May 2011

Automated Foreign Exchange Trading System

Daniel Alex Sarafconn
Worcester Polytechnic Institute

Jaymin Rajen Mehta
Worcester Polytechnic Institute

Marcus David Menghini
Worcester Polytechnic Institute

Automated Foreign Exchange Trading System

An Interactive Qualifying Project Report

Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirement for the
Degree of Bachelor of Science

Submitted on
May 23, 2011

Submitted to:

Project Advisor: **Professor Michael J. Radzicki,** Social Science & Policy Studies, WPI

Submitted by:

Jaymin R. Mehta, Computer Science
Marcus D. Menghini, Robotics Engineering
Daniel A. Sarafconn, Robotics Engineering

Abstract

We sought to use the TradeStation trading platform to develop an automated strategy to trade in the foreign exchange, or currency markets. Meeting with our advisor, and conducting independent research, we evaluated various trading methods and strategies. We then developed indicators and strategies in EasyLanguage, TradeStation's proprietary programming language, testing and evaluating which methods were successful. Finally, we developed a strategy, which incorporated concepts from several models, that trades successfully in the forex market.

Authorship

The development of the automated foreign exchange trading strategy and the written report were created with equal contributions from Jaymin R. Mehta, Marcus D. Menghini, and Daniel A. Sarafconn.

Acknowledgements

We would like to thank our project advisor, Professor Michael J. Radzicki. We greatly appreciated his guidance and support throughout our project.

Table of Contents

Table of Figures

Executive Summary

The foreign exchange (forex) market is a financial market for trading currencies. Trades are made in currency pairs, such as United States dollar and the euro, in which equivalent amounts of money are exchanged. The forex market has several purposes. For instance, when a company in the United States needs products from a supplier in England, they need to exchange dollars to pounds to pay for their goods, and this is a forex transaction. In addition, hedge funds and investors may choose to trade in the forex market for profit, as speculators, as the values of currency pairs change.

The forex market is rapidly growing, and an important contributor to this is the retail investor– the individual speculator who trades currency pairs for profit, either as a full-time job or for supplementary income. Technology and computers play a key role in bringing these individuals to the forex market. For example, technological improvements drove transaction costs down, allowing the benefits of trading in the forex market to be realized.

We decided to scientifically approach the foreign exchange market, and to evaluate whether we could develop a strategy that could automatically trade in the market successfully and could outperform existing basic strategies. We wished to evaluate new potential opportunities for individual traders. Using the TradeStation trading platform, we developed strategies in EasyLanguage, TradeStation's proprietary programming language, to autonomously execute buy and sell orders in the forex spot market based on a set of trading rules.

After familiarizing ourselves with the forex market, TradeStation, and EasyLanguage, we looked at the different market types (trending, directionless, and volatile), and the basic strategies which are ideal for each type. After deciding to trade the Euro - United States dollar pair at fifteen minute bars, we began developing some strategies. We tested a Double Moving Average

Cross strategy, a Bollinger Band/ Keltner Channel counter-trending strategy, and a Commodity Channel Index (CCI) counter-trending strategy. These strategies have varying levels of success and are unstable over long periods of time. As a final strategy, we took the CCI counter-trending strategy, added trade volume, and turned it into a breakout strategy. This strategy works on the basis that if the currency is overbought with high volume, indicating high bullish support, there would likely be a bullish breakout. This strategy, incorporating several elements of our previous strategies, has the best performance.

With this strategy, retail investors in the forex market have a new tool they can use. As it is, this strategy exhibits great potential, and with some further tuning, it could yield even greater results. Furthermore, we showed that retail investors in the forex market can greatly benefit by taking a scientific approach to trading through the development of carefully formulated and thoroughly tested strategies.

1. Introduction

The purpose of this project is to scientifically approach the foreign exchange market, and to evaluate whether we can develop a strategy that can automatically trade in the market successfully, and can outperform existing basic strategies. As the forex market and the number of individual retail investors grows, a new, successful strategy is valuable to those seeking financial prosperity by trading currencies.

Our approach was to first understand the various overall market conditions- trending, directionless, and volatile. This is crucial, since different trading strategies prove appropriate for differing market conditions. After determining the type of market, we tested basic strategies and examined their performance. After optimizing these systems, we discovered the best approach would be to develop our own system, incorporating the most successful features from several strategies, and come up with a strategy that greatly outperformed the basic ones we had tested.

2. Background

2.1 The Foreign Exchange Market (forex)

The forex market is a financial market for trading currencies. Trades are made in currency pairs, such as the United States dollar (USD) and the euro (EUR), in which equivalent amounts of money are exchanged. The forex market has several purposes. For instance, when a company in the United States needs products from a supplier in England, they need to exchange United States dollars and pounds sterling to pay for their goods; this is a forex transaction. In addition, hedge funds and investors may choose to trade in the forex market as speculators, and for profit, as the values of currency pairs change.

There are three types of forex markets- spot, future, and forward. The spot market is where the currencies trade at the current price, which supply and demand dictates. The future and forward markets do not directly trade currencies, but instead contractual claims to a certain currency type, for a certain value per unit, and a settlement date. In the futures market, the contracts are based on a standard size and settlement date on commodities markets, such as the Chicago Mercantile Exchange. The contracts have specific details such as minimum price increments that cannot be customized. The exchange is a counterparty to the trader, providing clearance and settlement. In the forwards market, contracts are bought and sold between two parties, who determine the terms themselves, instead of the exchanges.[1] For our project, we will be using the spot market for our trading and research.

There are four forex markets located in New York, NY, USA; London, England; Sydney, Australia; and Tokyo, Japan. These markets are each open for nine hours each day with overlaps between London and New York, New York and Sydney, Sydney and Tokyo, and Tokyo and London.[2] The most commonly traded currencies are the United States dollar (USD), the euro (EUR), the Japanese yen (JPY), the pound sterling (GBP) and the Swiss franc (CHF).[3]

The forex market is rapidly growing; daily turnover reached $4 trillion in April 2010, a 20% increase from 2007. Several important and related factors contribute to this growth. In the 1990's, retail investors, such as an individual amateur trader, placed a trade by calling a broker. With minimal competition within the brokers, customers suffered by paying a high spread. This certainly turned away casual traders from the forex market. When multi-bank electronic trading systems arrived in the late 1990's, they displayed competing quotes, increasing the competition amongst the brokers. The electronic infrastructure went through several further iterations;

[1] (Investopedia, 2010)
[2] (Forex Market Hours, 2006-2011)
[3] (TradeStation, Getting Started With Forex Trading: A Forex Primer, 2002-2007)

however, with the advent of this revolutionary technology, transaction costs were reduced, there was greater transparency in the market, and the barrier of entry to retail investors was lowered. Once this occurred, the other of advantages of forex could be realized. With 24 hour markets, and in the United States, up to 50:1 leverage options, forex offers much flexibility to retail investors. Retail investors now account for 8-10% of spot forex turnover, around $125-$150 billion.[4]

Retail investors account for a significant share in the spot forex market, and this can be attributed to technological advancements in trading infrastructure. However, technology also plays a major role in the trading itself, as these investors attempt to develop strategies for successful trading.

Individual traders seek new strategies or new optimizations for their current strategies. A strategy is a set of rules that a trader follows in order to make his trades. A strategy can refer to more than just a rule set; it can also be an automated process that trades, following the rules in the rule set. An important note is that due to the dynamic nature of the foreign exchange market, any static strategy is only profitable for some time. Even strategies that readjust themselves periodically, based upon past market data, may have periods of time with poor results. Market conditions may change again, and such strategies could once again be profitable. Using tools provided by TradeStation, traders can quickly formulate or adjust strategies, and see how profitable they would have been in previous time periods. A strategy will operate on a specific time frame, given in the unit of bars. If a system operates on fifteen minute bars, for example, this means that each bar in the graph represents fifteen minutes of trades, as seen in Figure 1.

[4] (King & Mallo, 2010)

Figure 1: An example of a candlestick graph, showing fifteen minute bars

Every trader must adapt and create new strategies, or revise old strategies, if they wish to continue making profits. This is necessary as strategies only work when the market is experiencing the economic conditions for which the strategy was designed. Strategies can fall in and out of profitability as the market experiences various phases.

2.2 TradeStation Platform and Features

The TradeStation platform is a desktop program that allows traders to access market data and to make orders in the equities, options, futures, and forex markets. In addition, a trader can create and test indicators and strategies to help with, or automatically make trades. Another feature of TradeStation is access to simulated accounts to test strategies on virtual money. A vast amount of historical data is available for use by the trader on which to test their systems. This, as well as other tools provided by TradeStation, allows the user to be confident in their system's likelihood of success before risking any money.

2.2.1 Back-testing

Using the historical data provided by TradeStation, a trader can evaluate their system. This is called back-testing; it is an important part of strategy development as users can assess the profitability of their strategy on real market data.

2.2.2 Optimization

Another useful tool is the optimization ability. This allows the user to improve the performance of a strategy by adjusting and finding the best input values to the strategy, based on the strategy's performance on historical market data. The optimization tool can perform an exhaustive optimization to test every possible value within a specified range for each variable. However, if this would result in too many tests to perform within a reasonable time period, a genetic algorithm can find optimal, but not necessarily the absolute best, values in less time.

