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Trading System Development

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Trading System Development

An Interactive Qualifying Project Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
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Degree of Bachelor of Science

By

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Submitted to:

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Abstract
The purpose of this project was to construct a system of trading systems that would demonstrate a successful long term return on investment across different market conditions. The team was given $300,000 to distribute amongst three scientifically developed systems on the TradeStation platform provided by our advisors. The strategies were designed to incorporate both technical and fundamental data as well as trade diverse markets. The resulting cultivation of systems involved the use of two automated trading strategies and one manual trading strategy that showed substantial profits in the long term.
Acknowledgments

We would like to thank Professor Radzicki and Professor Hakim for their guidance and support throughout the course of the project. We would also like to thank TradeStation for providing us with a platform for trading that made this project possible.
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Introduction

Our group’s task was to come together and form a successful mini hedge fund. To do this we had a concrete plan of creating individual strategies to trade in unison, such that we have the best performance with minimal risks taken. We applied common trading techniques to a trading platform, TradeStation, which provided methods of statistical analysis. This allowed us to construct trading strategies that we continuously honed and adapted based on system optimization results. Our group decided that our hedge fund should have a scientific approach to trading in order to gain an edge over other traders and TradeStation was our primary tool to do so.

TradeStation incorporates a coding platform called Easy Language which enables traders to take manual rules and code them in order for the system to then trade automatically. This allows for a variety of system quality analyses including backtesting the trading system on historical data, optimization of trading parameters, and walk forward analysis. Being able to record our trades in detail allowed our team to perform complex optimization and Monte Carlo analysis with our professor’s software. This analysis, in combination with expectancy ratios between the systems, lead to money allocation between each trading strategy.

By applying scientific methodology to trading, our team can create opportunities for managing a successful financial future. The tools available to us through TradeStation allow us to develop trading systems that require little to no micromanagement, suitable for trading even with a busy working lifestyle. Even should we choose not to trade in the future, building systems has left us with an understanding of money management so that in the future we can practice wise allocation of assets.
Our final system of systems is an amalgam of three systems that we developed. Each system offers a unique strategy and trades on a different target market. The coded trading strategy named bjo_BollingerBand works by trading different stocks in the S&P 500 and NYSE, trading off of input given by Bollinger Bands and three moving averages. A second coded strategy, Market Open Bulls - JPY, trades a simple support and resistance strategy on Foreign Exchanges with the unique benefit of developing its floors and ceilings based on the time of day at which key foreign markets open. The third strategy is an uncoded day trading system that utilizes the hot lists feature in TradeStation to formulate a refined list of company stocks to invest in a long position for that day. Within that list, there is a set of unique parameters that must be met to be considered buyable stocks for that particular day. By having three different systems which trade on independent markets, we were able to develop a system of systems more robust than its individual components.
Overview of Trading and Investing

In order to craft successful strategies our group needed to investigate trading at a rudimentary level. This involved everything from learning what to trade, how to trade and how to best analyze the market. Understanding the type of market that is being traded and the timeframe in which it is being traded, is necessary for the development of a sound trading strategy. With a solid foundation of indicators and what they represent, our group would be able to make informed decisions on how to create a strategy that works off of the given indicator, or a combination of indicators.

Trading Vs. Investing

Before one can learn how to trade or invest, one must know the difference between the two terms. Both trading and investing are methods for attempting to profit in the financial markets, but that is where the similarities end. Trading involves frequent buying and selling of stocks within a specified time frame. At the end of this time frame a trader will either have a profit or a loss and move on to the next trade. Time frames range greatly from a couple of minutes to as long as a few years. Traders believe that by using their systems they can outperform investors who buy and hold stocks for long periods of time (Folger, 2012). In addition to the fundamentals, they use tools such as moving averages and Bollinger bands to justify their trades and increase their probabilities of turning a profit.

In contrast, investing is a long term process. Investments are made and then left alone for many years, often until an individual’s retirement. There are unique classes of investments that distinguish it from trading as well, such as mutual funds and bonds.
Rather than trading in anticipation of the market’s movements, investors allow their holdings to sit through all fluctuations in price and trust in the market’s ability to return value over many years. Typically investors will forsake the use of many of the tools used by traders and instead look at the fundamental economics of companies and their respective industries, particularly the price-to-earnings ratio, the income statements, and the balance sheets, to make decisions (Folger, 2012).

**Types of Exchanges**

An exchange is an organized market through which tradable contracts are bought and sold. There are five primary assets sold on exchanges: securities, commodities, foreign exchange, futures, and options.

**Equities (Stocks).** Equity trading, also known as trading company stock is a very popular market for buying and selling shares of ownership in companies. Owning a share of a company allows an investor to have part of the company’s assets. The growth or decline of a company directly affects the value of the shareholder’s investment. Stocks offer limited liability which means that the owner of a share in a company is not liable for any debts that the company is unable to pay. An investor has the right to sell their shares to anyone who wants to buy partial ownership of the company during trading hours. Shares in large publicly traded companies are typically bought and sold through the New York Stock Exchange, London Stock Exchange, or Bombay Stock Exchange because they serve as the three major stock exchanges. It is a greater risk to trade stocks than bonds but the risk yields a greater return on investment. Historically stocks outperform both bonds and savings accounts over the long term.
**Bonds.** Bonds are a type of debt security that companies, banks, and even governments use to acquire a loan of money with the promise to pay the cost of the bond back in full supplemented with regular interest payments. A bond is sold at a specified price and has a greater face value that it is expected to reach in a specified amount of time called the maturity date. Bonds are typically a safe long term investment which provides a steady interest-based income for the holder of the bond. This interest-based income may accrue or it may be distributed annually in coupon amounts dependent on the face value of the bond and the coupon rate.

Bonds are versatile and vary in value based on the yield rate of the bond, the maturity date, the risk of the bond issuer being unable to make payments, and general inflation. High yielding bonds, usually offered by less credit-worthy bond issuers, are the riskiest to invest in. Investment grade bonds are offered by bond issuers with a proven positive bond issuing history and usually have lower yield rates due to the low risk of the investment. There are also higher yield rates accredited to bonds set up with longer term maturity dates. The versatility of bonds spreads bonds over many varying assets resulting in a low trade volume and causes a low liquidity market along with slow market growth. Due to the low liquidity and slow market growth, bonds are not very popular for traders who actively trade.

**Commodities.** A commodity is “a basic good used in commerce that is interchangeable with other commodities of the same type” (Commodity Definition, 2003). Generally, these are products that are used in the production of other goods and services with uniform quality between producers. Commodities make up a great deal of the products used in daily life, examples include gas, corn, gold, wheat, and coffee.
Trading commodities is usually done using futures contracts. What this means is the investor will buy or sell contracts for a commodity at a predetermined time in the future. The contracts that are traded standardize both the quantity and minimum quality of the commodity (DraKoln, 2008). As a result of this trading system, there can be a lot of volatility in the market before a trade is finalized. This makes commodities a risky investment.

**Forex.** Over the past few decades, many traders have looked to diversify their portfolios by trading foreign exchanges. This type of trading, often called Forex, involves the buying of one currency while simultaneously selling another. This allows an investor to trade outside of industries and instead trade based on large economies. As a result, Forex follows unique patterns of movement that investors can exploit in their strategies.

Trades in Forex are made in pairs of currencies. The first currency named in the pair is the base currency and the second is the counter currency. The value of the pair is a ratio of the relative value of the two currencies. For example, if EURUSD is quoted to be 1.06, this means that with one Euro an investor can buy 1.0600 United States Dollars. The inverse is also true, so in the same situation one United States Dollar can be used to buy approximately 0.9433 Euros. These ratios are often expressed by up to four decimals known as “pips.” The only exceptions to this rule are pairs involving the Japanese Yen which are typically expressed by up to two decimals (What is a Pip in Forex?, 2011).

More than 80% of all trades involve the United States Dollar (USD) as one of the currencies in the pair. Other widely traded currencies are the Euro (EUR), the Japanese Yen (JPY), the Great British Pound (GBP), the Australian Dollar (AUD), the Swiss Franc
(CHF), and the Canadian Dollar (CAD). Pairs involving currencies outside of these are known as “Exotic” pairs and typically have a much larger spread to overcome (Market Size and Liquidity, 2011).

The Forex market offers many advantages to investors. Due to its global nature, trading can happen at any time of the day with the market closed only from 5pm on Friday to 5pm on Sunday, Eastern Standard Time. The major Forex pairs are highly liquid and lots come in custom sizes, so any trade desired can be made instantly (Advantages of Trading Forex, 2011). High leverage ratios are also available in Forex. Brokers typically offer leverage in 50:1, 100:1, and 200:1 ratios depending on the size of a trade (Balasubramaniam, 2006). These advantages, in addition to no commission and low transaction costs, make Forex a lucrative investment for individual traders as well as large companies.

Futures. A futures contract is an agreement to buy or sell a financial instrument at specified price at some specified time in the future. Most other assets can be traded through futures markets; in fact it is the primary method by which commodities are traded. Futures are traded through exchanges which make them standardized with delivery dates, procedures, and locations (Futures Definition, 2003). A negative price change in futures of one party causes the positive price raise in futures of another party. There is a high risk associated with the volatility that occurs over the period of futures contracts.

The risk inherent in futures requires investors to deposit a performance bond with the broker to guarantee that they will be able to cover any loss in their position. The performance bond is the margin and it gains interest through the duration of the future.
If the margin drops in value below a predetermined balance, the broker may require additional deposits into the balance to protect the involved parties against failure for a party to pay their debts accrued in the contract. However, an open position in futures can be closed by trading a position in the opposite direction which will hedge some of the risk (Futures Definition, 2003).

