Percent Return for Live Cattle

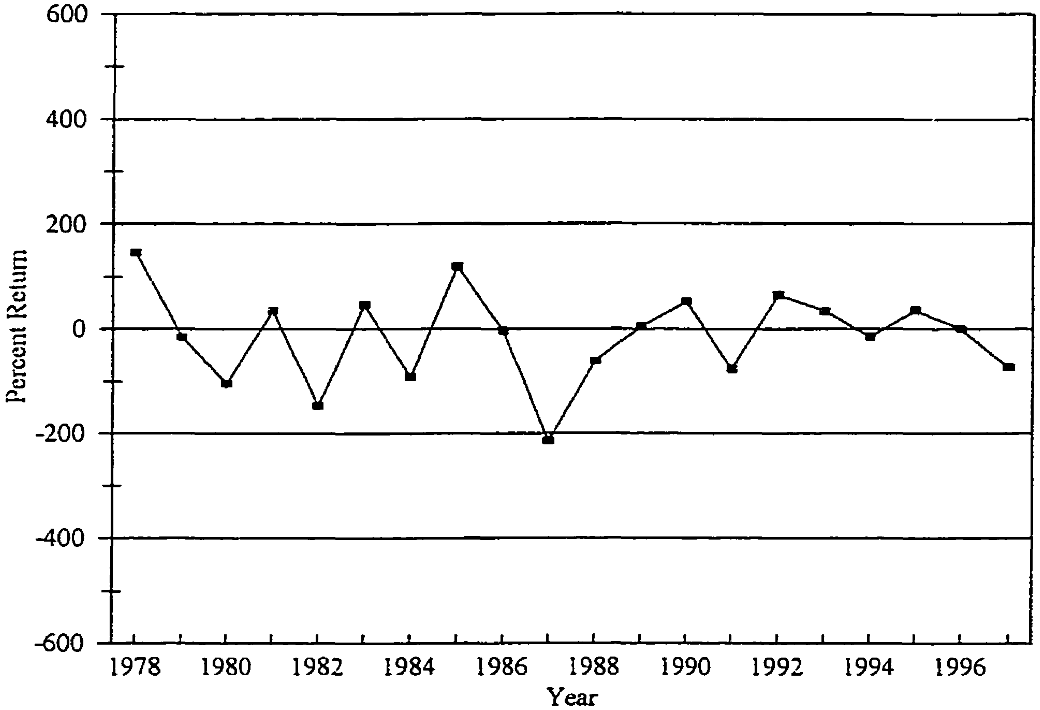


Figure C.10

Annual Percent Return for Live Hogs

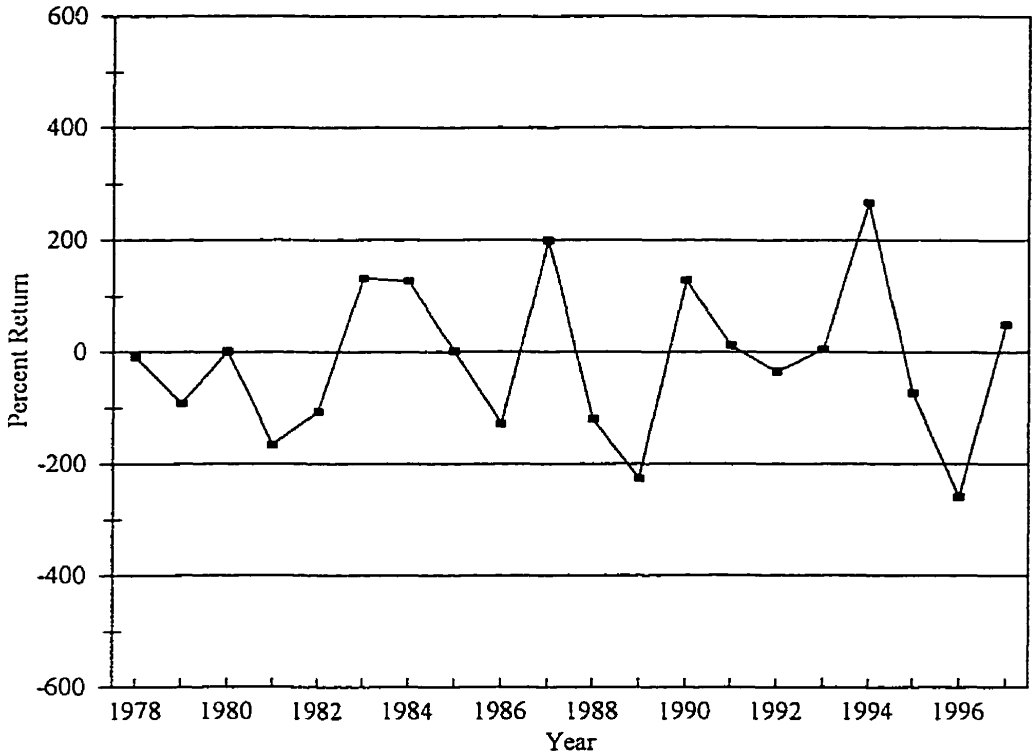