2.2.3 Walk Forward Cluster Analysis

The TradeStation platform now has the ability to do a walk forward cluster analysis. This simplifies the process of optimizing a system over long periods of time. This is done by first performing a standard optimization as described in the previous section, then using data collected during that optimization, to perform a walk forward optimization (WFO). The WFO is configured to have a certain time range for in-sample (INS) testing and for out-of-sample (OOS) testing. The WFO then runs a series of tests in which it optimizes over the INS and then checks results on the OOS for each INS and OOS period in the specified range. The end result determines how often the system should be re-optimized and how much past data should be used. Using the WFO helps users create systems that are more stable over long periods of time.

2.2.4 EasyLanguage

EasyLanguage is the programming language that traders use to create indicators, functions, and strategies for the TradeStation platform. EasyLanguage is a simple programming language designed to be accommodating to users with little to no prior programming experience. For example, the phrase "Buy next bar at market" is a valid EasyLanguage statement that translates to buying a given currency at the market price. EasyLanguage syntax and keywords

are intuitive and easy to learn, simplifying the process of coding new strategies and indicators or to modifying existing ones.

2.3 Market Types and Strategies

Our deliverable is a trading strategy, which is the set of rules that determine when to enter and exit the market. The components of a trading strategy include a set-up, an entry, money management stops, and exits. The set-up indicates that the market has become favorable. After the set-up conditions are satisfied, the entry conditions must be satisfied, indicating that the market is continuing to move in the favorable direction, and a buy order is executed. Once the set-up and entry conditions have been satisfied, and you are in the market, the money management stop conditions and the exit conditions determine when to exit. The money management stop condition indicates that the market is not moving as expected, and exits before incurring too much loss. The exit condition indicates that the market moved as expected, and it is now time to exit. The set-up and entry work together to get you into the market, and the exits and money management stops decide when to get you out.[5]

Prior to developing the trading strategy, however, it is important to recognize some basic information of the market, to develop the appropriate strategy. According to Charlie Wright, there are generally three types of markets: trending, directionless, and volatile.[6] Once you can recognize the market type, then you can evaluate which type of strategy to develop.

[5] (Wright, 1998)
[6] (Wright, 1998)

2.3.1 Trending

A trending market is categorized by large sustained increases or decreases.[7] In an increasing trend, the market will reach higher highs and lower lows, and in a decreasing trend, the market will reach lower lows and lower highs. Below is an example of a stock that is generally upward trending.

[8]

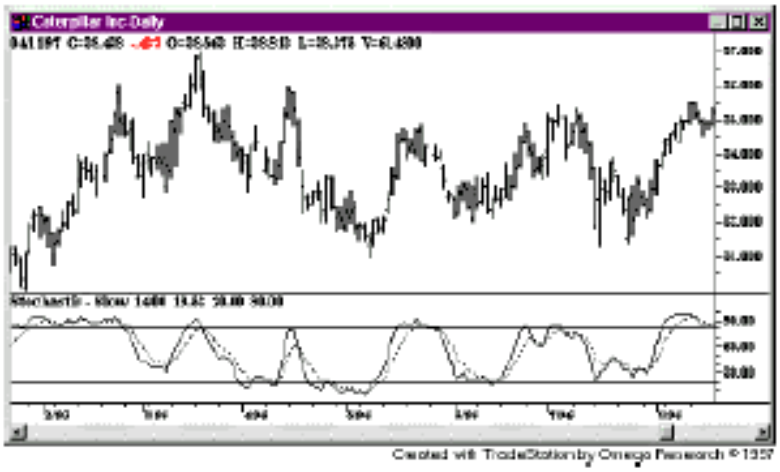
Figure 2: Trending Market with Moving Averages

The ideal strategies to trade in this market condition are trend following strategies. Trend following strategies profit off of large movements in the market; therefore, it is crucial to always stay in the market, to avoid missing these movements. It is just as important to minimize losses while we wait. A basic strategy that is trend following is using two moving averages, one that is calculated over a longer time, and one over a shorter time. When they cross over, the strategy will place a buy order, and when they cross over again, the strategy will sell. With this strategy however, most of the trades may be unsuccessful, as we wait for the major successful trades.[9] An example of this is above, where you can see the two moving averages, and where they intersect.

[7] (Wright, 1998)
[8] (Wright, 1998)
[9] (Wright, 1998)

2.3.2 Directionless

A directionless market is characterized by smaller, insignificant up and down movements in price, with the general movement sideways.[10] Below is an example of a directionless market, with no apparent trend.



[11]

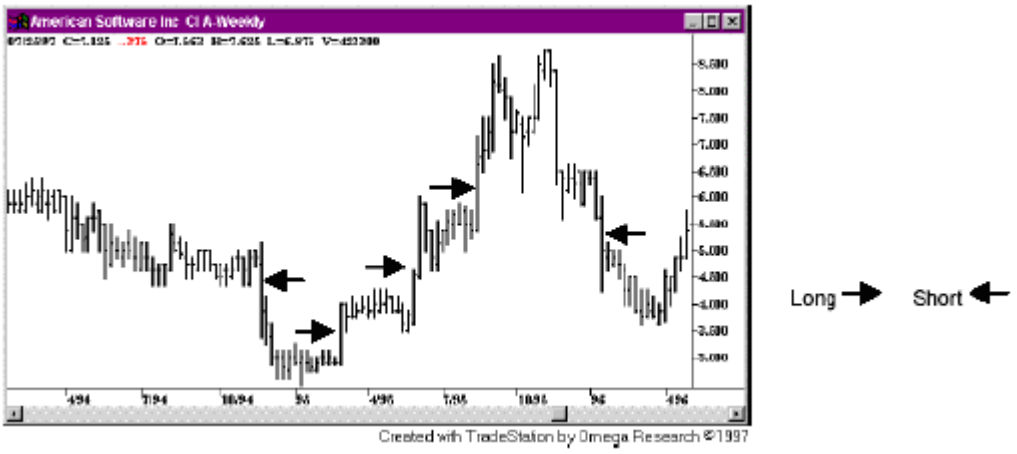
Figure 3: Directionless Market

Support and Resistance strategies are strategies for directionless markets. These strategies work on the principle of buying low and selling high, and they do this by counter-trending. Therefore, during a downward trend, the strategy will buy at the lowest point. When the trend is upward, the strategy will sell at the highest peak. The stochastic indicator in TradeStation (as shown in the bottom half of the image above) is an overbought/oversold indicator. A Support and Resistance strategy would set certain stochastic threshold values for overbought and oversold, then buy when it reaches the oversold limit, and sell when it reaches the overbought limit.[12] However, in the long run, this strategy may not be profitable, and should be considered along with other complementary strategies.[13]

[10] (Wright, 1998)
[11] (Wright, 1998)
[12] (Wright, 1998)
[13] (Wright, 1998)

2.3.3 Volatile

Sharp jumps in price indicate a volatile market.[14] Below, you can see the sharp increase and decrease jumps.



[15]

Figure 4: Volatile Market

A Volatility Expansion strategy is appropriate for this market condition. A Volatility Expansion strategy can work by measuring volatility, and buying during an immediate increase, and selling during an immediate decrease.[16] The points at which this strategy trades are shown above. This strategy would be out of the market for most of the time. There will be a higher percentage of winning trades; however, the net profit from each trade will be small.[17]

[14] (Wright, 1998)
[15] (Wright, 1998)
[16] (Wright, 1998)
[17] (Wright, 1998)

2.4 Indicators

2.4.1 Simple Moving Average

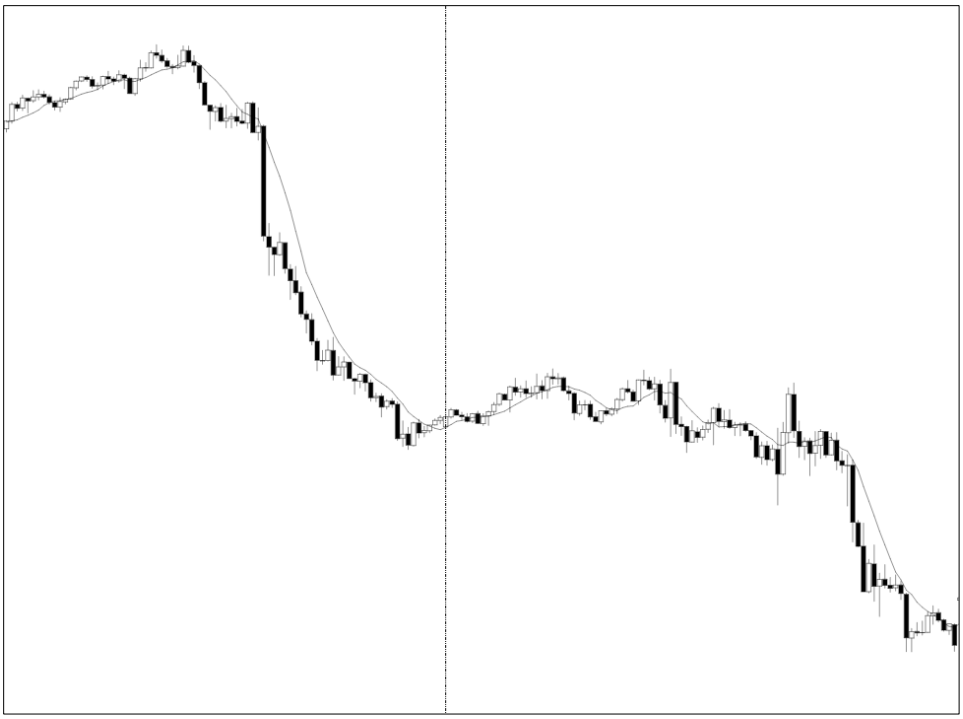


Figure 5: Simple Moving Average

The first indicator we looked at was the simple moving average (SMA). This is one of the most basic indicators available. This indicator calculates the average price at each bar over the specified length of previous bars. The SMA offers an indication of where the market is heading. If the market veers away from the SMA, it is likely to either return to the average or breakout. Additional analysis techniques are necessary to help determine which of these options the market is likely to take.