**Options.** Options are different from futures because they give the buyer the choice or option to buy or sell an asset at a certain price on or before its expiration date. If the buyer allows the expiration date to pass, the option becomes worthless. When the option loses its value following its expiration, the buyer loses all of the money they originally paid for the option. Options, also known as derivatives, are contracts that derive their value from underlying assets such as index funds or stocks.

Much like long positions and selling short with stocks, options can be categorized in calls and puts. Investors of calls anticipate that the price of the option will rise considerably before it expires much like a long position in stocks. Investors of puts anticipate that the price of the option will have a significant decrease in value before it expires.

Options investors can be categorized as holders or writers. Options holders buy or sell options for the long term while options writers buy or sell options for the short term. By contract, a holder is not obligated to buy or sell an option within a specific time frame. A writer on the other hand, is obligated through the terms of their contract, to buy or sell an option within a specific time frame.
**Investment Funds**

**Mutual funds.** A mutual fund is a professionally managed pool of funds, received from multiple investors or shareholders that is invested into a collection of diverse securities and assets. The mutuality of a mutual fund infers that all profits and losses are shared between each of the investors involved in a proportionate manner. Investment objectives are stated in the fund’s prospectus and are intended to influence the formation of the diversified portfolio. Mutual funds allow investors with limited or low capital to pool their money together for the benefit of a diversified portfolio controlled professionally by a money manager.

**Exchange traded funds.** An exchange traded fund (ETF) is a fund that holds stocks, bonds, or commodities in a tracked index. An ETF trades close to its net asset value but experiences price fluctuations as it is bought and sold throughout a typical trading day. The trading of an exchange traded fund is identical to the buying or selling of a stock but with less volatility than an individual stock because of the diversification of the numerous assets in the fund.

**Types of Orders**

**Market orders.** A market order is intended to buy or sell an investment at the current price that it is available. It is placed through through a broker and since a market order has no restriction of time or price it is guaranteed to be filled. Market orders have low commissions and are best utilized in markets of high trade and share volume because execution of the order does not involve much work on the broker’s end. The easy execution of market orders allows for fast placement, but lack of precision can cause considerable slippage between the time of the placed order and the time it is
filled. The amount of potential slippage makes market orders a poor decision in a highly volatile market. Market orders are considered to be the default market type due to their simplicity and high popularity with online brokers.

**Limit orders.** A limit order represents the buy or sell of a specific number of shares at a set price through a broker. A limit order is delivered to a broker with the intent to wait for the stock to reach a specified price or better before buying or selling the position. The time that an order remains outstanding before it is canceled can be limited as well. Limit orders allow for more precise trades and cater to equities with lower trade volumes and lower amounts of shares available for purchase. In a volatile market, a limit order may remain outstanding if the order is unreasonable or if there are a number cheaper orders that undercut the buy or sell price proposed. Limit orders are more risky in this respect because orders that remain outstanding indefinitely cannot make money until they are officially filled.

**Stop orders.** A stop order triggers a market or limit order once a specific price level has been reached. Depending on whether a market or limit order is previously specified, this price level also known as a stop level, will place the order to be filled in market. Stop orders are categorized as stop-market orders and stop-limit orders respectively.

Stop orders typically act as a safety net for investments and protect against a potentially volatile market. This acts as a great risk management tactic to protect profit gained on an investment and inversely minimize profit loss on an investment. Stop-losses enable a trader to quickly exit the market if a significant price drop occurs.
Buy orders for a short position stop are placed above the current market level and sell orders for a long position stop are placed below the current market level. Using this method instills a level of confidence in investors because following a triggered stop level, an investor can gain a learned understanding of market trends and make future purchases based off of the gathered data.

**Market Conditions**

There are three types of conditions to categorize the movement of the stock market. These three market conditions are known as trending, volatile, and directionless and are important to identify when selecting strategies and indicators to determine future movement or progression of market prices.

**Trending.** Market conditions that are trending tend to repeat patterns dependent on the identification of the type of trend. Generally, there are two ways to categorize a trending market known as bullish and bearish. A bull market signifies the uptrend of sustained increases in market prices. A bear market signifies the downtrend of a continuous decrease in market prices.

Primary market trends are used to describe bull and bear markets and they typically alternate every one to three years. Secular trends may last one to three decades and contain many primary trends within each secular time frame. Secular trends are relatively easy to identify due to their long time frame (Identifying Market Trends).

Intermediate trends represent sudden rallies and the switching of trend direction that can occur within a primary level. The sudden trend change can be justified through economic or political action that causes a corresponding reaction in the market. Each
bull and bear market in the primary trend supposedly has at least three intermediate cycles ranging from two weeks to eight weeks in length.

Long term trends represent significant continuity of a positive growth uptrend, or a negative growth downtrend. A trend of long term caliber includes numerous intermediate trends that prove to be insignificant with regards to the grand scale of the long term trend.

**Volatile.** Volatile market conditions arise when the nature of a market is to rise and fall unpredictably in a short time frame. Volatility may be measured by the standard deviation of a return on investment. Volatile markets contain large price variations that result from high trade volumes. True volatility depends on a number of factors that include trade order imbalance in one direction as well as economic and political releases that cause a market changing reaction that varies its price value. Periods of fluctuations are most likely due to the psychological forces causing day traders to make rash and uncalculated decisions based on intuition.

**Directionless.** Directionless market conditions are characterized by insignificant price movements in either direction causing the market value to move sideways on a chart. A market may be directionless if it is between definite trends. Directionless market conditions occur nearly 85% of the time and must be accounted for or protected against with any trend following system (Wright, 1998).

**Trading Different Time Frames**

**Time intervals.** An important aspect when viewing a chart and ultimately making a trade is what time interval does one bar represent. This time interval changes the overall patterns which can be seen. For example a strategy that works off of being in the
market for only five minutes would not get much information about placing a trade by viewing daily bars. The opposite is also true. When coming up with a strategy that trades daily bars and stays in the market for weeks at a time, it would not help much by having information that can be gathered from five minute bars.

Shorter time intervals allow for more price movement to be taken advantage of because there are more bars per unit time. A consequence for this increased price movement is an inherent increase in noise. When the time interval is increased it removes noise that can be seen in shorter time intervals. Therefore finding the right time interval and understanding the time interval that is being traded are important when creating a trading system.

**Bar length.** Trading systems can be designed to trade any type bar length. A system may be designed to only trade after a certain hour using five or ten minute bars, or perhaps only during a certain time of year using daily bars. No matter the timing, the trader who implements timing in their trades believes that there are significant factors at play in the market at the time they choose to trade.

**Time of day.** Strategies designed for intraday and swing trading can be based on trading at different times of day. For some traders this is practical; for example, they may be unable to trade at certain times of the day. For other traders, the time of day that they trade is a necessity for their system to operate properly. Volatility and volume change throughout the day resulting in unique trading opportunities at different hours with regards to slippage, liquidity, and risk.

When the market opens at nine-thirty each morning and orders from the overnight session are filled there is an incredible amount of movement. By 10 o’clock,
this movement tends to slow down and remain steady for the rest of the day. After the
morning rush is over, the salient highs and lows for the day are set. This premise is
known as the 10 O'clock Bulls, and is used as the foundation for many trading
strategies (Bysshe, 2004). This phenomenon is just one of the more popular subsets of
trading based on time of day.

**Annual trends.** The market experiences natural movements on an annual basis
too. Certain industries perform better during some seasons than during other seasons.
While this effect is often negligible in the long run, longer term investments traded
based on time of year can add diversity to a portfolio.

**The Costs of Trading and Investing**

Another consideration that needs to be made when developing a system is the
costs associated with trading. There are obvious costs, such as commissions and fees
charged by brokers, and there are less apparent costs, such as slippage and bid-ask
spread. For different assets, the severity of these costs vary. Therefore it is important
for a trader to decide how costs impact their strategy.

**Commissions and fees.** Commissions and fees charged by brokers are the
most common costs encountered when trading. Commissions may be charged as a flat
fee per trade, a cost per share, or as a percentage of the total sale (Marrion, 2012).
With the advent of the Internet, these costs are much lower than they have been
historically with prices as low as $5 per trade. For a system with high frequency trading,
this can become a great burden. However, for Forex, most brokers do not charge
commissions and instead embed a small markup in the spread they show. Often this
results in fees much lower than those for other exchanges, making Forex a friendlier environment for high frequency traders.

**Slippage.** Slippage is an unseen cost associated with trading. It is the difference between the price a trade is executed at and the price the order is filled at (Slippage Definition, 2003). For example, a trader may request to buy a stock at $10, but by the time the broker fulfills the trade the stock is being sold for $10.05. Generally, traders can avoid slippage by using limit orders which can only be fulfilled at a specific price or better. Particular care needs to be taken when trading low volume stocks or when placing large orders as traders can create their own slippage as their orders slowly get filled. Again, Forex has an advantage in this regard as the massive volume of Forex trading makes slippage virtually nonexistent and allows most trades to go through instantly.

**Bid-ask spread.** The bid-ask spread is another major cost of trading that is sometimes overlooked by novice traders. For any exchange, there is a value at which assets are being sold and another value at which they can be bought. The difference between these prices is known as the spread. In order for a trade to be profitable, it must first overcome the value of the spread (Edelen, Evans, & Kadlec, 2012). A spread exists for all trades and can often make strategies unprofitable if the trader is not careful.