Figure C.11

Annual Percent Return for Orange Juice

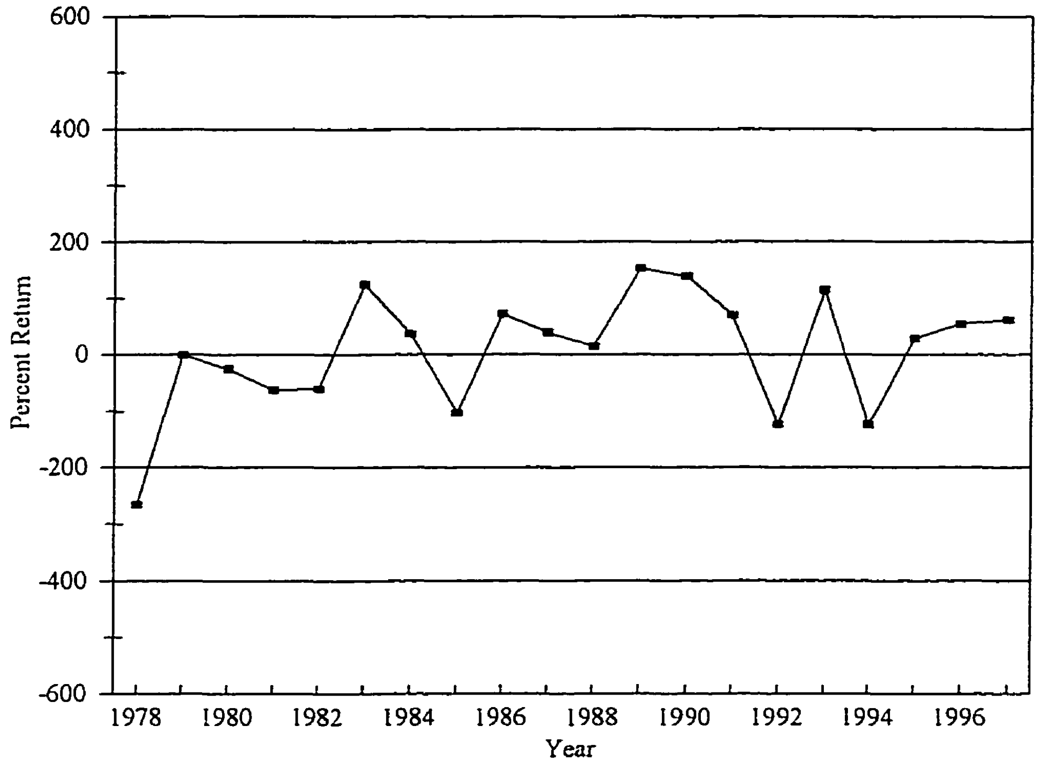


Figure C.12

Annual Percent Return for Silver

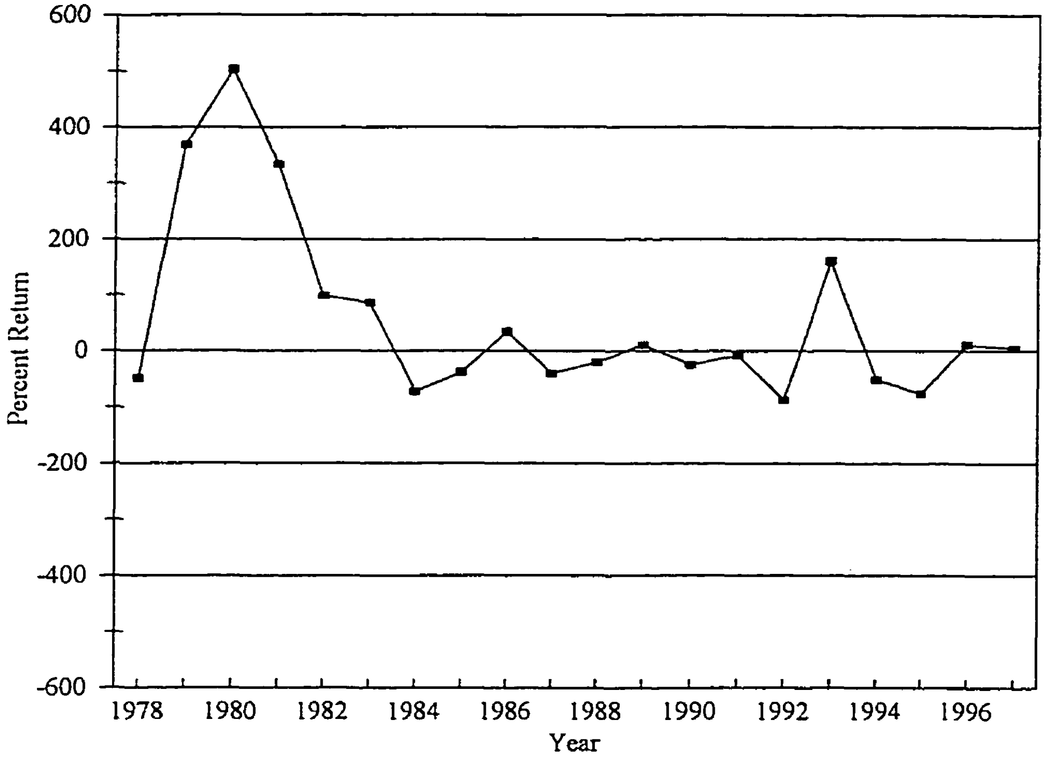