2.4.2 Bollinger Bands

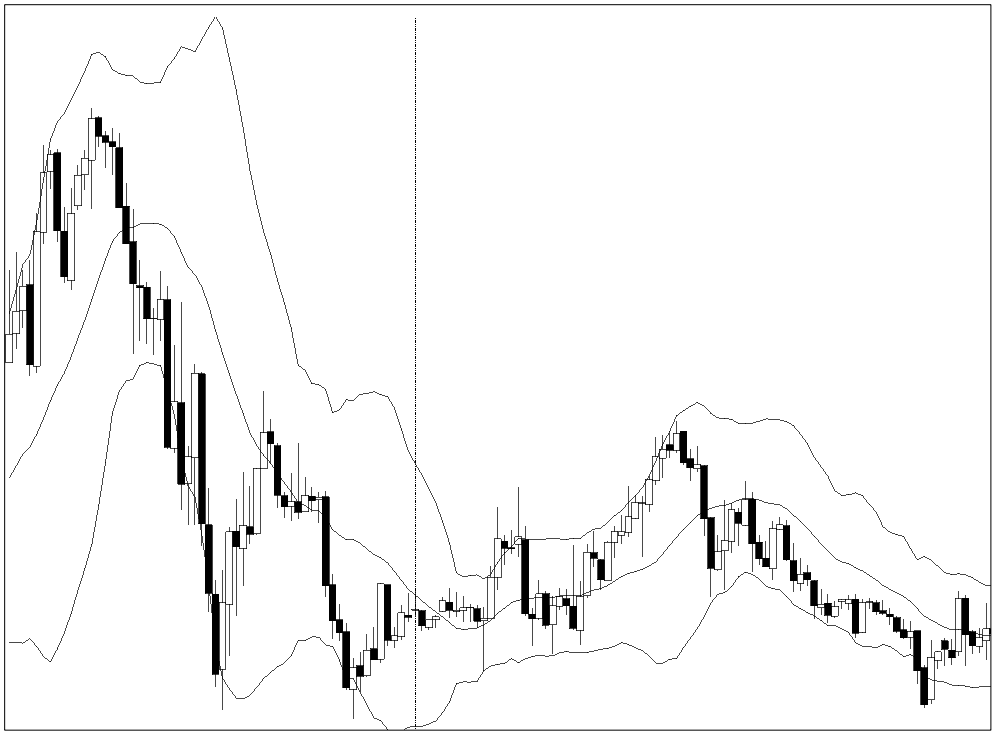


Figure 6: Bollinger Bands

Bollinger Bands are an analysis technique created by John Bollinger in the 1980s. This technique calculates a simple arithmetic average over a specified length, and then it creates an upper band two standard deviations above the average and a lower band two standard deviations below the average. Bollinger Bands are intended to provide a relative definition of high and low. Prices near the upper band are considered high and prices near the lower band are considered low. In this way, Bollinger bands can be used for pattern recognition. Bollinger bands can be used in conjunction with other indicators, such as momentum, volume, volatility, trend, and market strength, to make buy and sell decisions. Prices tend to walk up the upper band and down the lower band.[18]

[18] (Bollinger Bands, 2009)

2.4.3 Keltner Channel

Figure 7: Keltner Channel

A Keltner channel is an analysis technique created by Chester W. Keltner in 1960.[19] Similar to the Bollinger Band, the Keltner channel calculates a central moving average line with channel lines a certain distance above and below. The central moving average line is determined by calculating a simple moving average of typical price. The upper and lower channel lines are then drawn at a distance above and below the central line, which is the ten day simple moving average of the trading range (high – low). Theoretically, prices are likely to stay within the channel.[20]

[19] (Keltner, 1960)
[20] (Kaufman, 1987)

2.4.4 Commodity Channel Index

Figure 8: CCI Average

The commodity channel index (CCI) is an oscillator invented by Donald Lambert in 1980. It was originally intended for use in commodities trading, but can also be applied to equities and currencies. It is often used to determine if a security is overbought or oversold. The CCI quantifies the relationship between the asset's price, a moving average of the asset's price, and normal deviations from that average. The CCI is calculated by the following formula:

$$CCI = \frac{Price\ - Average}{0.015 \times Deviations}$$

When used in conjunction with other oscillators, the CCI can be used to identify potential peaks and valleys in the asset's price, and thereby provide insight into changes in the direction of price movement of an asset.[21]

[21] (Commodity Channel Index - CCI, 2011)

2.4.5 Volume Oscillator

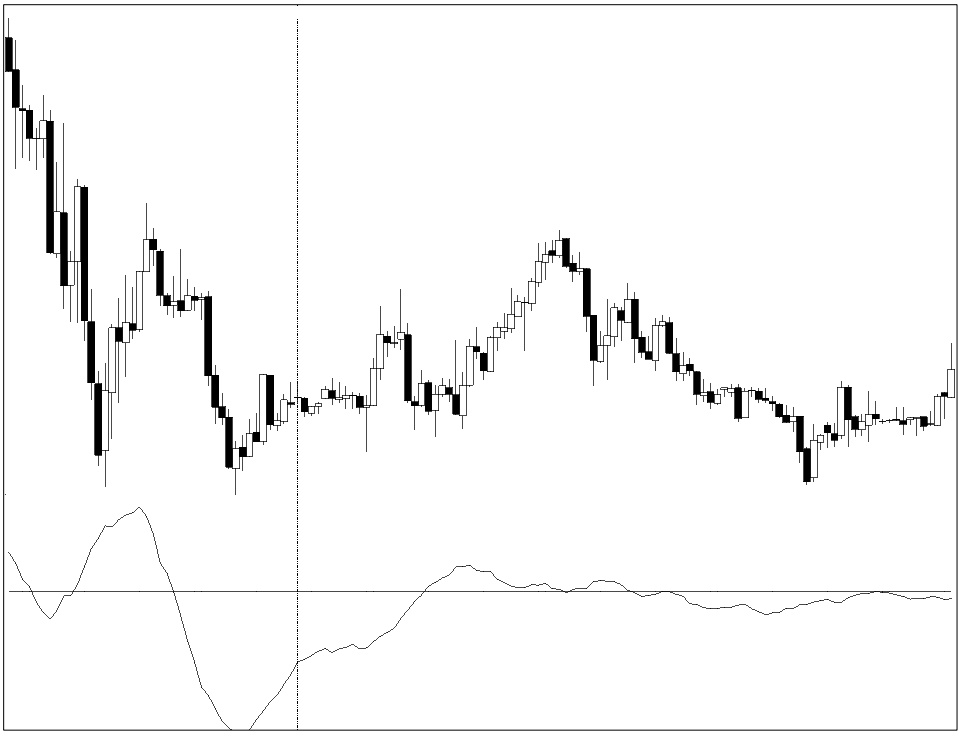


Figure 9: Volume Oscillator

The volume oscillator is an indicator used to determine support for a trend based on trade volume. In the forex market, volume is based on tick count. The volume oscillator calculates the difference between fast and slow moving averages of volume. This value fluctuates above and below a zero line with high values indicating high support for a trend and low values indicating low support for a trend.[22]

[22] (TradeStation, Volume Osc (Indicator), 2001-2011)

2.4.6 Volume Ratio

Figure 10: Volume Ratio

The volume ratio indicator is another method of determining support for a trend based on volume. The volume ratio is determined by calculating the exponential moving average of the ratio between up and down volume. Like the volume oscillator, this indicator fluctuates above and below a zero line with high values indicating support for a trend and low values indicating lack of support for a trend.[23]

3. Procedure

We used TradeStation's Chart Analysis, Trade Manager, EasyLanguage Development Environment, Strategy Optimizer, and Walk Forward Optimizer to formulate and test automated trading strategies. We started by familiarizing ourselves with the forex market and with the

[23] (TradeStation, Volume Ratio (Indicator), 2001-2011)

process of automated trading. In our exploration of the forex market, we followed the evolution of a trader from discretionary, to technical, and to strategy-based as described by Charlie Wright in his book, Trading as a Business. We began as discretionary traders, basing our decisions on intuition and non-quantifiable data. Once we became more familiar with the forex market and the TradeStation platform, we became technical traders, basing our decisions on technical indicators and objective trading rules. Finally, after becoming familiar with the technical aspects of trading, we began using strategy-based trading, in which our trades were based on objective entry and exit criteria validated on historical, quantifiable data. [24]

3.1 Currencies

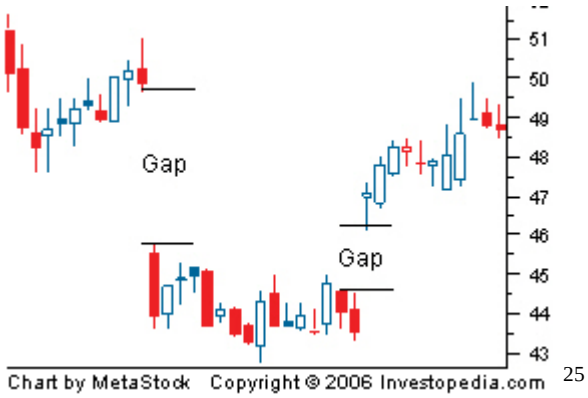
We decided to use commonly traded currency pairs in our trading systems. All of our tests used United States dollars (USD) versus Japanese yen (JPY) or one of the commonly traded European currencies: euros (EUR), pounds sterling (GBP) or Swiss francs (CHF). Ultimately, we decided to use a single currency pair for testing our strategies. Accordingly, our tests and results displayed are all using the Euro-Dollar (EURUSD) currency pair.