**Fundamental Analysis Vs. Technical Analysis**

Fundamental analysis and technical analysis are two different ways to effectively analyze the market. Both analysis techniques support the idea that the market follows trends and that trends in the market have the tendency to repeat over a period of time.
A trader who uses fundamental analysis believes that the market price of a stock or currency does not necessarily represent the true value of the company or currency. Conversely, a trader who utilizes technical analysis believes that the price of a stock or currency directly includes the fundamental elements.

**Fundamental analysis.** Fundamental analysis of the stock market involves the understanding of economic and political influence on the price value of stocks or currencies. Fundamental analysis also infers a degree of a trader’s psychological “gut feeling” of the movement in the price value of the stock or currency. The economics of fundamental analysis of company stock include observing the performance of a company and the performance of the industry in which the company is involved in. Economic factors of a company that are popularly reviewed are its profitability, income statement, balance sheet, and management effectiveness.

Political factors typically have a heavy impact on the value of currencies since most forex market movement corresponds with announcements from government officials. These statements regard the economics of countries and either report a past time frame’s economic statistics or informing the public of future economic plans. Examples of statistics given in these announcements are unemployment rates, industry growth, gross domestic product, inflation and bank interest rates. Most movement occurs before these announcements in an effort by currency traders to predict the movement of that specific currency value using psychological reasoning.

**Technical analysis.** Technical Analysis in regards to stock and currency pairs trading differs from fundamental analysis because it is the use of indicators on trade graphs to scientifically predict the movement of price values. Technical analysis relies
heavily on the historical prices and movement of a stock or currency to form a trend that a trader can use to understand the potential future of the prices and movement with considerable accuracy. Indicators, trend lines, and channels are tools that are commonly used to make such predictions.

**Basic Strategies**

Strategies are scientifically supported analyses that use historical data to make predictions of the future movement of a market. Charlie Wright goes into great detail about these strategies in his 1998 book, *Trading as a Business*. Successful utilization of each of the many strategies is dependent on several factors specific to each particular strategy. Every strategy is unique and the following strategies are general trade concepts that help distinguish the differences and uses associated with each one.

**Trend following.** A trend following strategy is a great method that uses historical data to predict the price movement of the market. A trend following strategy suggests that a downtrending market has the tendency to continue losing value while an uptrending market tends to continue gaining value. Although there are multiple ways to determine market trends, the pattern of high and low prices moving in the same direction up or down, is the best trend signal.

Trend following strategies trigger buys on upward moving markets and short sells on downward moving markets because the movement implies trends which signal these triggered reactions. An ideal trend following system remains in market for a majority of the time. The benefit of an ideal trend following system being in the market for a large majority of time is that there will be a high percentage of minimized losing trades and a low percentage of maximized winning trades. Ideal systems are able to capitalize on
large price movements that offset the high losing percentage enough to have a net profit.

Whether it is written in an automated system or used to by a manual trader in real time, the trader must decide on time frame and price change parameters to distinguish between an established trend and a volatile price fluctuation. Choosing these parameters wisely is crucial with any trend following strategy because an overly cautious system will buy into uptrends late resulting in smaller profits on winning trades and increase the chance of making less trades if market conditions are too volatile. An overly aggressive system will buy into uptrends prematurely, increasing the risk of buying into a false trend. The optimal mix of aggression and caution with regards to these system parameters, allows a trader to be in the market for longer periods of time, increasing the chance that they will catch large upswings.

**Volatility expansion.** Volatility expansion strategies spend the majority of time out of the market monitoring stocks with low volatility in the current time frame or recent history. Volatility expansion is essentially a quick profit strategy. A trader who utilizes volatility expansion has a set range that the price of the stock must exceed, in the positive or negative direction, before they react with a buy or sell short respectively. The set price range causes a delayed reaction to a moving market, but this delay allows the market to establish a definitive movement. The goal of this strategy is to enter the market quickly during a price movement and exit quickly with small profit as the market calms down.

Due to late entry in a market movement, profits of winning trades are fairly conservative. Alternatively, this late entry ensures a greater level of confidence in a
favorable transaction which results in a moderately high winning percentage with volatility expansion systems.

**Counter-trending.** Counter-trending strategies reflect the belief in there being ceilings and floors of established stocks. Ceilings and floors refer to there being a certain high or low point in market value that a stock will not break past. These lows and highs are established over a long period of time and are often viewed as support and resistance of a stock. The idea behind a counter-trending strategy is that a buy or sell short is triggered if the market price of a stock breaks through the low or high lines respectively. In theory, following the breakthrough, market prices will return to the range and continue to move in the opposite direction.

Relatively young stocks are not a favorable market to exercise counter-trending due to the high volatility and uncertainty of their price values. Fast entry is important to maximize profit gains of the price counter trends. In depth historical analysis of a stock’s highs and lows over a substantial period of time gives a trader peace of mind to know that there is considerable data backing to their strategy and thus results in a high winning percentage. Unfortunately, high winning percentage is supplemented with small profits per trade and there is a risk of sizable losses if a stock breaks through its ceiling or floor.

**Stop and reverse.** Stop and reverse strategies are similar to counter-trending strategies because they closely monitor the market and try to predict the change or flip of direction of market prices. Stop and reverse is different however, because it remains in the market for a majority of the time similar to trend following systems. The name stop and reverse refers to the immediate position exit and entry of the opposite position.
following the change of direction in the market. For example, if a trader is currently involved in a purchased long position and the stock value switches direction, the trader will quickly sell all shares in his position and sell short a new position in the same stock.

A system solely based on stop and reverse will only observe and consider the most recent changes in stock price when determining the directional movement of price. Often times, recent changes in price do not hold enough historical support to accurately analyze the direction of the market. The use of long term trend analysis or support and resistance lines to translate price movement is necessary to make well rounded decisions in a stop and reverse system.

Stop and reverse systems have high win percentages when balanced with other direction defining systems but generally lose money over time. Due to the extended periods of time in the market, there is potential for having large profit trades similar to trend following systems. There is also a potential for a high volatility market that changes direction often, to cause loss in profits due to commission fees associated with many small profit trades.

**Basic Tools**

**Trend lines.** A trend line connects a series of price points in a straight line which if extended can act as support and resistance of the particular stock or currency pair being analyzed. Depending on a company’s growth, trend lines can display negative or positive slopes. A negative slope represents a downtrend while inversely a positive slope represents an uptrend in growth. A downtrend signals a bearish market with increases in supply and the trend line acting as resistance for growth. An uptrend signals a bullish market with increases in demand and the trend line acting as support.
for growth. Trend lines use recent historical price data to predict the future movement of company stocks. The breakage of a price point below a supporting uptrend or above a resistance downtrend indicates a potential swing to the opposite respect.

An educated trader who uses trend lines takes into account factors like the number of price points used to concur the trend, price point spacing or time frame, and trend line steepness. If no price points break a trend line, then the trend line is accurately representing a trend. Trend lines containing significantly high steepness and drawn between price points too far apart or too close together are not valid enough to make adequate market judgements. Trend lines are best used as a warning of trend changes accompanied by the use of other analysis methods to form profitable trading strategies.

Japanese candlesticks. Japanese candlestick charts display the opening prices, closing prices, highs, and lows of a security. The reason candlesticks were invented was because the Japanese believed that the actual price of a stock does not reflect its true underlying value. Each candlestick chart represents price fluctuation within a specific time frame. An hourly chart would imply that each candlestick displays an hour of value change. A white or hollow candlestick closes higher than its open price and a color-filled candlestick closes lower than its open price. The body of the candlestick signifies the open and close price while the the thin lines above and below the body known as the shadows signify the high and low of the time frame respectively.

A candlestick with a small body and a long lower shadow but no upper shadow is categorized as a “hammer.” Hammers indicate a downtrend in the market. A candlestick with a small body and a long upper shadow but no lower shadow is categorized as a
“hanging man.” Conversely a hanging man indicates an uptrend in the market. The last categorized candlestick is known as a “doji” and it indicates a relatively unmoving trend. A doji opens and closes at nearly the same level causing it to resemble a cross.

**Moving averages.** Exponential and simple moving averages are tools used by investors to view price movement differently. They can take the noise of the market and distill it into a line that shows where the price is moving based on the given time frame of the moving average.

Simple moving average simply adds up the price total for each day included in the length of the moving average. For example if the moving average length is nine days, then the simple moving average would be the price for each of the previous nine days divided by nine. This gives an indicator that is a smoothed out version of the price movement. The simple moving average gives equal weight to each day’s price, giving rise to a slower moving average compared to the exponential moving average.

The exponential moving average gives more weight to the values closer to the current price. This way the exponential moving average mirrors price movement faster than the simple moving average. This means that line representing the value for the exponential moving average lies closer to the price than a slower moving average. If the moving average is the tool used for entering the market, then using an exponential moving average could get into the market sooner rather than waiting for the simpler moving average to reach the same value. This leads to two potential outcomes: entering the market too early and being misled by price movement, or entering earlier than with a simple moving average and catching more price movement leading to more money gained.
Moving averages can be used for many different reasons. One reason can be to determine whether or not a market is trending in a certain direction. This can be done by having two different moving averages with different lengths and seeing whether or not the fast moving average is above or below the slow moving average. A slow moving average with a large time frame which resists current price movement by including values from a longer period of time. A fast moving average with a shorter time frame would allow the line to mirror the price more accurately. Using a combination of these two indicators can show if the current market conditions are trending up or down. An uptrend would be happening if the fast moving average is above the value of the slow moving average. A downtrend would be occurring if the slow moving average is above the fast moving average indicating the long term average price has been above the shorter term average price.