Figure C.13

Annual Percent Return for Soybean Oil

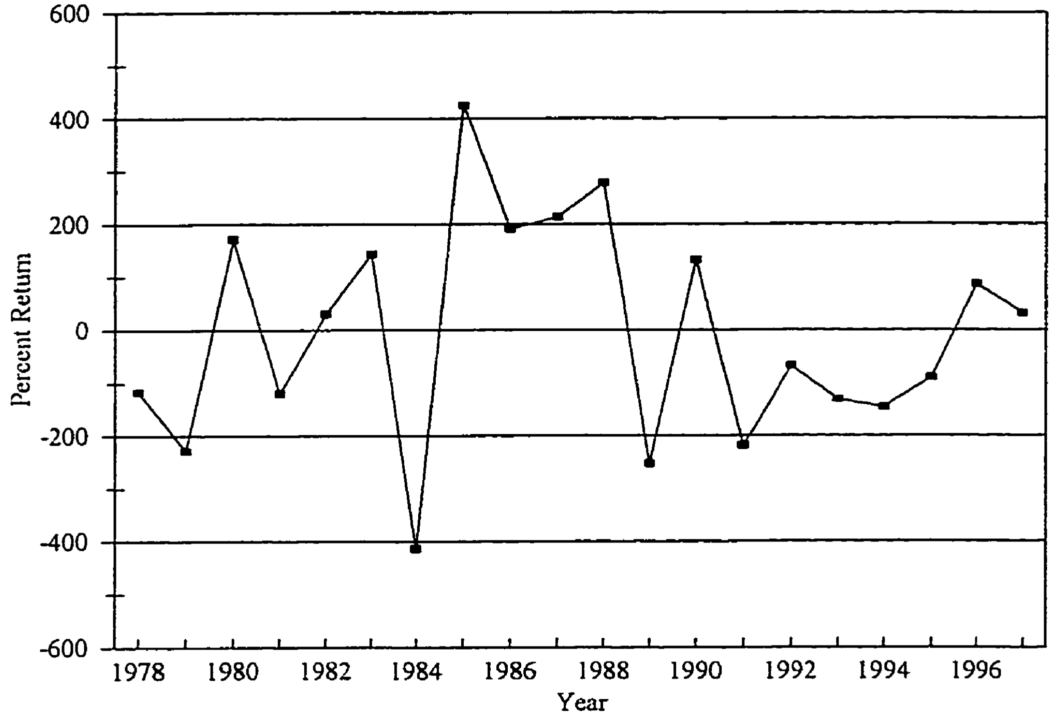


Figure C.14

Annual Percent Return for Soybean Meal