3.2 Trading Strategies

As strategy-based traders, we used technical indicators to develop automated trading strategies. We then tested the performance of these strategies on historical data provided by TradeStation. We used TradeStation's optimization tools to improve the performance of the strategies. We will highlight three trading strategies, which we developed and evaluated, and used as a foundation for our final strategy. All strategies use only long positions. Since the forex market is open 24 hours a day, there is minimal gapping, which is a sharp change in price with no trading occurring in between and commonly happens between the close of one day and the

[24] (Wright, 1998)

open of the next (seen below in Figure 11). Therefore, we run our systems 24 hours a day, with overnight trades and trades lasting longer than one day.



[25]

Figure 11: Gapping

3.2.1 Double Moving Average Cross

The first strategy we examined is a double moving average cross strategy. We used two moving averages with different lengths, one moving average with a short length and the other with a long length. The short length moving average uses fewer bars to calculate the moving average than the long length moving average. When the short moving average crosses the long moving average, it generates a signal to enter the market in the direction of the cross. If the short moving average crosses upwards, it indicates a buy signal and conversely, if it crosses downwards, it indicates a sell signal.

3.2.2 Bollinger Band/ Keltner Channel Counter-Trend

For the next attempt, we developed a Support and Resistance based counter-trending strategy using Bollinger Bands and Keltner Channels. Based on our observations, we decided to use the upper Bollinger Band and the lower band of the Keltner channel because prices appeared to follow the upper Bollinger Band more closely on upwards trends, and follow the lower band of the Keltner channel better on downwards trends. This strategy generates sell signals if the

[25] (Investopedia, 2011)

price crosses above the upper band and buy signals if the price crosses below the lower band. We also added a damage control condition to close an open long position if the price crosses under the middle line.

3.2.3 CCI Counter-Trend

Our next attempt is a counter-trending strategy based on the Commodity Channel Index Average (CCI). Buy signals are generated if the currency becomes oversold and sell signals are generated if the currency becomes overbought.

3.2.4 CCI and Trade Volume Breakout

Our final trading strategy is a breakout system based on the CCI average and trade volume. The CCI average determines if the currency is overbought or oversold, then the volume oscillator and volume ratio indicators determine if these price movements were breakouts based on the level of support for the price movement. If the currency is overbought and there are positive values on both volume indicators, then an upwards breakout is indicated, and a buy signal is generated. The exit conditions are based on two possible situations. First, if the currency is overbought with low support, indicated by the volume indicators, the price is not likely to continue to rise, so a sell signal is generated. Second, if the currency becomes oversold with high support, indicated by the volume indicators, the currency is likely to breakout downwards, so a sell signal is generated.

4. Results

We used TradeStation's back-testing features to test the strategies. The strategies were optimized over an in-sample (INS) period of two months, and then tested on an out-of-sample

(OOS) period, which is the following month. This provides reasonably accurate results which account for realistic optimization of the strategies without curve fitting to the OOS data.

Expected value, expectancy, expectunity, and system quality were calculated for each system and can be seen below in Figure 12. Expectancy is the sum of the profit/ loss of each trade divided by the amount risked on each trade.[26] This value is known as the R multiple of the trade. Expectunity takes the number of trading opportunities provided by a trading system into account. It is calculated by multiplying the expectancy of a system by the number of trading opportunities. System quality is calculated by dividing the expectunity by the standard deviation of the R multiples.

	CCI & Volume	Simple CCI	Bollinger/ Keltner	DMAC
Expected Value	151.05	140.17	55.93	9.94
Expectancy	60.42	11.24	22.37	3.98
Expectunity	8988.55	2889.80	2841.32	3217.60
System Quality	26.41	9.13	15.47	21.14

Figure 12: Analysis of Trading Strategies

4.1 Double Moving Average Cross (DMAC)

Total Net Profit	$4,056.90
Gross Profit	$9,830.30
Gross Loss	($5,773.40)
Profit Factor	1.7
Total Number of Trades	86
Percent Profitable	54.65%
Winning Trades	47
Losing Trades	39

Figure 13: DMAC Strategy Performance Report

This is a simple strategy with relatively poor results compared to later attempts at trading strategies. As seen in Figure 12, the DMAC strategy has relatively good values for expectunity and system quality, but it has the worst values of all the strategies in expected value and

[26] (Cagigas, 2009)

expectancy. While the total net profit is encouraging, the system makes a high volume of poor trades.

4.2 Bollinger Band/ Keltner Channel Counter-Trend

Total Net Profit	$1,872.00
Gross Profit	$4,129.00
Gross Loss	($2,257.00)
Profit Factor	1.83
Total Number of Trades	18
Percent Profitable	66.67%
Winning Trades	12
Losing Trades	6

Figure 14: Bollinger/ Keltner Strategy Performance Report

This strategy performs better than the double moving average cross strategy (higher profit factor and higher percentage profitable trades) but still makes many losing trades. As seen in Figure 12, this strategy has mediocre expected value, expectunity, and system quality. Its expectancy is the second highest of the strategies tested, but is still only one third of the expectancy of the best strategy.

4.3 CCI Counter-Trend

Total Net Profit	$2,330.00
Gross Profit	$5,096.00
Gross Loss	($2,766.00)
Profit Factor	1.84
Total Number of Trades	22
Percent Profitable	54.55%
Winning Trades	12
Losing Trades	10

Figure 15: CCI Counter-Trend Strategy Performance Report

This strategy performs well given its simplicity. As seen in Figure 12, this strategy has a high expected value, mediocre expectancy and expectunity, and low system quality. The low

system quality comes from a large standard deviation in the R multiples, which indicates a large amount of variability in the profitability of trades. While testing, we found the performance of this strategy to be quite variable. Some weeks net very large profits, while others have very low profits or even result in losses. It is this variable nature that makes the CCI Counter-Trend by itself an unreliable system. However, we were certain that by modifying the entry and exit triggers, we could increase the reliability of the system allowing for more predictable behavior.

4.4 CCI & Volume Breakout

Total Net Profit	$3,176.00
Gross Profit	$4,677.00
Gross Loss	($1,501.00)
Profit Factor	3.12
Total Number of Trades	11
Percent Profitable	72.73%
Winning Trades	8
Losing Trades	3

Figure 16: CCI & Volume Strategy Performance Report

This strategy performs very well. As seen in Figure 12, this strategy has the highest values in all four analyses indicating that this strategy is the most likely to perform well. Tests show consistently high profit factors of around 3, and approximately 75% profitable trades. As predicted, modified entry and exit triggers increase the reliability of the system. The average profit factor is no longer exceedingly high on various weeks, but the losses are minimized, and through further optimization, this strategy can yield even better performance.

5. Conclusions

With $4 trillion USD in daily turnover, and significant activity from retail investors, the forex market presents exciting opportunities. Using a scientific approach we examined trading

strategies and attempted to develop an automated strategy that could trade successfully and with greater results than existing basic strategies.

We began by researching the various market types (trending, directionless, volatile), and the basic strategies that are well suited to those types. After evaluating the market, we concluded that the market is directionless. Nevertheless, we decided to attempt a simple double moving average as a baseline. Monitoring its performance, we determined that it could occasionally perform well, but could also incur major losses. Next, we decided to look at counter-trending techniques; therefore, we developed a hybrid Keltner Channel/ Bollinger Band strategy that performs reasonably well. This strategy is overcomplicated and despite its highly technical nature does not have a strong scientific basis for success.

Our next step was a commodity channel index counter-trending strategy, which performs well, but had flaws. Finding the commodity channel index promising, we decided to modify it, and develop our final strategy, the commodity channel index and volume breakout strategy. The CCI is a good indicator for overbought/oversold, so by incorporating volume, we were able to make reasonable estimates about whether a trend would continue or not thus giving us the ability to predict breakouts fairly successfully. Volume is a good indicator of support of a trend in the direction the market is moving. Therefore, if CCI indicates that the currency is overbought and there is high level of support we can capitalize on a bullish breakout. Given the results, this strategy is the best performer.

In the future, we can look at thoroughly developing this system with the inclusion of short positions, and improving our entry and exit strategies. By utilizing stop and limit orders instead of market orders for our entries and exits, we can potentially increase gross profits and

decrease gross losses. In addition, it will be crucial to run this strategy over an extended period of real-time data to further evaluate actual performance.

As a scientific project, we took the strategic approach to trading, with research and extensive testing. As individual retail investors flock to the forex market, a scientific approach to trading could prove to be a successful method of developing trading strategies.

References

Bollinger Bands. (2009, Aug 25). *International Business Times* .

Cagigas, O. G. (2009). Winning Percentage of a Trading System. *Technical Analysis of Stocks and Commodities* .

Commodity Channel Index - CCI. (2011). Retrieved April 30, 2011, from Investopedia: http://www.investopedia.com/terms/c/commoditychannelindex.asp

Forex Market Hours. (2006-2011). Retrieved April 30, 2011, from Forex Market Hours: http://www.forexmarkethours.com/

Investopedia. (2010). *Forex Tutorial: What is Forex Trading?* Retrieved April 30, 2011, from Investopedia: http://www.investopedia.com/university/forexmarket/forex1.asp

Investopedia. [Image of Gapping]. (2011). *Gap Definition*. Retrieved May 22, 2011, from http://www.investopedia.com/terms/g/gap.asp

Kaufman, P. J. (1987). *The New Commodity Trading Systems and Methods.* New York: Wiley.