Due to the trend spotting ability of moving averages, they can be used to trade changes in trends. If the fast moving average moves across the slow moving average, that indicates there is a change in the trend of the price movement. Trading at these intersections can be profitable. Longer term moving averages can create more reliable moving average crosses that predict longer term trends.

Not only can moving averages be used for tracking price movement and indicating the trend of a market, but they also can serve as dynamic support and resistance lines for price movement. When trading it is common to use moving averages as a trigger to get into or out of the market. This reason alone could be why some moving averages become support and resistance lines, due to the people trading as if they were these support or resistance lines.
**MACD.** The MACD basic indicator stands for “moving average convergence and divergence”. This tool can be used in order to spot trends, much like the moving averages it is calculated with. The indicator shows two moving averages in their own chart, accompanying a histogram with the value of the divergence. When the value of the difference is equal to zero then it is either an indication of a market with sideways trading or the trend is switching direction. The value of the histogram indicates the strength of the divergence.

**Bollinger band.** An interesting indicator that shows both price movement and volatility, are Bollinger Bands. They are comprised of a middle line which tends to be a simple moving average with an intermediate length, such as twenty days. The upper and lower band that extend past the simple moving average are standard deviations of the price movement. Typically the value for the standard deviation of both bands is two, two standard deviations above the price and two below the price. In statistics, standard deviations are used to represent data and the population of data that exist a given distance from the average. This means if the upper and lower standard deviation for the Bollinger bands is equal to two then 95% of the data must exist in the area between the bands and only 5% of the time will the price be located outside the lines.

Using the statistical approach to Bollinger bands leads to the realization that if the market traded according to statistics, then if the price moves beyond a Bollinger band that is two standard deviations away from the average then there will be a 95% chance that the trade will move in the direction so that the data will lie between the bands. Using this thought process, one could create a system that trades in between the bands, expecting the price to bounce between the two lines.
As many traders can attest to, the market does not like to listen to statistical information and sometimes when the price breaks out of the Bollinger band it creates a trend in that given direction. This is called a breakout. Breakout strategies can be employed in a variety of different ways. With regards to Bollinger bands, a breakout is when the price trades between the lines for an extended period of time, often with a narrow difference in Bollinger band values, then breaks up or below the bands creating an often drastic change in price, and along with it a widening of the Bollinger bands.

**True range.** The true range is the greater of the current high minus the current low, the absolute value of the current high minus the previous close, and the absolute value of the current low minus the previous close. Alone, the true range does not mean very much. The average true range (ATR) is a moving average of the true ranges over a given period of time. This value has many practical applications in trading such as measuring volatility, trend spotting, and verifying large movement (Average True Range (ATR), n.d.). One thing to take into consideration when thinking of using the ATR is that it is an absolute indicator; therefore it does not inherently show direction of movements.

**Manual Trading Vs. Automatic Trading**

The capabilities of the internet and computing technology revolutionized trading in the stock market. Today, there is the convenience of allowing a set of code to be written to create an automated trading system as opposed to manual trading, which has been the sole method of trading since the inception of the Stock Market in 1817. Manual trading has also come a long way since then with the development of online stock brokerages allowing traders to make trades from the comfort of their home or office without the need to call a broker to hand fill out a stock certificate to record the trade.
There is a tendency of manual traders to use fundamental analysis while automatic traders use technical analysis.

**Manual trading.** Manual trading is said to be a stressful process but with guided entry and exit strategies and a set of unique rules formulated by an experienced trader, it still has potential to be a very lucrative form of trading. Manual traders are disadvantaged by their own reaction time and tend to miss out on making the highest potential profit before a downtrend or being too late buying into a stock or currency that has a large uptrend. On the other hand, a manual trader who does adequate research of stocks or currency pairs may pick up on a tipped off downtrend. Whether it be a company’s announced product recall or a government’s announced refusal to to lower interest rates accompanied by increased unemployment rates within a specific time frame. In this case, a manual trader may sell their position to minimize loss before an automated system can receive enough information to recognize the downtrend and react accordingly depending on the code written.

Manual traders tend to stay in a position over a long period of time but oftentimes a manual day trader who plans to hold a position for a short period of time will be consumed by his own vices and keep a constant eye on his investments. This method of manual trading causes immense stress of loss and may result in a misconducted psychological decision to sell early instead of following the rules of their exit strategy, potentially costing them a significantly more profitable investment.

**Automatic trading.** Automatic trading has many advantages when compared with manual trading. An automatic trading system consists of a coded strategy instructs the computer to make observations of the movement of the market and react with
actions based on the commands written in the code. There is a degree of difficulty with writing code due intricacies being lost in translation. Sometimes, the way a trader hopes to implement a strategy and how to put it in a coded format that works properly can be counterintuitive or not immediately apparent. The benefits of a coded system often make the effort worth it.

TradeStation offers the ability to back test a developed system which enables the trader to refine their system and smooth out any errors based on how their system would have performed if it was executed in the past. Having the ability to back test an automated system instills an increased confidence in the trader by providing instant feedback on the success of their system and how it reacts to market swings. By executing actions automatically based on calculated data gathered from the market, the trader does not even have to watch their system much of the time. Therefore, a successful automated system relieves the stress and potential emotional discomfort that a manual trading system causes. The potential need for system refinement in the future is nearly inevitable due to certain unpredictable market swings or catastrophic change that the automated system is not prepared to handle. This infers that it is necessary to make routine checks of an automatic trading system and to not leave it running unattended for long periods of time.

The choice of manual trading or automatic trading directly depends on the preferences of the trader and the time they have available to trade and manage investments.
Why TradeStation and Scientific Analysis Were Key to Success

ShowMes, indicators and strategies. The TradeStation platform includes amenities which help traders visualize the market being traded. The chart window allows for the implementation of three major tools, ShowMes, indicators and strategies. These three tools can be created by any trader with access to the EasyLanguage platform.

EasyLanguage is TradeStation’s coded language which is responsible for creating automatic trading systems, indicators, functions and ShowMes. The system comes with a variety of stock code that comes in handy when coding. Predefined functions would include code such as “buy” and “sell” or even a plethora of functions that are the basis for indicators. EasyLanguage is rightly named due to the simplicity of the language.

ShowMes can help by finding certain market conditions and highlighting them with an image pasted onto the chart window. This functionality allows them to be useful when crafting rules for trading system by being able to picture situations that can be potential set ups, entries or exits.

Indicators can be applied to charts in order to visualize the price movement differently than a chart with just price bars. Essentially indicators are visual representations of functions defined in TradeStation’s EasyLanguage. Indicators can be based off of multiple inputs, such as price value at high, low, close or open or values that are not based on stock value but rather the volume of stocks being traded. Any indicator that is used to facilitate trading and market analysis can be used when creating a strategy in EasyLanguage.
TradeStation calls coded automatic trading systems in EasyLanguage, strategies. When a strategy is applied to a chart, TradeStation automatically calculates how that strategy would have traded with the historical data for the given time period. The chart shows when the trades took place, including the entry price and exit price. These trades can also be recorded by extracting key information into a csv file using a combination of functions. When TradeStation records the trades, it also performs a variety of tests with the data included in the performance report.

**Optimization and performance report.** TradeStation also allows strategies to be optimized, varying input values of the coded strategy and recording the best performance. Optimization can quickly find the best set of values necessary for the trading strategy to be most profitable. This type of optimization technique is subject to being over fit to the specific market that it is applied to. To avoid over fit data requires multiple optimizations for different markets or different time frames within a market, to find values that work in many situations. The performance report generated by TradeStation’s platform contains relevant information about how the strategy traded on the market it is applied to.

TradeStation performance report shows quality information about how the system traded including total net profit, profit factor, percent trades profitable and other pertinent information that helps picture how the system trades on the market. The profit factor is the amount of money gained by every dollar invested. Having a profit factor that is greater than one indicates that the system is profitable. The performance report also shows the maximum times that a system wins or loses consecutively. This is a comforting number to know when trading a system.
Walk forward analysis. A more dynamic system optimization technique is walk forward analysis which performs optimization for various overlapping time frames in historical data and records the data. The results from this optimization gives a set of input values that will be most profitable in the next traded time frame. This information is less likely to over fit the specific market due to the dynamic approach to optimization. A combination of strategy optimization and walk forward analysis is key to understanding the minutia of how trading systems perform and how they should be augmented to be more proficient.

Monte Carlo. Monte Carlo analysis is a method of analyzing large sets of data for the purposes of optimization and obtaining probability distributions (Monte Carlo Simulation, n.d.). The simulation that we used took the trades produced by our systems and rearranged them in a random order, allowing us to see the adverse effects of drawdown and develop confidence intervals for system profitability. Due to the nature of the Monte Carlo software we used, it was also convenient for us to analyze our system of systems with it. By combining our trades list from each system we could implement advanced position sizing analyses and test the full system for profitability.

Piecing Together the System

To facilitate gearing a trading system to a specific market type, three areas should be considered; the set up that tells the system that the market is primed and ready for a trade, the entry which is a specific set of rules that governs entering the market, and the exit which is the set of rules which gets a position out of the market. Designing a trading system with these three aspects in mind allows for a proper system to be built. The idea of breaking a trading system into components of set up, entry and
exit has been laid out in Charlie Wright’s book, *Trading as a Business* (1998). This view is pretty simple and allows for an efficient compilation of rules when piecing together a trading system.