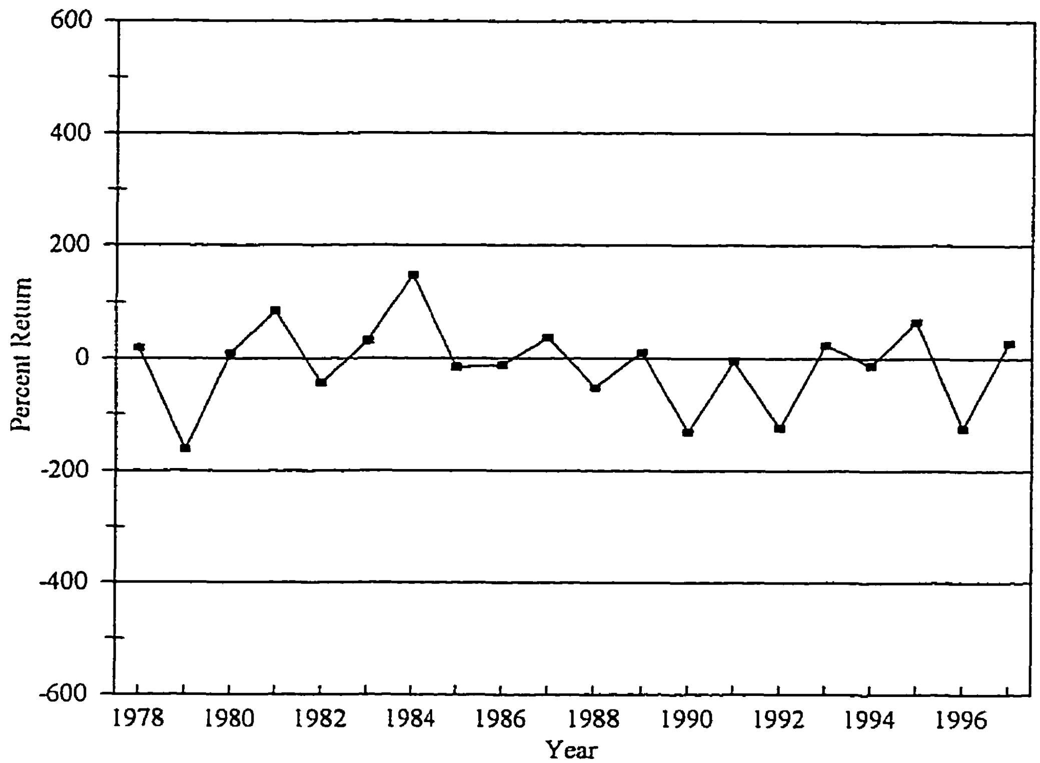


Figure C.15

Annual Percent Return for Soybeans

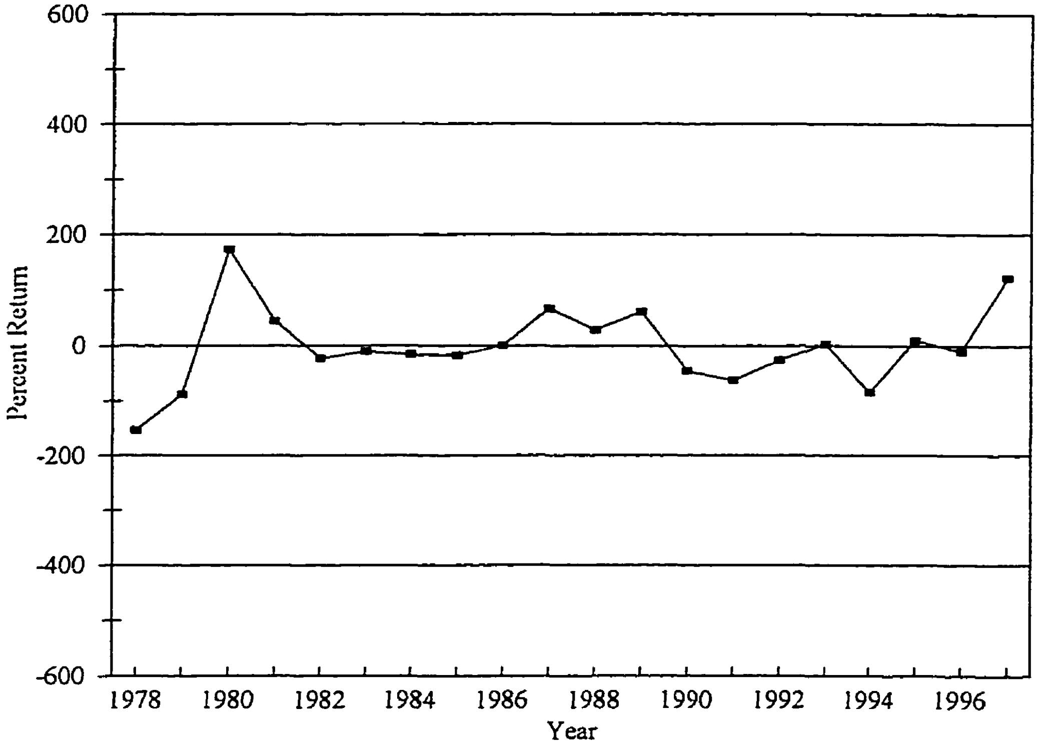


Figure C.16

Annual Percent Return for Sugar