Keltner, C. W. (1960). *How to Make Money in Commodities.* Kansas City, MO: Keltner Statistical Service.

King, M. R., & Mallo, C. (2010, Dec). *A user's guide to the Triennial Central Bank Survey of foreign exchange market activity.* Retrieved April 30, 2011, from Bank for Internatinoal Settlements: http://www.bis.org/publ/qtrpdf/r_qt1012h.pdf

TradeStation. (2002-2007). *Getting Started With Forex Trading: A Forex Primer.* Retrieved April 30, 2011, from TradeStation: https://www.tradestation.com/support/books/pdf/introduction_to_forex_trading.pdf

TradeStation. (2001-2011). Volume Osc (Indicator). *TradeStation Platform Help* .

TradeStation. (2001-2011). Volume Ratio (Indicator). *TradeStation Platform Help* .

Wright, C. F. (1998). *Trading as a Business.* Mequon, WI: Charlie F. Wright.

Wright, C. F. [Image of Directionless Market]. (1998). *Trading as a Business.* Mequon, WI: Charlie F. Wright. 22.

Wright, C. F. [Image of Trending Market with Moving Averages]. (1998). *Trading as a Business.* Mequon, WI: Charlie F. Wright. 21.

Wright, C. F. [Image of Volatile Market]. (1998). *Trading as a Business.* Mequon, WI: Charlie F. Wright. 23.

Appendix A: DMAC Strategy Code

```
inputs: Price( Close ), FastLength( 9 ), SlowLength( 18 ) ;
variables: FastAvg( 0 ), SlowAvg( 0 ) ;

FastAvg = AverageFC( Price, FastLength ) ;
SlowAvg = AverageFC( Price, SlowLength ) ;

if FastAvg crosses over SlowAvg then
     Buy ( "DMAC LE" ) next bar at market ;

if FastAvg crosses under SlowAvg then
     Sell ( "DMAC Exit" ) next bar at market ;
```

Appendix B: Bollinger/ Keltner Counter-Trend Strategy Code

```
inputs:
     Price( Close ),
     LowPrice( Low ),
     HighPrice( High ),
     TestPriceUBand( Close ),
     TestPriceLBand( Close ),
     Length( 20 ),
     NumDevsUp( 2 ),
     NumDevsDn( -2 ),
     NumATRs( 1.5 ),
     PercentLoss( 0.9 ),
     Displace( 0 ) ;

variables:
     Avg( 0 ),
     SDev( 0 ),
     LowerBBand( 0 ),
     UpperBBand( 0 ) ,
     Shift( 0 ),
     LowerKBand( 0 ),
     UpperKBand( 0 ),
     Mom( 0 ),
     Flag( 0 ),
     EntryPt( 0 ),
     BuyPrice( 0 ) ;

Avg = AverageFC( Price, Length ) ;
// Bollinger
SDev = StandardDev( Price, Length, 1 ) ;
UpperBBand = Avg + NumDevsUp * SDev ;
LowerBBand = Avg + NumDevsDn * SDev ;
// Keltner
Shift = NumATRs * AvgTrueRange( Length ) ;
UpperKBand = Avg + Shift ;
LowerKBand = Avg - Shift ;

Condition1 = Price crosses over LowerKBand ;
Condition2 = Price crosses under UpperBBand;
Condition3 = Price crosses under Avg;

if Condition1 then
     begin
     Buy ( "BK Long Entry" ) next bar at LowerKBand stop ;
     end;
```

```
if Condition2 then
     begin
     Sell ( "BK Long Exit" ) next bar at market ;
     end;

if Condition3 then
     begin
     Sell ( "BK Damage Control" ) next bar at Avg limit ;
     end;
```

Appendix C: CCI Counter-Trend Strategy Code

```
inputs:
   CCILength( 14 ),
   CCIAvgLength( 9 ),
   OverSold( -100 ),
   OverBought( 100 ) ;

variables:
   CCIValue( 0 ),
   CCIAvg( 0 ) ;

CCIValue = CCI( CCILength ) ;
CCIAvg = Average( CCIValue, CCIAvgLength ) ;

Condition1 = CCIAvg crosses under OverSold ;
Condition2 = CCIAvg crosses under OverBought ;

if Condition1 then
   Buy ( "CCI LE" ) next bar at market ;

if Condition2 then
   Sell ( "CCI exit" ) next bar at market ;
```

Appendix D: CCI and Trade Volume Breakout Strategy Code

```
inputs:
 OscLimit( 0 ),
 RatLimit( 0 ),
 AvgLength( 14 ),
 FastLength( 14 ),
 SlowLength( 28 ),
 CCILength( 14 ),
 CCIAvgLength( 9 ),
 OverSold( -100 ),
 OverBought( 100 ) ;

variables:
 TotalTicks( 0 ),
 VolRatio( 0 ),
 VolRatioAvg( 0 ),
 Flag( false ),
 SetUp( False ),
 Trigger( False ),
 Exit( False ),
 VolOsc( 0 ),
 CCIValue( 0 ),
 CCIAvg( 0 ) ;

TotalTicks = UpTicks + DownTicks ;
if TotalTicks > 0 then
     VolRatio = 100 * ( UpTicks - DownTicks ) / TotalTicks
else
     VolRatio = 0 ;
VolRatioAvg = XAverage( VolRatio, AvgLength ) ;

VolOsc = VolumeOsc( FastLength, SlowLength ) ;
CCIValue = CCI( CCILength ) ;
CCIAvg = Average( CCIValue, CCIAvgLength ) ;

SetUp = CCIAvg crosses over OverBought;
Trigger = Flag and VolOsc > OscLimit and VolRatioAvg > RatLimit;
Exit = (CCIAvg > OverBought and VolOsc < -OscLimit and
VolRatioAvg > -RatLimit) or (CCIAvg < OverSold and VolOsc >
OscLimit and VolRatioAvg > RatLimit);

if SetUp then
    Flag = true ;

if Trigger then
```

```
 begin
 Buy ( "CCI-Vol LE" ) next bar at market ;
 Flag = false ;
 end;

if Exit then
 begin
 Sell ( "CCI-Vol SE" ) next bar at market ;
 end;
```

Appendix E: DMAC Performance Report

	All Trades	Long Trades		Short Trades
Total Net Profit	$4,056.90	$4,056.90		$0.00
Gross Profit	$9,830.30	$9,830.30		$0.00
Gross Loss	($5,773.40)	($5,773.40)		$0.00
Profit Factor	1.7	1.7	n/a	
Roll Over Credit	$11.90	$11.90		$0.00
Open Position P/L	$50.00	$50.00		$0.00
Select Total Net Profit	$3,654.90	$3,654.90		$0.00
Select Gross Profit	$8,849.30	$8,849.30		$0.00
Select Gross Loss	($5,194.40)	($5,194.40)		$0.00
Select Profit Factor	1.7	1.7	n/a	
Adjusted Total Net Profit	$1,698.52	$1,698.52		$0.00
Adjusted Gross Profit	$8,396.40	$8,396.40		$0.00
Adjusted Gross Loss	($6,697.88)	($6,697.88)		$0.00
Adjusted Profit Factor	1.25	1.25	n/a	
Total Number of Trades	86	86		0
Percent Profitable	54.65%	54.65%		0.00%
Winning Trades	47	47		0
Losing Trades	39	39		0
Even Trades	0	0		0
Avg. Trade Net Profit	$47.17	$47.17		$0.00
Avg. Winning Trade	$209.16	$209.16		$0.00
Avg. Losing Trade	($148.04)	($148.04)		$0.00
Ratio Avg. Win:Avg. Loss	1.41	1.41	n/a	
Largest Winning Trade	$981.00	$981.00		$0.00
Largest Losing Trade	($579.00)	($579.00)		$0.00
Largest Winner as % of Gross Profit	9.98%	9.98%	n/a	
Largest Loser as % of Gross Loss	10.03%	10.03%	n/a	
Net Profit as % of Largest Loss	700.67%	700.67%	n/a	
Select Net Profit as % of Largest Loss	631.24%	631.24%	n/a	
Adjusted Net Profit as % of Largest Loss	293.35%	293.35%	n/a	

Max. Consecutive Winning Trades	7	7	0
Max. Consecutive Losing Trades	8	8	0
Avg. Bars in Total Trades	13.03	13.03	0
Avg. Bars in Winning Trades	12.34	12.34	0
Avg. Bars in Losing Trades	13.87	13.87	0
Avg. Bars in Even Trades	0	0	0
Max. Shares/Contracts Held	100000	100000	0
Total Shares/Contracts Held	8700000	8700000	0
Account Size Required	$1,634.00	$1,634.00	$0.00
Total Slippage	$0.00	$0.00	$0.00
Total Commission	$0.00	$0.00	$0.00
Return on Initial Capital	4.06%		
Annual Rate of Return	67.66%		
Buy & Hold Return	2.84%		
Return on Account	248.28%		
Avg. Monthly Return	$4,106.90		
Std. Deviation of Monthly Return	n/a		
Return Retracement Ratio	n/a		
RINA Index	23.56		
Sharpe Ratio	n/a		
K-Ratio	n/a		
Trading Period	21 Dys, 11 Hrs, 14 Mins		
Percent of Time in the Market	78.22%		
Time in the Market	16 Dys, 19 Hrs, 1 Min		
Longest Flat Period	8 Hrs		
Max. Equity Run-up	$5,683.90		
Date of Max. Equity Run-up	4/21/2011 5:30		
Max. Equity Run-up as % of Initial Capital	5.68%		
Max. Drawdown (Intra-day Peak to Valley)			
Value	($1,991.00)	($1,991.00)	$0.00
Date	4/18/2011 3:45		
as % of Initial Capital	1.99%	1.99%	0.00%
Net Profit as % of Drawdown	203.76%	203.76%	n/a