With Charlie Wright’s trading system model in mind, the next step was to find a market to trade. Our newly founded hedge fund diversified by each individual choosing a different type of market to trade. Bjo_BollingerBand is designed to trade S&P 500 and NYSE stocks with moderate volatility, Market Open Bulls is designed to trade Forex currency pairs, and Hot Lists is designed to trade company stocks that fall inside the top twenty-five percent gainers of the five days preceding the current trading day.

By trading both Forex and stocks we have decreased overall risk by avoiding market specific risks, such as a decline in the stock market. Within stock trading, we diversify the systems by gearing them towards different market behaviors. Bjo_BollingerBand stays in the market for at least two days and works off of taking profit from market price swings that sometimes last for a few weeks. Whereas the hotlist trading system looks at which stocks are moving early in the day and tries to take advantage of that fast price movement.

In addition to market type, indicators should be used in systems to help visualize and describe price movement and help make decisions when to place trades. When it comes to applying indicators to these three different areas, Charlie Write suggests being creative. He suggests that if the popular trading indicators are used in a particular way that a creative system would implement them differently. For example if a common entry for a system happens to be when a nine day moving average crosses a twenty day moving average, then a more creative take on that system would be to use the
cross as a set up and change the short and long lengths to twelve and twenty-five respectively. Trading differently than other traders can give great advantages when it comes to profitability of the system. Being able to understand these three aspects of system design, market type, and implementation of indicators, allowed our team to craft unique trading systems.
Individual Trading Systems

Bjo_BollingerBand

Bjo_BollingerBand is a swing trading strategy that is applied to daily bars for stocks traded in the S&P 500 and NYSE. It uses a combination of three indicators in order to make appropriate trades. These three indicators are the Bollinger bands, a fast moving average, and the convergence and divergence of two slow moving averages. After applying a nine day simple moving average along with Bollinger bands, a pattern began to emerge with price movement staying within channels between the fast moving average and a Bollinger band. The fast moving average seemed to work as a resistance and support line that guided the price movement between the Bollinger bands. Bjo_BollingerBand attempts to take advantage of this relationship by trading the swings of price movement between opposing Bollinger bands, using the fast moving average as trigger into the market.

Setup. The setup for entering the market happens when the high or low price for the daily bar crosses two standard deviations away from the twenty day exponential moving average, also known as the upper or lower Bollinger band. This acts as a filter to only enter the market when the price is moving more rapidly towards the center of the Bollinger bands. Although the statistics indicate that 95% of the time you can predict the direction of the market after the price moves into this area, that is not always true. For this reason, the price movement beyond two standard deviations is not the entry for this strategy, but merely a way to enable entering the market in favorable conditions.
While optimizing the early form of this strategy it became apparent that having asymmetric Bollinger bands could give preference to either shorting or buying. Raising the lower and upper band would allow for more long orders because the price does not have to move as far down to set up a trade. When the Bollinger band is lowered then the strategy prefers to go short. This became advantageous when dealing with trending markets. The application of the divergence of two slow moving averages allows the strategy to be able to tell whether or not the stock is trending, how drastic the trend is and what direction the trend is moving in. This information allowed two asymmetric Bollinger band values to be applied in either an uptrend or a down trending market. The divergence of these two lines has to be above 2.5% the value of the close in order to trigger the asymmetry of the bands. When the divergence is less than 2.5% then the bands are symmetric and set to 2.2 standard deviations away from the exponential twenty day moving average.

**Entry.** The entry for this strategy is triggered when the price of the day moves beyond the fast nine day moving average coming from the respective Bollinger band from the set up. This allows the strategy to enter into the market after the market has shown signs of reversing price movement. Waiting until the price moves beyond this point will diminish returns by losing potential monetary gains from the Bollinger band to the fast moving average, however it allows the strategy to be more dynamic than a simple Bollinger band strategy that only works off of the price bouncing between the two Bollinger bands. A strategy like the one previously suggested, is subject to being faked out by the market by not having much information to make the decision.
Another reason for the fast moving average being the entry rule is that the fast moving average acts as a dynamic support and resistance line. When the price crosses below the fast moving average, it becomes the resistance line for upward movement. Considering this, when the price breaks beyond this resistance line it is a good time to enter long into the market, thinking that the price will resist falling below the fast moving average.

**Exit.** There are two exits that get bjo_BollingerBand out of the market. The first is when the price moves beyond the fast moving average in the opposite direction than the direction that allowed the strategy to enter the market. For example if the strategy enters long into the market than any time the price moves below the fast moving average the position will be sold. This exit rule is a bit cautious and sometimes exits the strategy prematurely. That being said, it also works as a trailing stop. As the market value changes the fast moving average will follow and lag behind. This allows the strategy to secure profits if the trade was initially successful and allows the strategy to exit if the trade was not initially successful.

The other exit in bjo_BollingerBand occurs when the price moves beyond 2.3 standard deviations beyond the opposing band than the band included in the set up. This means that after the entry, if the price continues to move in a favorable direction, so much so that the price moves 2.3 standard deviations out, then as soon as the price reverts back to less than 2.3 standard deviations out then the position is closed. This is included as an exit strategy in order to secure profits made by a soaring price that breaks through the Bollinger band in a favorable direction.
The final way out of the market in bjo_BollingerBand is when the stop loss value is reached. The stop loss is included in order to limit risk taken with each trade. This stop loss value is 2.5% of the close price. This means that if the market were to drop 2.5% without triggering other exits in the strategy then the stop loss will get you out of the market. The stop loss in combination with the fast moving average leave bjo_BollingerBand with low risk taken.

```plaintext
In[3]:= Input: AvrgLen(20), fastLen(9), val1(3), val2(3), StopL(2.5):
    variables: var1(true), var2(true), var3(true), var4(true), var5(true), SetStopL(1), StDevSell(2), StDevBuy(-2):

If Absvalue(average(close, 200) - average(close, 100)) > 0.02* Close then begin
    if average(close, 100) < average(close, 200) then var2 = true;
    if average(close, 100) > average(close, 200) then var2 = false;
End;

If var2 = True then begin
    StDevSell = 2.2 - val1;
    StDevBuy = -2.2 - val2;
    end;
If var2 = False then begin
    StDevSell = 2.2 + val1;
    StDevBuy = -2.2 + val2;
    End;
End;
If Absvalue(average(close, 200) - average(close, 100)) < 0.02*Close then begin
    StDevBuy = -2.2;
    StDevSell = 2.2;
    end;

If var1 = true and high crosses above average(close, fastLen) then buy next bar at market:
    //buy1
If var1 = false and high < average(close, fastLen) then sell next bar at market:
    //sell1
If high crosses above bollingerband(close, avrglen,2.3) and var1 = False then var3 = True;
If Close < BollingerBand(close, avrglen,2.3) and var3 = True then sell next bar at market:
    //sell2
If Close < bollingerband(close, avrglen,2.3) and var5 = True then var5 = false;
If high crosses above bollingerband(close, avrglen,StDevSell) then var3 = true;
If var3 = True and low crosses below average(close,fastLen) then sell short next bar at market:
    //short1
If low crosses below average(close,fastLen) then var3 = False;
If var3 = False and low < average(close,fastLen) then buycover next bar at market:
    //Cover1
If close crosses below bollingerband(close,avglens,2.3) and var3 = false then var3 = true;
If Close > BollingerBand(close, avrglen,-2.3) and var6 = True then buycover next bar at market:
    //Cover2
If Close > BollingerBand(close, avrglen, -2.3) and var6 = False then var6 = true;

SetStopL = Close*StopL;
SetStopLoss(SetStopL);
```

Figure 1.1 EasyLanguage strategy bjo_BollingerBand

The coded system. Figure 1.1 is the strategy file that shows the inner workings of the system. The inputs available for optimization are the lengths of the moving averages for the fast moving average and the Bollinger band, the variable for
determining asymmetry and the stop loss value. The “if then begin” section of the code calculates the divergence and sets the Bollinger band standard deviation values. If the divergence of 2.5% of close is not met then the standard deviation values are reset to be symmetric with the next “if then begin” statement. The next series of “if then” statements includes the setup, entry and exit of long position orders, indicated by the comments written in the code. The second series of “if then” statements is the section for selling short on the market also including setup, entry and exit. The last bit of code is the stop loss that is set with every trade.

**TradeStation performance report.** In order to depict how the performance report looks and can help create and adapt a trading system, bjo_BollingerBand was applied to a daily chart of COF from 4/30/13 to 4/30/15 as a model. Figure 1.2 is the chart of COF including an overlay of Bollinger bands and three moving averages. The cyan and red bands that surround and follow the price movement are the upper and lower Bollinger band which are used in the setup of this strategy. The moving average that passes through bars in the market most frequently is the nine day simple moving average which acts as the trigger in and out of the market. The purple and cyan moving averages that are nearly horizontal are the 200 and 100 day simple moving averages respectively. These are used in unison as a moving average convergence and divergence indicator that allows the system to determine the general market trend and based magnitude of this divergence decide if asymmetric Bollinger bands are preferable.
The performance report is shown in figure 1.3 on the left. The profit factor for this analysis was 2.58 for all the trades making it relatively profitable. The profit factor for long trades is 9.36 which is impressive along with the high win percentage of 85%. The image on the right of figure 1.3 shows the equity curve for trading COF from 4/30/13 to 4/30/15. The upward trend in the equity curve with little drawdown shows the system worked well with relatively low risk, in this market, in this time frame.
Figure 1.4 depicts how each trade performed while in the market, including the amount of drawdown experienced per trade. This parameter is important because a system can have a high net profit, but have many trades with low profit and high drawdown. This would mean the system spends most of its time as a losing trade. The performance of COF over this time frame showed high profit with low drawdown, with the highest drawdown being the 2.5% stop loss amount which was reached three times.