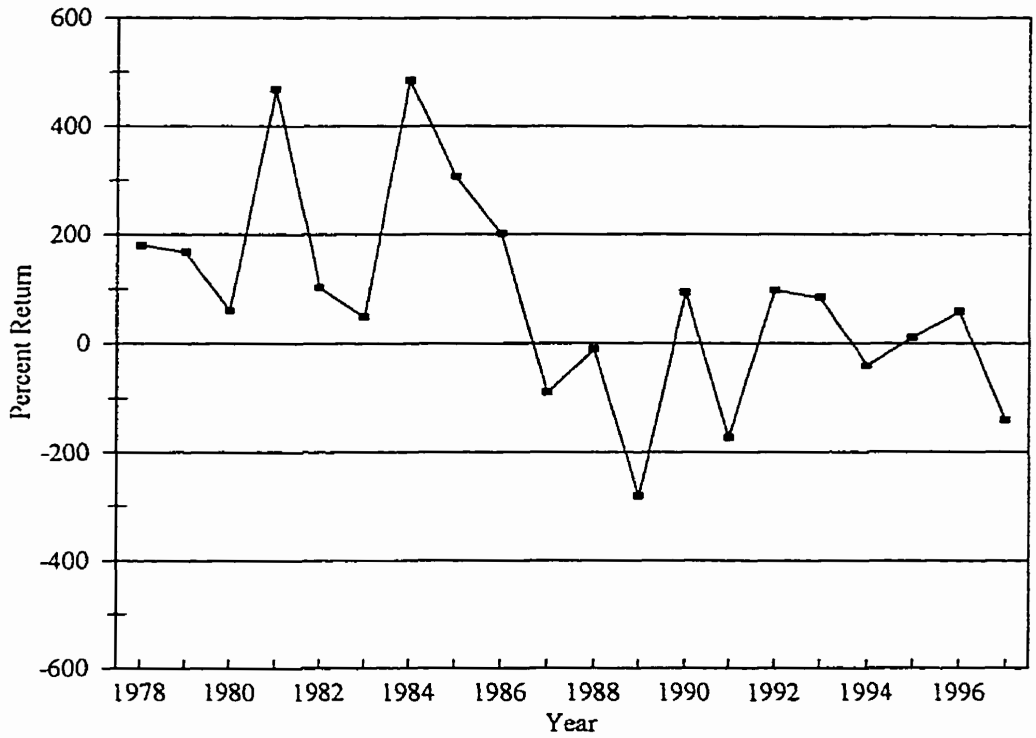


Figure C.17

Annual Percent Return for Swiss Franc

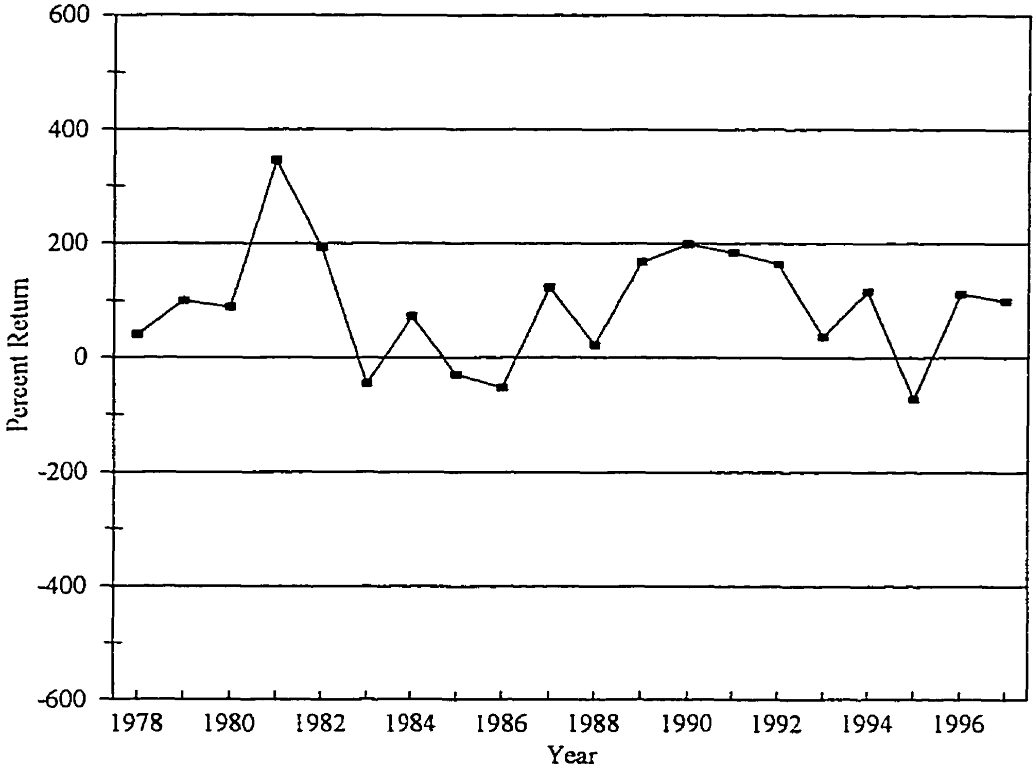


Figure C.18

Annual Percent Return for U.S. T-Bonds