Select Net Profit as % of Drawdown	183.57%	183.57%	n/a	
Adjusted Net Profit as % of Drawdown	85.31%	85.31%	n/a	
Max. Drawdown (Trade Close to Trade Close)				
Value	($1,634.00)	($1,634.00)		$0.00
Date	4/19/2011 1:00			
as % of Initial Capital	1.63%	1.63%		0.00%
Net Profit as % of Drawdown	248.28%	248.28%	n/a	
Select Net Profit as % of Drawdown	223.68%	223.68%	n/a	
Adjusted Net Profit as % of Drawdown	103.95%	103.95%	n/a	
Max. Trade Drawdown	($980.00)	($980.00)		$0.00

All Trades

Total Net Profit	$4,056.90	Profit Factor	1.7
Gross Profit	$9,830.30	Gross Loss	($5,773.40)
Roll Over Credit	$11.90		
Open Position Profit/Loss	$50.00		
Select Total Net Profit	$3,654.90	Select Profit Factor	1.7
Select Gross Profit	$8,849.30	Select Gross Loss	($5,194.40)
Adjusted Total Net Profit	$1,698.52	Adjusted Profit Factor	1.25
Adjusted Gross Profit	$8,396.40	Adjusted Gross Loss	($6,697.88)
Total Number of Trades	86	Percent Profitable	54.65%
Winning Trades	47	Losing Trades	39
Even Trades	0		
Avg. Trade Net Profit	$47.17	Ratio Avg. Win:Avg. Loss	1.41
Avg. Winning Trade	$209.16	Avg. Losing Trade	($148.04)
Largest Winning Trade	$981.00	Largest Losing Trade	($579.00)
Largest Winner as % of Gross Profit	9.98%	Largest Loser as % of Gross Loss	10.03%
Net Profit as % of Largest Loss	700.67%		

Slct. Net Profit as % of Largest Loss	631.24%	Adj. Net Profit as % of Largest Loss	293.35%
Max. Consecutive Winning Trades	7	Max. Consecutive Losing Trades	8
Avg. Bars in Winning Trades	12.34	Avg. Bars in Losing Trades	13.87
Avg. Bars in Total Trades	13.03		
Max. Shares/Contracts Held	100000	Account Size Required	$1,634.00
Total Commission	$0.00	Total Slippage	$0.00
Return on Initial Capital	4.06%	Annual Rate of Return	67.66%
Buy and Hold Return	2.84%	Return on Account	248.28%
Avg. Monthly Return	$4,106.90	Std. Deviation of Monthly Return	n/a
Return Retracement Ratio	n/a	RINA Index	23.56
Sharpe Ratio	n/a	K-Ratio	n/a
Trading Period	21 Dys, 11 Hrs, 14 Mins	Percent of Time in the Market	78.22%
Time in the Market	16 Dys, 19 Hrs, 1 Min	Longest Flat Period	8 Hrs
Max. Equity Run-up	$5,683.90		
Date of Max. E. Run-up	4/21/2011 5:30	Max. E. Run-up as % of Initial Capital	5.68%
Max. Drawdown (Intra-day Peak to Valley)		Max. Drawdown (Trade Close to Trade Close)	
Value	($1,991.00)	Value	($1,634.00)
Date	4/18/2011 3:45	Date	4/19/2011 1:00
as % of Initial Capital	1.99%	as % of Initial Capital	1.63%
Net Profit as % of Drawdown	203.76%	Net Profit as % of Drawdown	248.28%
Slct. Net Profit as % of Drawdown	183.57%	Slct. Net Profit as % of Drawdown	223.68%
Adj. Net Prof as % of Drawdown	85.31%	Adj. Net Profit as % of Drawdown	103.95%
Max. Trade Drawdown	($980.00)		

Appendix F: Bollinger/ Keltner Strategy Performance Report

	All Trades	Long Trades		Short Trades
Total Net Profit	$1,872.00	$1,872.00		$0.00
Gross Profit	$4,129.00	$4,129.00		$0.00
Gross Loss	($2,257.00)	($2,257.00)		$0.00
Profit Factor	1.83	1.83	n/a	
Roll Over Credit	$2.00	$2.00		$0.00
Open Position P/L	$0.00	$0.00		$0.00
Select Total Net Profit	$1,872.00	$1,872.00		$0.00
Select Gross Profit	$4,129.00	$4,129.00		$0.00
Select Gross Loss	($2,257.00)	($2,257.00)		$0.00
Select Profit Factor	1.83	1.83	n/a	
Adjusted Total Net Profit	($241.36)	($241.36)		$0.00
Adjusted Gross Profit	$2,937.06	$2,937.06		$0.00
Adjusted Gross Loss	($3,178.42)	($3,178.42)		$0.00
Adjusted Profit Factor	0.92	0.92	n/a	
Total Number of Trades	18	18		0
Percent Profitable	66.67%	66.67%		0.00%
Winning Trades	12	12		0
Losing Trades	6	6		0
Even Trades	0	0		0
Avg. Trade Net Profit	$104.00	$104.00		$0.00
Avg. Winning Trade	$344.08	$344.08		$0.00
Avg. Losing Trade	($376.17)	($376.17)		$0.00
Ratio Avg. Win:Avg. Loss	0.91	0.91	n/a	
Largest Winning Trade	$1,160.00	$1,160.00		$0.00
Largest Losing Trade	($1,020.00)	($1,020.00)		$0.00
Largest Winner as % of Gross Profit	28.09%	28.09%	n/a	
Largest Loser as % of Gross Loss	45.19%	45.19%	n/a	
Net Profit as % of Largest Loss	183.53%	183.53%	n/a	
Select Net Profit as % of Largest Loss	183.53%	183.53%	n/a	
Adjusted Net Profit as % of Largest Loss	-23.66%	-23.66%	n/a	

Max. Consecutive Winning Trades	5	5	0
Max. Consecutive Losing Trades	2	2	0
Avg. Bars in Total Trades	40.11	40.11	0
Avg. Bars in Winning Trades	38.25	38.25	0
Avg. Bars in Losing Trades	43.83	43.83	0
Avg. Bars in Even Trades	0	0	0
Max. Shares/Contracts Held	100000	100000	0
Total Shares/Contracts Held	1800000	1800000	0
Account Size Required	$1,255.00	$1,255.00	$0.00
Total Slippage	$0.00	$0.00	$0.00
Total Commission	$0.00	$0.00	$0.00
Return on Initial Capital	1.87%		
Annual Rate of Return	31.56%		
Buy & Hold Return	2.91%		
Return on Account	149.16%		
Avg. Monthly Return	$1,872.00		
Std. Deviation of Monthly Return	n/a		
Return Retracement Ratio	n/a		
RINA Index	10.67		
Sharpe Ratio	n/a		
K-Ratio	n/a		
Trading Period	21 Dys, 11 Hrs, 14 Mins		
Percent of Time in the Market	43.48%		
Time in the Market	9 Dys, 8 Hrs		
Longest Flat Period	3 Dys, 21 Hrs, 45 Mins		
Max. Equity Run-up	$3,517.00		
Date of Max. Equity Run-up	4/14/2011 2:45		
Max. Equity Run-up as % of Initial Capital	3.52%		
Max. Drawdown (Intra-day Peak to Valley)			
Value	($2,085.00)	($2,085.00)	$0.00
Date	4/18/2011 9:00		
as % of Initial Capital	2.08%	2.08%	0.00%
Net Profit as % of Drawdown	89.78%	89.78%	n/a

Select Net Profit as % of Drawdown	89.78%	89.78%	n/a	
Adjusted Net Profit as % of Drawdown	-11.58%	-11.58%	n/a	
Max. Drawdown (Trade Close to Trade Close)				
Value	($1,255.00)	($1,255.00)		$0.00
Date	4/18/2011 9:45			
as % of Initial Capital	1.25%	1.25%		0.00%
Net Profit as % of Drawdown	149.16%	149.16%	n/a	
Select Net Profit as % of Drawdown	149.16%	149.16%	n/a	
Adjusted Net Profit as % of Drawdown	-19.23%	-19.23%	n/a	
Max. Trade Drawdown	($1,556.00)	($1,556.00)		$0.00

All Trades

Total Net Profit	$1,872.00	Profit Factor	1.83
Gross Profit	$4,129.00	Gross Loss	($2,257.00)
Roll Over Credit	$2.00		
Open Position Profit/Loss	$0.00		
Select Total Net Profit	$1,872.00	Select Profit Factor	1.83
Select Gross Profit	$4,129.00	Select Gross Loss	($2,257.00)
Adjusted Total Net Profit	($241.36)	Adjusted Profit Factor	0.92
Adjusted Gross Profit	$2,937.06	Adjusted Gross Loss	($3,178.42)
Total Number of Trades	18	Percent Profitable	66.67%
Winning Trades	12	Losing Trades	6
Even Trades	0		
Avg. Trade Net Profit	$104.00	Ratio Avg. Win:Avg. Loss	0.91
Avg. Winning Trade	$344.08	Avg. Losing Trade	($376.17)
Largest Winning Trade	$1,160.00	Largest Losing Trade	($1,020.00)
Largest Winner as % of Gross Profit	28.09%	Largest Loser as % of Gross Loss	45.19%
Net Profit as % of Largest Loss	183.53%		