**Walk Forward Analysis.** Figure 1.5 represents the optimization of bjo_BollingerBand, varying the two values that determine the asymmetry of the Bollinger bands. This information is found by optimizing over the full time frame rather than the different time segments. The best average variables for this strategy applied to COF are -0.8 for var1 and 0.7 for var2. These optimal values change throughout time which is why walk forward analysis gives the optimal values for the next interval of time.
Figure 1.5 Walk forward optimization of var1 and var2 in bjo_BollingerBand applied to COF from 1/19/2001 to 2/24/2015

Figure 1.6 and 1.7 are distribution analyses that help view how the strategy performed over its time trading. This takes into account each trade made in each time interval with their given optimal conditions. For bjo_BollingerBand the data shows that most trades that make it past 11 days in the market are profitable trades and trades that stay in the market 6-10 days are 45% of the time profitable. This is a direct result from the first exit rule in the strategy which gets out of the market as soon as the price moves back beyond the fast moving average that got the system into the market. Most of the trades made in 1-5 days are losing trades due to the premature nature of the exit. Figure 1.7 shows that the average profit in each trade increases as the length in the market increases. Trades that occur in 1-5 days have an average profit of around -$50 while longer trades like from 6-10 days have an average profit of around positive $50. Unfortunately there are many more short trades than there are trades from 6-10, however the trades that are in the market longer than 11 allow the system to be profitable.
Figure 1.6 Distribution analysis of average percent trades profitable versus the number of bars per trade.

Figure 1.7 Distribution analysis of average profit per trade versus the number of bars per trade.

Figure 1.8 represents the pertinent information for the results of bjo_BollingerBand applied to this large time frame of 1/19/01 - 2/24/15. The system performed fairly well with a total net gain of 4.86%, but not spectacularly or well enough for application of this system. Through optimization, TradeStation will find the best values for this situation.
Figure 1.8 Performance of COF using bjo_BollingerBand from 1/19/2001 to 2/24/2015

<table>
<thead>
<tr>
<th>Performance Summary</th>
<th>2001/01/19 - 2015/02/24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Net Profit</td>
<td>$4,855.00</td>
</tr>
<tr>
<td>Gross Profit</td>
<td>$21,560.00</td>
</tr>
<tr>
<td>Gross Loss</td>
<td>$-16,705.00</td>
</tr>
<tr>
<td>Total # of trades</td>
<td>185</td>
</tr>
<tr>
<td>Percent profitable</td>
<td>30.27%</td>
</tr>
<tr>
<td>Number winning trades</td>
<td>56</td>
</tr>
<tr>
<td>Number losing trades</td>
<td>129</td>
</tr>
<tr>
<td>Largest winning trade</td>
<td>$1,994.00</td>
</tr>
<tr>
<td>Average winning trade</td>
<td>$385.00</td>
</tr>
<tr>
<td>Largest losing trade</td>
<td>$-500.00</td>
</tr>
<tr>
<td>Average losing trade</td>
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</tr>
<tr>
<td>Ratio avg win/avg loss</td>
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</tr>
<tr>
<td>Avg trade (win &amp; loss)</td>
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</tr>
<tr>
<td>Median trade</td>
<td>$-102.00</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>$320.48</td>
</tr>
<tr>
<td>Max consec. winners</td>
<td>4</td>
</tr>
<tr>
<td>Max consec. losers</td>
<td>9</td>
</tr>
<tr>
<td>Avg # bars in winners</td>
<td>13</td>
</tr>
<tr>
<td>Avg # bars in losers</td>
<td>3</td>
</tr>
<tr>
<td>Max intraday drawdown</td>
<td>$-2,946.00</td>
</tr>
<tr>
<td>Max intraday drawdown %</td>
<td>2.95%</td>
</tr>
<tr>
<td>Profit Factor</td>
<td>1.29</td>
</tr>
<tr>
<td>Return on Initial Capital</td>
<td>4.86%</td>
</tr>
</tbody>
</table>

Note: Drawdown % based on Initial capital

Figure 1.9 shows the data from the walk forward analysis from 1/19/2001 to 2/24/2015 showing how the system optimized for different overlapping time frames. The results from this test show the optimal parameters for the next given time frame and also gives a value of days until further optimization is necessary. For this optimization report, the optimal variables for the next 255 bars are -0.4 for var1 and 0.0 for var2.
Further optimization and Monte Carlo analysis. In order to perform a Monte Carlo analysis with the bjo_BollingerBand trading system that had significant statistical value, a list of many trades needed to be generated. The more trades available for the software to analyze the closer the statistical data will fit to future experimental data. To create the list, bjo_BollingerBand was applied to five different stocks including, KO, FDX, GILD, MET, and AMGN. Figure 1.10 is the equity curve of all of the trades by trade number in relation to time the stock was traded. The green area on the graph is the projected value of the portfolio with 95% statistical confidence. This depiction of the strategy is without any further optimizations using position sizing.
Figure 1.10 Equity curve for bjo_BollingerBand applied to five stocks from 1/17/14 - 3/26/15, including Monte Carlo analysis with 5%, 50%, and 95% confidence intervals

The image on the left in figure 1.11 shows the Monte Carlo results for bjo_BollingerBand trading the five previously mentioned stocks, from 1/17/14 to 3/26/15, at 95% confidence. The profit factor for this portfolio is 2.019 which a fair value for a swing trading system. The rate of return for this one year period of time is 9.43% with a max drawdown of 2.33% making it a relatively safe, profitable system for these markets in combination. With position sizing optimization for the lowest max drawdown value, results on the right of figure 1.11, the system performed equally as well in regards to net profit. The return of starting equity unfortunately dropped to 8.43%, however the max drawdown value also dropped to 1.67% which makes this position sizing more comfortable to trade, having inherently less risk and a higher return to drawdown ratio.
Figure 1.11 Confidence levels and results of Monte Carlo analysis for bjo_BollingerBand

Figure 1.12 is the results and equity curve of bjo_BollingerBand optimization for total net profit using position sizing. A twenty thousand net profit is equivalent to 20.6% return on the starting fund size. With a drawdown of 4.54%, the return to drawdown ratio is 4.55 which is comparable to the max drawdown optimization at 5.83 return to drawdown ratio which shows it is relatively safe to trade even with a drawdown higher than previously calculated. The main difference in this optimization is that there is more profit gained with the smaller wins by increasing their position size.
**Conclusion.** Although this strategy has been applied to stocks in the S&P 500 and NYSE, bjo_BollingerBand trades off of only information that can be taken from price values making it applicable to any market that trades. With a few adaptations for specific markets, bjo_BollingerBand can work as a formidable backbone for an advanced trading system. All of the data supporting bjo_BollingerBand as a solid trading system shows that this strategy is ready to be traded as an individual component of the system of systems.
Market Open Bulls – JPY

The Market Open Bulls strategy is a time of day strategy that was inspired by the 10 O’clock Bulls phenomenon. The premise of this strategy is that at different times of the day different markets open globally. At these times there are flurries of activity, similar to what happens as the New York Stock Exchange opens. Using these periods of high volatility it then becomes possible to form ceilings and floors to base strategies on.

Setup. The first step in the Market Open Bulls strategy is calculating a ceiling and a floor from which to make trades. To do this, a Forex Market must first be chosen. For this project, the Japanese market is used as the basis and as such all trading based on the parameters set is most effective for pairs involving JPY. After choosing a market, the ceiling and floor for the day will be set based on the high and low prices of a period before the market open. This period is generally three to five hours in length depending on the basis currency. With the ceiling and floor set, entries and exits may be applied.

It is critical that the strategy’s time parameters be optimized any time the exchange market changes. Assuming a single starting time proves to be ineffective and the use of a static period length severely hurts the strategy’s profitability.

Entry. To signal a buy or a short sell, the ATR is implemented. To test the system with EURJPY, if the value of the currency pair exceeds the ceiling by 10% of the true range then the strategy buys. Likewise, if the strategy drops 15% of the ATR below the floor a short sell is made. All trades made by this strategy are in standard lots of 100,000 units.

Exit. Generally, the strategy is always in the market either long or short so an
exit strategy is not entirely necessary. Still, additional exits can always improve the profitability of a system. A trailing stop helps to curb profit loss between transitions from long to short. For the JPY optimization, a trailing stop of 10,000 was most effective. As with the other parameters this must be optimized for each basis currency and in this case the importance is clear. A trailing stop of 10,000 JPY is approximately 84 USD. If USD were to be traded with the same parameters, a 10,000 USD trailing stop would be useless while trading single lots of currencies.

```plaintext
[LegacyColorValue = true ];

Inputs:
startime    (1500),
endtime      (1600),
trailing     (10000),
var1         (.15),
var2         (.15),
rangelnth    (6);

Variables:
Bardatetime.Hour         (0),
PeriodHigh                   (0),
PeriodLow                    (0),
TruRange                     (0),
TimeNow                      (0),
CurrentDay                   (-1);

CurrentDay = DayofWeek (Date);
TimeNow = Time;

IF CurrentDay = 1 then
  For TimeNow = startime to endtime begin
    IF PeriodHigh < High then PeriodHigh = High;
    IF PeriodLow > Low then PeriodLow = Low;
    TruRange = AveTrueRange(rangelnth);
  End;

IF Time >= endtime or Time < startime then
  IF PeriodHigh > 0 and open > (PeriodHigh + var1*TruRange) then Buy next bar at market;
  IF PeriodHigh > 0 and open < (PeriodLow - var2*TruRange) then SellShort next bar at market;

SetDollarTrailing(trailing);
```

Figure 2.1 EasyLanguage code for Market Open Bulls - JPY strategy
The coded system. In Figure 2.1 the full code for the Market Open Bulls - JPY strategy can be viewed. There are six inputs available for optimization, the starting time, the ending time, the value of the trailing stop loss, the two fractions that modify the ATR, and the range length for the ATR. In practice, the only two variables that will be changed are the two ATR modifiers. The other four inputs are for generalizing the system to currency pairs not involving JPY and only need to be optimized once after changing basis currencies. The first “if then” statement in the code sets the daily channel and ATR. The second set of “if then” statements sets the criteria for going long or short. Finally, there is a trailing stop loss order coded at the end that is implemented on every trade. It should also be noted that because of the way the system is coded it can only be traded on hourly bars.