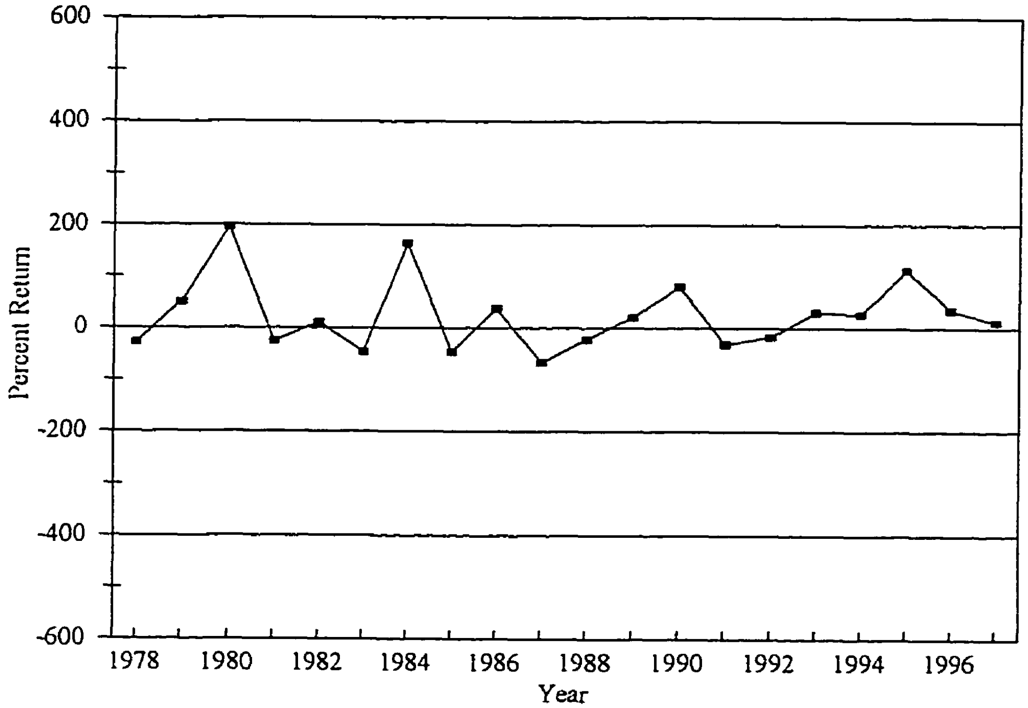


Figure C.19

Annual Percent Return for Wheat

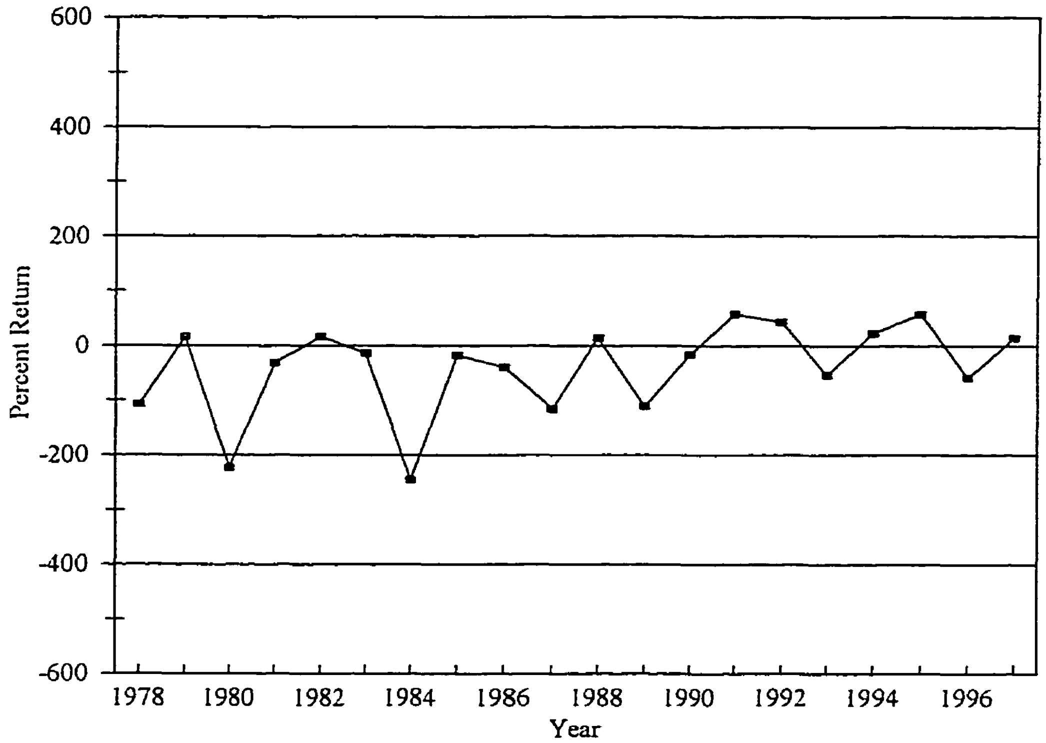
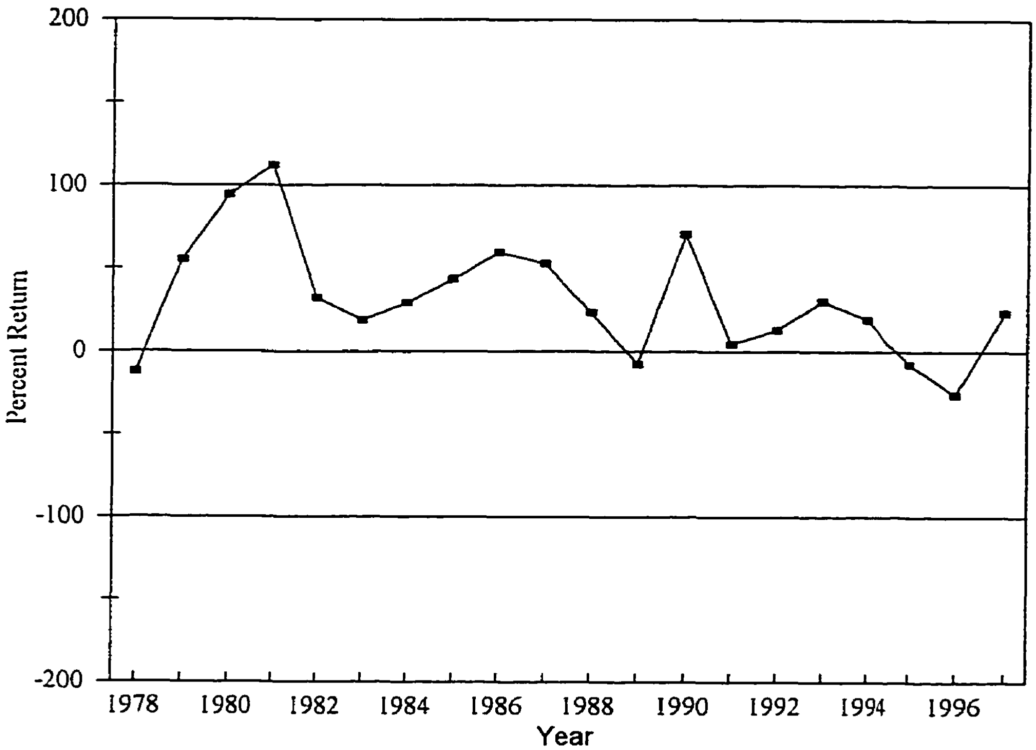