Slct. Net Profit as % of Largest Loss	183.53%	Adj. Net Profit as % of Largest Loss	-23.66%
Max. Consecutive Winning Trades	5	Max. Consecutive Losing Trades	2
Avg. Bars in Winning Trades	38.25	Avg. Bars in Losing Trades	43.83
Avg. Bars in Total Trades	40.11		
Max. Shares/Contracts Held	100000	Account Size Required	$1,255.00
Total Commission	$0.00	Total Slippage	$0.00
Return on Initial Capital	1.87%	Annual Rate of Return	31.56%
Buy and Hold Return	2.91%	Return on Account	149.16%
Avg. Monthly Return	$1,872.00	Std. Deviation of Monthly Return	n/a
Return Retracement Ratio	n/a	RINA Index	10.67
Sharpe Ratio	n/a	K-Ratio	n/a
Trading Period	21 Dys, 11 Hrs, 14 Mins	Percent of Time in the Market	43.48%
Time in the Market	9 Dys, 8 Hrs	Longest Flat Period	3 Dys, 21 Hrs, 45 Mins
Max. Equity Run-up	$3,517.00		
Date of Max. E. Run-up	4/14/2011 2:45	Max. E. Run-up as % of Initial Capital	3.52%
Max. Drawdown (Intra-day Peak to Valley)		Max. Drawdown (Trade Close to Trade Close)	
Value	($2,085.00)	Value	($1,255.00)
Date	4/18/2011 9:00	Date	4/18/2011 9:45
as % of Initial Capital	2.08%	as % of Initial Capital	1.25%
Net Profit as % of Drawdown	89.78%	Net Profit as % of Drawdown	149.16%
Slct. Net Profit as % of Drawdown	89.78%	Slct. Net Profit as % of Drawdown	149.16%
Adj. Net Prof as % of Drawdown	-11.58%	Adj. Net Profit as % of Drawdown	-19.23%
Max. Trade Drawdown	($1,556.00)		

Appendix G: CCI Counter-Trend Performance Report

	All Trades	Long Trades	Short Trades
Total Net Profit	$883.60	$883.60	$0.00
Gross Profit	$4,466.30	$4,466.30	$0.00
Gross Loss	($3,582.70)	($3,582.70)	$0.00
Profit Factor	1.25	1.25	n/a
Roll Over Credit	$7.60	$7.60	$0.00
Open Position P/L	($70.00)	($70.00)	$0.00
Select Total Net Profit	$883.60	$883.60	$0.00
Select Gross Profit	$4,466.30	$4,466.30	$0.00
Select Gross Loss	($3,582.70)	($3,582.70)	$0.00
Select Profit Factor	1.25	1.25	n/a
Adjusted Total Net Profit	($2,049.61)	($2,049.61)	$0.00
Adjusted Gross Profit	$2,887.22	$2,887.22	$0.00
Adjusted Gross Loss	($4,936.83)	($4,936.83)	$0.00
Adjusted Profit Factor	0.58	0.58	n/a
Total Number of Trades	15	15	0
Percent Profitable	53.33%	53.33%	0.00%
Winning Trades	8	8	0
Losing Trades	7	7	0
Even Trades	0	0	0
Avg. Trade Net Profit	$58.91	$58.91	$0.00
Avg. Winning Trade	$558.29	$558.29	$0.00
Avg. Losing Trade	($511.81)	($511.81)	$0.00
Ratio Avg. Win:Avg. Loss	1.09	1.09	n/a
Largest Winning Trade	$1,125.00	$1,125.00	$0.00
Largest Losing Trade	($1,701.00)	($1,701.00)	$0.00
Largest Winner as % of Gross Profit	25.19%	25.19%	n/a
Largest Loser as % of Gross Loss	47.48%	47.48%	n/a
Net Profit as % of Largest Loss	51.95%	51.95%	n/a
Select Net Profit as % of Largest Loss	51.95%	51.95%	n/a
Adjusted Net Profit as % of Largest Loss	-120.49%	-120.49%	n/a

Max. Consecutive Winning Trades	3	3	0
Max. Consecutive Losing Trades	2	2	0
Avg. Bars in Total Trades	53.07	53.07	0
Avg. Bars in Winning Trades	34.88	34.88	0
Avg. Bars in Losing Trades	73.86	73.86	0
Avg. Bars in Even Trades	0	0	0
Max. Shares/Contracts Held	100000	100000	0
Total Shares/Contracts Held	1600000	1600000	0
Account Size Required	$2,542.00	$2,542.00	$0.00
Total Slippage	$0.00	$0.00	$0.00
Total Commission	$0.00	$0.00	$0.00
Return on Initial Capital	0.88%		
Annual Rate of Return	14.97%		
Buy & Hold Return	3.22%		
Return on Account	34.76%		
Avg. Monthly Return	$813.60		
Std. Deviation of Monthly Return	n/a		
Return Retracement Ratio	n/a		
RINA Index	3.97		
Sharpe Ratio	n/a		
K-Ratio	n/a		
Trading Period	21 Dys, 11 Hrs, 14 Mins		
Percent of Time in the Market	40.27%		
Time in the Market	8 Dys, 15 Hrs, 29 Mins		
Longest Flat Period	3 Dys, 4 Hrs		
Max. Equity Run-up	$3,025.00		
Date of Max. Equity Run-up	4/21/2011 8:00		
Max. Equity Run-up as % of Initial Capital	3.03%		
Max. Drawdown (Intra-day Peak to Valley)			
Value	($3,583.00)	($3,583.00)	$0.00
Date	4/18/2011 11:15		
as % of Initial Capital	3.58%	3.58%	0.00%
Net Profit as % of Drawdown	24.66%	24.66%	n/a

Select Net Profit as % of Drawdown	24.66%	24.66%	n/a	
Adjusted Net Profit as % of Drawdown	-57.20%	-57.20%	n/a	
Max. Drawdown (Trade Close to Trade Close)				
Value	($2,542.00)	($2,542.00)		$0.00
Date	4/19/2011 4:45			
as % of Initial Capital	2.54%	2.54%		0.00%
Net Profit as % of Drawdown	34.76%	34.76%	n/a	
Select Net Profit as % of Drawdown	34.76%	34.76%	n/a	
Adjusted Net Profit as % of Drawdown	-80.63%	-80.63%	n/a	
Max. Trade Drawdown	($2,563.00)	($2,563.00)		$0.00

All Trades

Total Net Profit	$883.60	Profit Factor	1.25
Gross Profit	$4,466.30	Gross Loss	($3,582.70)
Roll Over Credit	$7.60		
Open Position Profit/Loss	($70.00)		
Select Total Net Profit	$883.60	Select Profit Factor	1.25
Select Gross Profit	$4,466.30	Select Gross Loss	($3,582.70)
Adjusted Total Net Profit	($2,049.61)	Adjusted Profit Factor	0.58
Adjusted Gross Profit	$2,887.22	Adjusted Gross Loss	($4,936.83)
Total Number of Trades	15	Percent Profitable	53.33%
Winning Trades	8	Losing Trades	7
Even Trades	0		
Avg. Trade Net Profit	$58.91	Ratio Avg. Win:Avg. Loss	1.09
Avg. Winning Trade	$558.29	Avg. Losing Trade	($511.81)
Largest Winning Trade	$1,125.00	Largest Losing Trade	($1,701.00)
Largest Winner as % of Gross Profit	25.19%	Largest Loser as % of Gross Loss	47.48%
Net Profit as % of Largest Loss	51.95%		

Slct. Net Profit as % of Largest Loss	51.95%	Adj. Net Profit as % of Largest Loss	-120.49%
Max. Consecutive Winning Trades	3	Max. Consecutive Losing Trades	2
Avg. Bars in Winning Trades	34.88	Avg. Bars in Losing Trades	73.86
Avg. Bars in Total Trades	53.07		
Max. Shares/Contracts Held	100000	Account Size Required	$2,542.00
Total Commission	$0.00	Total Slippage	$0.00
Return on Initial Capital	0.88%	Annual Rate of Return	14.97%
Buy and Hold Return	3.22%	Return on Account	34.76%
Avg. Monthly Return	$813.60	Std. Deviation of Monthly Return	n/a
Return Retracement Ratio	n/a	RINA Index	3.97
Sharpe Ratio	n/a	K-Ratio	n/a
Trading Period	21 Dys, 11 Hrs, 14 Mins	Percent of Time in the Market	40.27%
Time in the Market	8 Dys, 15 Hrs, 29 Mins	Longest Flat Period	3 Dys, 4 Hrs
Max. Equity Run-up	$3,025.00		
Date of Max. E. Run-up	4/21/2011 8:00	Max. E. Run-up as % of Initial Capital	3.03%
Max. Drawdown (Intra-day Peak to Valley)		Max. Drawdown (Trade Close to Trade Close)	
Value	($3,583.00)	Value	($2,542.00)
Date	4/18/2011 11:15	Date	4/19/2011 4:45
as % of Initial Capital	3.58%	as % of Initial Capital	2.54%
Net Profit as % of Drawdown	24.66%	Net Profit as % of Drawdown	34.76%
Slct. Net Profit as % of Drawdown	24.66%	Slct. Net Profit as % of Drawdown	34.76%
Adj. Net Prof as % of Drawdown	-57.20%	Adj. Net Profit as % of Drawdown	-80.63%
Max. Trade Drawdown	($2,563.00)		