TradeStation performance report. The strategy in Figure 2.1 was implemented on the EURJPY pair from 1/1/15 to 4/30/2015 to produce a model performance report. On the left side of Figure 2.2 is the strategy performance report for these trades. For this time period, no long trades were produced, so the data is entirely based on short trades. The profit factor is 2.20, which is a strong number for any system. Of the 1,451 trades, only 44.45% were profitable but the winning trades were much higher than the losing trades. Even with more than half of the trades being losses, the system made $49,525.77 in profit over the 4 month period. The equity curve for these trades can be viewed on the right of Figure 2.2. The curve has an upward trend indicative of the system’s profitability.
As can be seen in Figure 2.3, Market Open Bulls - JPY showed very little drawdown on each trade of EURJPY while still having high profits. This is shown more clearly in the right side of the figure which depicts the maximum adverse excursion. While at a glance it may appear that most positive trades go very negative to start, it is important to note that the maximum drawdown is less than $90. This is a negligible drawdown on the $100,000 account which was traded.
Walk forward analysis. In this section, please note that TradeStation does not account for currency conversions in its walk forward optimizer, so profit/loss values are inflated by a factor of approximately 130.

Figures 2.4 and 2.5 show the optimizations which were made on Market Open Bulls - JPY during a walk forward optimization from 1/1/2010 to 5/1/2015 on EURJPY. Figure 2.4 shows the optimizations for the start time and end time used to determine the ceilings and floors each day. The optimal numbers for this currency pair are 1500 and 1800 for start and end time respectively. In Figure 2.5, a similar optimization is shown for the variable ATR modifiers with 0.25 being optimal for var1 and 0.3 being optimal for var2.

![Figure 2.4](image1.png)

Figure 2.4 Walk forward optimization of the inputs starttime and endtime from 1/1/2010 to 5/1/2015

![Figure 2.5](image2.png)

Figure 2.5 Walk forward optimization of the inputs var1 and var2 from 1/1/2010 to 5/1/2015
The distribution analysis in Figure 2.6 shows the percent of trades that were profitable as a function of the number of bars per trade. This reveals that over the five year optimization, every trade that was open for 16 to 20 hours was profitable. Trades that lasted between 6 and 15 hours also performed well, but trades that lasted only 1 to 5 hours were profitable less than half the time. The vast majority of trades occur in this 1 to 5 bar range, so even though long trades perform well they do not occur frequently.

Figure 2.6 Distribution analysis of average percent trades profitable versus the number of bars per trade.

Figure 2.7 also shows a distribution analysis with the number of bars per trade, but shows the average profit associated with each interval. Each bar in the histogram is positive which indicates that for all time intervals the system is profitable.

Figure 2.7 Distribution analysis of average profit per trade versus the number of bars per trade.
Figure 2.8 provides a detailed look at the analysis of the walk forward optimization. The results from this test show the optimal parameters for the next given time frame and also gives a value of days until further optimization is necessary.

Figure 2.8 Data from the walk forward analysis from 1/1/2010 to 5/1/2015 showing how the system optimized for different overlapping time frames.

Figure 2.9 shows that the system had approximately a $470,000 profit over the five year test. The 44.09% trade profitability and 1.83% maximum intraday drawdown are consistent with the four month test case that was showcased earlier.
Monte Carlo system performance analysis. Figure 2.10 and 2.11 each represent the equity curve of Market Open Bulls - JPY as presented in our Monte Carlo analyzer. The currency used in these is EURJPY and the time frame is 1/6/2015 to 3/31/2015. In addition to the equity curve, Figure 2.11 also has a representation of the 5%, 50%, and 95% confidence intervals for the system’s profits. The way the equity curve dips slightly below the 95% line is reason for mild concern. This means there is potential for the system to underperform in some conditions.
Figure 2.10 Equity curve and share volume histogram for Monte Carlo analysis of Market Open Bulls - JPY

Figure 2.11 Modified equity curve for Monte Carlo analysis of Market Open Bulls - JPY with 5%, 50%, and 95% confidence intervals
Figure 2.12 contains a full list of the confidence levels for different important statistics as well as overall performance results for the Monte Carlo simulations. Since this report is done on a shorter time interval than the other reports, the net profit is only $13,357.51 before optimization for profit and $15,454.25 after optimization. After optimization, the system improved in almost all aspects except for an increase in the number of losing trades and worst case drawdown. However, the amount lost per losing trade was decreased after the optimization, lowering the average drawdown.
The results below the graph in Figure 2.13 show that when optimized for drawdown, the return to drawdown ratio of the system can reach 22.77 which is incredibly high. This result comes from the percent drawdown reaching as low as 0.68% and further justifies the system is a comfortable one to trade.

Figure 2.13 Market Open Bulls - JPY optimized for drawdown in Monte Carlo analysis

**Conclusion.** The Market Open Bulls strategy is a diverse tool for trading Forex markets that has proven to be secure and profitable. It shows that the 10 O’clock Bulls mindset can be applied to Forex successfully. The data gathered from our analyses further prove that the system is robust and ready to trade as part of our system of systems. By trading Forex, Market Open Bulls also adds a key component of diversity to our combined system which will improve its security overall.
Hot List Trading

The Hot List Trading System involves extensive use of the Hot List feature in TradeStation. The goal of the system is to formulate a narrowed down list, derived from the Hot List of the top twenty-five percent gaining stocks of the five days preceding each particular trading day. A long position is then purchased if a stock in the derived list meets a set of defined parameters.

Setup. The primary setup of a position involves the derivation of a formulated list which originates from the top twenty-five, percent gaining stocks of the five days preceding that particular trading day. The main goal of the derivation is to create a refined list of relatively low-risk stock to analyze, using technical and fundamental analysis strategies, and base trade decisions off of the corresponding data collected. Initial parameters that must be met are the net percent change must fall between 1 and 20 percent, price per share between $3.50 and $275, capital volume greater than $1,000,000, and trade volume greater than 1,000 trades.

The range of percent change of 1 to 20 percent is used because it gathers stocks, with relatively consistent growth, into the trade consideration group rather than stocks that have a significant gap up in value upon market open in the past five days. Also higher percent change usually implies that the stock price is low and potentially volatile, thus being a higher risk investment. The price per share range of $3.50 to $275 was chosen because stock prices cheaper that the low tend to have higher volatility and prices that exceed the high tend to have low trade volume and low demand causing a higher chance of decline. The $1,000,000 capital volume and 1,000 trades or greater trade volume, is imperative because they insinuate that the market has steady growth.
with a widespread distribution of assets among a large multitude of people which minimizes volatility risk. The reasoning behind each parameter aids in trading stocks that share similar characteristics and produce more consistent results with low risk.

**Entry.** Manual entry of any trade in the refined list of stocks is directly dependent on a moderate combination of technical analysis techniques on its fifteen minute chart. Most entries occur following 10:30am after the volatile movement of the opening markets have defined stock price movement of each particular stock for the short term.

Technical analysis entry rules involve a combination of volatility expansion and trend following. After opening chart analysis windows of each of the stocks in the refined list, volatility is assessed. This is done by scrolling back through the past 5 days of historical data to answer important questions about the direction the stock is moving that day. Certain questions asked are; was there a significant gap up at market open in the past five days, has the stock been consistently uptrending, has there been a lot of volatility, and is the stock defiantly uptrending in the present time frame? The aim of asking these questions is to narrow down the refined list into low volatility, uptrending stocks that are showing signs of having substantial positive growth during that trading day. The use of trend following is used to depict how the stock moves in reaction to the movement occurring in the first hour of open market. For instance, a stock may tend to uptrend following a gap down at market open or a stock may tend to downtrend if a stock experiences large fluctuations of volatility in the first two hours following market open. The primary way to take notice of these trends is to use moving average crosses to support the suspected continuation of upward or downward movement ensuing the first hour of open market.
Upon concrete technical evidence that the stock may continue in an uptrend, the purchase of a long position takes place with plans to exit at some point before market close at the end of the day.

**Exit.** The exit rules of the system are reactive towards the true movement of the stock price and how it compares with the uptrending theory required for the initial purchase of the long position. The sell of a profitable long position is triggered with relative correspondence to the slow moving average line approaching a cross above the fast moving average line. This cross allows for justification of the market price changing its previous uptrend. In the case of a losing position, an exit is triggered if it is clear that the stock price is definitively losing value. The net loss of a position is not to exceed $500. The duration of time spent in a long position does not extend past market close unless extenuating circumstances occur that demonstrate a benefit of staying in a position overnight and into the next day.