Figure C.20

Annual Percent Return for Commodity Portfolio



APPENDIX D

GARCH (1,1) Results Explaining Single Variable Factors Related to Returns

Table D.1

Monthly Econometric Results GARCH (1,1) Explaining Factors Related to Returns for Nineteen Commodities and Commodity Portfolio using System Trading, 1978-1997, Independent Variable: Time [a,b,c,d,e,f]

Dependent Variable	Independent Variable		
Mean Percent Return	Intercept	Time	R^2
British Pound	13.74 (2.70)*	-.09 (-2.60)*	0.01
Canadian Dollar	-.01 (-.01)	-.01 (-.36)	0.01
Coffee	11.68 (1.94)**	-.08 (-1.77)**	0.01
Corn	1.51 (.35)	-.01 (-.25)	0.01
Cotton	6.66 (1.69)**	-.02 (-.60)	0.01
Deutsche Mark	5.88 (1.06)	.01 (.22)	0.01
Gold	-1.95 (-.40)	.01 (.47)	0.01
Japanese Yen	6.67 (1.33)	-.01 (.34)	0.01
Live Cattle	-6.32 (-1.24)	.03 (1.06)	0.01
Live Hogs	-2.47 (-.47)	.01 (.29)	0.01
Orange Juice	-4.89 (-1.73)**	.05 (2.24)*	0.02
Swiss Franc	9.07 (1.53)	-.01 (-.25)	0.01
Silver	2.43 (.54)	-.02 (-.73)	0.03
Soybeans	-.24 (-.07)	.01 (.06)	0.01
Soybean Oil	-11.83 (-1.96)*	.05 (1.26)	0.01

Soybean Meal	-.29 (-.08)	-.01 (-.33)	0.01
Sugar	14.46 (2.16)*	-.09 (-2.12)*	0.02
T Bonds	3.39 (1.08)	-.01 (-.46)	0.01
Wheat	-8.51 (-2.82)*	.04 (1.60)**	0.01
Portfolio	4.21 (2.56)*	-.01 (-1.70)**	0.01

[a] T-Ratio appears in parenthesis.
[b] * indicates statistically significant coefficient at 5% level and ** indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then his return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH is a Generalized Autoregressive Conditional Heteroskedascity econometric model GARCH(1,1)

Table D.2

Monthly Econometric Results GARCH (1,1) Explaining Factors Related to Returns for Nineteen Commodities and Commodity Portfolio using System Trading, 1978-1997, Independent Variable: Inflation [a,b,c,d,e,f]

Dependent Variable	Independent Variable		
Mean Percent Return	Intercept	Inflation	R^2
British Pound	-.84 (-.20)	9.14 (1.15)	0.01
Canadian Dollar	-1.31 (-.75)	1.36 (.41)	0.01
Coffee	3.47 (.74)	-1.89 (-.21)	0.01
Corn	-.46 (-.14)	2.86 (.45)	0.01
Cotton	2.17 (.70)	5.92 (1.01)	0.01
Deutsche Mark	.45 (.11)	16.53 (2.04)*	0.02
Gold	-2.91 (-1.16)	12.13 (1.86)*	0.03
Japanese Yen	5.26 (1.33)	6.07 (.80)	0.01
Live Cattle	1.99 (.67)	-8.84 (-1.26)	0.01
Live Hogs	4.87 (1.23)	-15.60 (-2.06)	0.02
Orange Juice(OLS)	3.62 (1.62)**	-7.59 (-1.78)**	0.01
Swiss Franc	7.88 (.03)	9.13 (1.64)**	0.02
Silver	-1.95 (-.57)	-1.95 (-.63)	0.06
Soybeans	-.51 (-.20)	3.16 (.62)	0.01
Soybean Oil	1.48 (.32)	-15.55 (-1.75)**	0.01