Appendix H: CCI & Volume Breakout Strategy Performance Report

	All Trades	Long Trades		Short Trades
Total Net Profit	$3,176.00	$3,176.00		$0.00
Gross Profit	$4,677.00	$4,677.00		$0.00
Gross Loss	($1,501.00)	($1,501.00)		$0.00
Profit Factor	3.12	3.12	n/a	
Roll Over Credit	$9.00	$9.00		$0.00
Open Position P/L	$34.00	$34.00		$0.00
Select Total Net Profit	$3,176.00	$3,176.00		$0.00
Select Gross Profit	$4,677.00	$4,677.00		$0.00
Select Gross Loss	($1,501.00)	($1,501.00)		$0.00
Select Profit Factor	3.12	3.12	n/a	
Adjusted Total Net Profit	$655.83	$655.83		$0.00
Adjusted Gross Profit	$3,023.43	$3,023.43		$0.00
Adjusted Gross Loss	($2,367.60)	($2,367.60)		$0.00
Adjusted Profit Factor	1.28	1.28	n/a	
Total Number of Trades	11	11		0
Percent Profitable	72.73%	72.73%		0.00%
Winning Trades	8	8		0
Losing Trades	3	3		0
Even Trades	0	0		0
Avg. Trade Net Profit	$288.73	$288.73		$0.00
Avg. Winning Trade	$584.62	$584.62		$0.00
Avg. Losing Trade	($500.33)	($500.33)		$0.00
Ratio Avg. Win:Avg. Loss	1.17	1.17	n/a	
Largest Winning Trade	$1,355.00	$1,355.00		$0.00
Largest Losing Trade	($1,075.00)	($1,075.00)		$0.00
Largest Winner as % of Gross Profit	28.97%	28.97%	n/a	
Largest Loser as % of Gross Loss	71.62%	71.62%	n/a	
Net Profit as % of Largest Loss	295.44%	295.44%	n/a	
Select Net Profit as % of Largest Loss	295.44%	295.44%	n/a	
Adjusted Net Profit as % of Largest Loss	61.01%	61.01%	n/a	

Max. Consecutive Winning Trades	5	5	0
Max. Consecutive Losing Trades	2	2	0
Avg. Bars in Total Trades	54.36	54.36	0
Avg. Bars in Winning Trades	66.75	66.75	0
Avg. Bars in Losing Trades	21.33	21.33	0
Avg. Bars in Even Trades	0	0	0
Max. Shares/Contracts Held	100000	100000	0
Total Shares/Contracts Held	1200000	1200000	0
Account Size Required	$1,080.00	$1,080.00	$0.00
Total Slippage	$0.00	$0.00	$0.00
Total Commission	$0.00	$0.00	$0.00
Return on Initial Capital	3.18%		
Annual Rate of Return	53.20%		
Buy & Hold Return	2.36%		
Return on Account	294.07%		
Avg. Monthly Return	$3,210.00		
Std. Deviation of Monthly Return	n/a		
Return Retracement Ratio	n/a		
RINA Index	38.97		
Sharpe Ratio	n/a		
K-Ratio	n/a		
Trading Period	21 Dys, 11 Hrs, 14 Mins		
Percent of Time in the Market	31.88%		
Time in the Market	6 Dys, 20 Hrs, 14 Mins		
Longest Flat Period	4 Dys, 15 Hrs, 15 Mins		
Max. Equity Run-up	$4,032.00		
Date of Max. Equity Run-up	4/22/2011 2:45		
Max. Equity Run-up as % of Initial Capital	4.03%		
Max. Drawdown (Intra-day Peak to Valley)			
Value	($1,323.00)	($1,323.00)	$0.00
Date	4/14/2011 6:30		
as % of Initial Capital	1.32%	1.32%	0.00%

Net Profit as % of Drawdown	240.06%	240.06%	n/a	
Select Net Profit as % of Drawdown	240.06%	240.06%	n/a	
Adjusted Net Profit as % of Drawdown	49.57%	49.57%	n/a	
Max. Drawdown (Trade Close to Trade Close)				
Value	($1,080.00)	($1,080.00)		$0.00
Date	4/14/2011 6:45			
as % of Initial Capital	1.08%	1.08%		0.00%
Net Profit as % of Drawdown	294.07%	294.07%	n/a	
Select Net Profit as % of Drawdown	294.07%	294.07%	n/a	
Adjusted Net Profit as % of Drawdown	60.72%	60.72%	n/a	
Max. Trade Drawdown	($1,144.00)	($1,144.00)		$0.00

All Trades

Total Net Profit	$3,176.00	Profit Factor	3.12
Gross Profit	$4,677.00	Gross Loss	($1,501.00)
Roll Over Credit	$9.00		
Open Position Profit/Loss	$34.00		
Select Total Net Profit	$3,176.00	Select Profit Factor	3.12
Select Gross Profit	$4,677.00	Select Gross Loss	($1,501.00)
Adjusted Total Net Profit	$655.83	Adjusted Profit Factor	1.28
Adjusted Gross Profit	$3,023.43	Adjusted Gross Loss	($2,367.60)
Total Number of Trades	11	Percent Profitable	72.73%
Winning Trades	8	Losing Trades	3
Even Trades	0		
Avg. Trade Net Profit	$288.73	Ratio Avg. Win:Avg. Loss	1.17
Avg. Winning Trade	$584.62	Avg. Losing Trade	($500.33)
Largest Winning Trade	$1,355.00	Largest Losing Trade	($1,075.00)
Largest Winner as % of Gross Profit	28.97%	Largest Loser as % of Gross Loss	71.62%

Net Profit as % of Largest Loss	295.44%		
Slct. Net Profit as % of Largest Loss	295.44%	Adj. Net Profit as % of Largest Loss	61.01%
Max. Consecutive Winning Trades	5	Max. Consecutive Losing Trades	2
Avg. Bars in Winning Trades	66.75	Avg. Bars in Losing Trades	21.33
Avg. Bars in Total Trades	54.36		
Max. Shares/Contracts Held	100000	Account Size Required	$1,080.00
Total Commission	$0.00	Total Slippage	$0.00
Return on Initial Capital	3.18%	Annual Rate of Return	53.20%
Buy and Hold Return	2.36%	Return on Account	294.07%
Avg. Monthly Return	$3,210.00	Std. Deviation of Monthly Return	n/a
Return Retracement Ratio	n/a	RINA Index	38.97
Sharpe Ratio	n/a	K-Ratio	n/a
Trading Period	21 Dys, 11 Hrs, 14 Mins	Percent of Time in the Market	31.88%
Time in the Market	6 Dys, 20 Hrs, 14 Mins	Longest Flat Period	4 Dys, 15 Hrs, 15 Mins
Max. Equity Run-up	$4,032.00		
Date of Max. E. Run-up	4/22/2011 2:45	Max. E. Run-up as % of Initial Capital	4.03%
Max. Drawdown (Intra-day Peak to Valley)		Max. Drawdown (Trade Close to Trade Close)	
Value	($1,323.00)	Value	($1,080.00)
Date	4/14/2011 6:30	Date	4/14/2011 6:45
as % of Initial Capital	1.32%	as % of Initial Capital	1.08%
Net Profit as % of Drawdown	240.06%	Net Profit as % of Drawdown	294.07%
Slct. Net Profit as % of Drawdown	240.06%	Slct. Net Profit as % of Drawdown	294.07%
Adj. Net Prof as % of Drawdown	49.57%	Adj. Net Profit as % of Drawdown	60.72%
Max. Trade Drawdown	($1,144.00)		

Appendix I: Strategy Analysis

CCI & Volume Complete Stats	
Sum R	5196.12
Number of Trades	86
Expected Value	151.05
Expectancy	60.42
Expectunity	8988.548815
Std Dev R	340.4031026
E / StdDev	0.177495444
Study Days	211
Opportunities	148.7677725
System Quality	26.4056019
Percent Winning Trades	0.593023256
Percent Losing Trades	0.372093023
Average Winning Trade	606.2764706
Average Losing Trade	560.30625

Bollinger/ Keltner Complete Stats	
Sum R	2841.32
Number of Trades	127
Expected Value	55.931496
Expectancy	22.372598
Expectunity	2841.32
Std Dev R	183.7033
E / StdDev	0.1217866
Study Days	365
Opportunities	127
System Quality	15.466897
Percent Winning Trades	0.5826772
Percent Losing Trades	0.4173228
Average Winning Trade	283.05405
Average Losing Trade	261.18302

CCI Counter-Trend Complete Stats	
Sum R	2889.8
Number of Trades	257
Expected Value	140.1746628
Expectancy	11.24435798
Expectunity	2889.8
Std Dev R	316.4704673
E / StdDev	0.035530513
Study Days	365
Opportunities	257
System Quality	9.13134178
Percent Winning Trades	0.634241245
Percent Losing Trades	0.365758755
Average Winning Trade	461.7190184
Average Losing Trade	417.3969325

DMAC Complete Stats	
Sum R	3217.6
Number of Trades	809
Expected Value	9.943139679
Expectancy	3.977255871
Expectunity	3217.6
Std Dev R	152.1981022
E / StdDev	0.026132099
Study Days	365
Opportunities	809
System Quality	21.14086807
Percent Winning Trades	0.373300371
Percent Losing Trades	0.622991347
Average Winning Trade	346.6990066
Average Losing Trade	191.7839286