Soybean Meal	-1.11 (-.40)	.08 (.01)	0.01
Sugar	-1.77 (-.42)	8.87 (1.00)	0.01
T Bonds	-.73 (-.31)	7.40 (1.64)**	0.01
Wheat	-2.41 (-.83)	-2.45 (-.44)	0.01
Portfolio	.08 (.07)	5.03 (2.11)*	0.01

[a] T-Ratio appears in parenthesis.
[b] * indicates statistically significant coefficient at 5% level and ** indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then his return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH is a Generalized Autoregressive Conditional Heteroskedascity econometric model GARCH(1,1)

Table D.3

Monthly Econometric Results GARCH (1,1) Explaining Factors Related to Returns for Nineteen Commodities and Commodity Portfolio using System Trading, 1978-1997, Independent Variable: Commodity Price Level [a,b,c,d,e,f]

Dependent Variable		Independent Variable	
Mean Percent Return	Intercept	Commodity Price Level	R^2
British Pound	-16.13 (-.92)	.11 (1.09)	0.01
Canadian Dollar	-.65 (-.40)	-.01 (-.01)	0.01
Coffee	-10.66 (-1.02)	.11 (1.37)	0.01
Corn	-5.73 (-.47)	.02 (.54)	0.01
Cotton	5.64 (.43)	-.01 (-.07)	0.01
Deutsche Mark	-1.55 (-.10)	.16 (.58)	0.01
Gold	.27 (.02)	.01 (.03)	0.01
Japanese Yen	3.96 (.47)	.06 (.47)	0.01
Live Cattle	-30.89 (-1.45)	.42 (1.39)	0.01
Live Hogs	10.07 (.62)	-.23 (-.70)	0.01
Orange Juice	-5.21 (-.80)	.05 (.92)	0.01
Swiss Franc	5.40 (.35)	.04 (.16)	0.01
Silver	-16.14 (-3.20)*	.03 (3.65)*	0.09
Soybeans	-15.51 (-1.26)	.03 (1.31)	0.01
Soybean Oil	31.51 (1.58)	-1.57 (-1.83)*	0.01

Soybean Meal	-2.95 (-.26)	.01 (.15)	0.01
Sugar	1.64 (.20)	-.06 (-.08)	0.01
T Bonds	7.39 (.80)	-.06 (-.62)	0.01
Wheat	4.16 (.38)	-.02 (-.68)	0.01

[a] T-Ratio appears in parenthesis.
[b] * indicates statistically significant coefficient at 5% level and ** indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then his return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted.
[f] GARCH is a Generalized Autoregressive Conditional Heteroskedascity econometric model GARCH(1.1)

Table D.4

Monthly Econometric Results GARCH (1,1) Explaining Factors Related to Returns for Nineteen Commodities and Commodity Portfolio using System Trading, 1978-1997, Independent Variable: Price Variation [a,b,c,d,e,f]

Dependent Variable	Independent Variable		
Mean Percent Return	Intercept	Price Variation	R^2
British Pound	4.57 (1.68)**	-9.25 (-2.85)*	0.05
Canadian Dollar	-.48 (-.44)	7.09 (2.37)*	0.02
Coffee	1.34 (.46)	3.57 (3.33)*	0.01
Corn	.49 (.23)	.95 (1.02)	0.01
Cotton	4.28 (2.16)*	-.99 (-1.85)**	0.01
Deutsche Mark	6.25 (2.29)*	8.45 (2.55)*	0.03
Gold	.34 (.22)	3.45 (2.80)*	0.05
Japanese Yen	6.75 (2.55)*	.53 (.18)	0.01
Live Cattle	-1.19 (-.64)	1.08 (.99)	0.01
Live Hogs	-1.42 (-.54)	.15 (.14)	0.01
Orange Juice (OLS)	.64 (.44)	.39 (.75)	0.01
Swiss Franc	7.78 (2.63)*	3.67 (1.15)	0.01
Silver	-.95 (-.46)	2.13 (1.97)*	0.05
Soybeans	.52 (.32)	1.06 (1.14)	0.01
Soybean Oil	-4.02 (-1.29)	3.88 (2.08)*	0.05

Soybean Meal	-.83 (-.46)	.70 (.68)	0.01
Sugar	1.14 (.41)	.78 (.67)	0.01
T Bonds	2.13 (1.38)	7.29 (3.54)*	0.05
Wheat	4.21 (2.56)*	-.02 (-1.70)**	0.01

[a] T-Ratio appears in parenthesis.
[b] * indicates statistically significant coefficient at 5% level and ** indicates significance at 10% level.
[c] Traded with Dual Moving Average Crossover System using 20 day and 50 day parameters.
[d] For example, a trader who invested $1000 would use $250 for the actual markets and would set aside $750 for margin calls. If the trader profited $100 from the futures market then his return would be 10% or $100/$1000.
[e] R^2 is defined as the squared correlation coefficient between observed and predicted..
[f] GARCH is a Generalized Autoregressive Conditional Heteroskedascity econometric model GARCH(1,1)