**Position sizing.** The sizing of long positions varies in shares purchased due to the differences there are in stock prices. Position size is chosen with regard to risking no more than $25,000 on one particular stock purchase and assessing the risk of a stock based on volatility and stock price. For instance, 5,000 shares of a $5 stock has too much risk because the volatility of the stock price can cause significant loss. Cheap priced stocks under $10 are typically bought in more modest position sizes. With this principle in mind, the adjustment of position sizing is necessary.

**TradeStation performance report.** The Hot List strategy was implemented on a multitude of stocks from 11/18/2014 to 3/27/2015. Throughout the four month period 36 trades were made on 20 different stocks. There was one major profit outlier during the
test period that was removed from the sample space of data. The outlier was a profit of approximately $5,000 and was the first trade made with the system. It was removed because it was not a true representation of the typical outcomes associated with the defined system. All trades in this time period were long positions and the total gross profit, not including the $5,000 outlier, was $3,831.21 accompanied by a gross loss of $1,812.81. The net profit was $2,018.40 with a profit factor of 2.11. Out of the 36 trades, 20 were profitable which proved the system to be profitable 55.56% of the time. Refer to Figure 3.1.

![TradeStation strategy performance report and performance report equity curve](#)

**Figure 3.1** TradeStation strategy performance report (left) and performance report equity curve (right) for Hot List Strategy
In Figure 3.2, the Hot List Strategy showed almost no drawdown on each profitable trade. The right side of the figure, which depicts the maximum adverse excursion, shows all the profitable trades on the left axis. Based on the axis labels on the graph, this implies that none of the profitable trades experienced drawdown. This is a revealing sign that the Hot List System managed risk very well.

Monte Carlo system performance analysis. Figure 3.3 and 3.4 each represent the equity curve of Hot List System as presented in our Monte Carlo analyzer. The time frame is 11/18/2014 to 3/27/2015. In addition to the equity curve, Figure 3.4 also has a representation of the 5%, 50%, and 95% confidence intervals for the system’s profits. The way the equity curve dips below the 50% interval implies that there is potential for the system to underperform in poor market conditions but since the tail-end of the trades fall within the 5% and 95% intervals, it is inferred that the Hot List Strategy will remain consistent.
Figure 3.3 Equity curve and share volume curve for Monte Carlo analysis of Hot List Strategy

Figure 3.4 Modified equity curve for Monte Carlo analysis of Hot List Strategy with 5%, 50%, and 95% confidence intervals
Figure 3.5 contains a full list of the confidence levels for different important statistics as well as overall performance results for the Monte Carlo simulations. According to the figure, after 10,000 Monte Carlo samples the net profit is $1,276.43.

After optimization of fixed fraction of the Hot List Strategy, the net profit becomes $7,067.47 with the maximum drawdown being $3,561.62. The optimized system has a Sharpe ratio of 0.4142, and a profit factor of 1.49.
Conclusion. The Hot List Strategy is a great strategy for manual traders who have adequate time to analyze stocks. Due to the time demand of the analysis, further optimization is necessary to make the system more profitable and consistent. There is potential for creating a coded system that utilizes all of the initial stock derivation parameters. An automated system would make for a much less time demanding system which would allow the trader to focus more on making tweaks to optimize the system instead of spending a majority of the time managing positions open in the market. Refinement is also necessary to maximize profits during uptrending market conditions to make profitable trades more profitable and negate the losing trades.
How the Individual Systems Work Together

After running analyses and optimizations on our systems we developed a system of systems. With the profitability of the individual systems verified, we analyzed the profitability and stability of the systems combined to determine that the most effective distribution. To do this, we first determined key characteristics that we wished to improve by creating a system of systems. Characteristics we considered include drawdown, equity curve, expectancy, and expectunity.

Drawdown

The drawdown of a trade is defined as the maximum loss potential over the course of the trade and it can be used to measure system quality. In our Monte Carlo analyses, the maximum percent drawdown at optimum was calculated. This percentage represents the drawdown of a system relative to the size of the account being traded, so the lower the number, the stronger the system. For example, with a maximum percent drawdown of 5% a system can be expected to never be in the negative more than 5% of the trader's capital at any given time. The max percent drawdown for our systems at 95% confidence are 1.592% for bjo_BollingerBand, 1.052% for Market Open Bulls - JPY, and 0.5753% for Hot List Strategy. The max percent drawdown for our systems at optimal efficiency are 4.54% for bjo_BollingerBand, 0.68% for Market Open Bulls - JPY, and 0.13% for Hot List Strategy. These numbers are low enough that we can be confident in the quality of our individual systems.
Monte Carlo on the portfolio

Figure 4.1 and 4.2 show the equity curve for the portfolio containing our hedge fund’s three strategies that were optimized for net profit. Figure 4.1 shows the Monte Carlo confidence intervals for the entirety of the chart, while figure 4.2 shows the projected equity curve after using the data for the first 725 trades out of the 1000 trades taken.

Figure 4.1 Equity curve for the three systems with Monte Carlo confidence intervals

Figure 4.2 Equity curve for the three systems with projected Monte Carlo confidence intervals
The software used when performing Monte Carlo analysis could also optimize portfolios by dividing up the assets between the component systems, seen in figure 4.3. The results for net profit for our portfolio show that 39.85% of our total funds should be allocated towards bjo_BollingerBand while 3.125% of the funds go to Market Open Bulls and 0.0% towards the hot list trading strategy. This fixed fraction value for each system will be used when deciding how to allocate money.

![Optimized for Net Profit](image)

Figure 4.3 Money allocation to each system optimized for net profit

The total portfolio without optimization performed well with have a return of 27.28% at 95% confidence. The max drawdown for the systems together is 5.38% giving a return to drawdown ratio of 5.77. This can be seen on the left side of figure 4.5. The right side of figure 4.5 shows the results for the optimization of the portfolio for net profit. Under the most optimal conditions for position sizing and money allocation, our net profit is 37.58% with a max drawdown of 4.04%. The return to drawdown ratio went up to 9.28 and the profit factor went up to 1.86. Though these values are more profitable and less risky based on max drawdown, further optimization for return to drawdown ratio would help limit risk taken.
Figure 4.4 Confidence levels and results of Monte Carlo analysis on system of systems.

Figure 4.5 is the equity curve for all of the systems optimized the money allocation and position sizing for the return to drawdown ratio. The fixed fraction of each component system can be seen in figure 4.6. The result from optimization gave a return to drawdown ratio of 27.97, almost three times the value given by the net profit optimization. Due to this high return to drawdown value, we took the fixed fraction of each system to use in the final money allocation.
Expectancy and expectunity

Expectancy and expectunity are terms used when dealing with system quality. Expectancy is the profit or loss per dollar risked on the market while expectunity is the expectancy multiplied by the number of opportunities to trade per year (Van Tharp, 2006). System quality is the annualized expectancy divided by the variability of
profit/loss per trade. Comparing these values between the three systems allows our team to strategically allocate money based on the system quality ratios. Below are the calculated results for the expectancy, expectunity, system quality and money allocation based on system quality. This value in combination with the fixed risk sizing method will determine the fraction of funds allocated in each strategy.

<table>
<thead>
<tr>
<th></th>
<th>BJO_BollingerBand</th>
<th>Hot List</th>
<th>Market Open Bulls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectancy</td>
<td>0.50</td>
<td>0.50</td>
<td>0.30</td>
</tr>
<tr>
<td>Annualized Expectancy</td>
<td>40.36</td>
<td>50.42</td>
<td>1148.82</td>
</tr>
<tr>
<td>System Quality</td>
<td>1.89</td>
<td>1.50</td>
<td>5.01</td>
</tr>
<tr>
<td>Fraction Money</td>
<td>0.224782917</td>
<td>0.178984168</td>
<td>0.596232915</td>
</tr>
<tr>
<td>Allocated to Each</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Allocation of money**

The $300,000 that our hedge fund manages will be divided into each system by using a combination of the expectunity and the results from the two different portfolio optimizations. We used the sum of the fixed fractions for each portfolio optimization. The total fixed fraction sum allocated 55% of the funds. The remainder of the funds were divided by using the expectunity results. The final calculated percent for each system are 55.27%, 36.85%, and 7.88% for bjo_BollingerBand, Market Open Bulls, and the Hot List trading strategies respectively. This equates to $165,800 towards bjo_BollingerBand, $110,500 for Market Open Bulls and $23,700 for the Hot List strategy.

These values are subject to change as the system trades and updates the system quality values. The values may also be changed if inconsistencies arise in the markets we trade. For example, if there is a massive United States recession like the
one experienced in 2008, more weight would be placed in Forex. We believe that by dividing our funds in this manner to begin the trading process we will minimize risk taken while still having a high return.
Conclusions

Through the process of creating trading systems, our amateur hedge fund learned much about how to handle finances through trading and investing. Our end product is a portfolio comprised of multiple strategies aimed at profiting off of different types of markets and market conditions. The aggregate equity for both the return to drawdown ratio and the net profit optimizations show that this portfolio performs well with a high yield and low drawdown.

We have proven through scientific analysis that each of our systems is profitable and secure. As a result, not only can we feel confident that our system of systems is profitable and secure, but we also have shown methods that traders can use to feel confident in creating their own trading systems. By this measure, we feel that our work to become knowledgeable traders has been successful. In the future we will possess the skills to be able to be profitable traders should we choose to.

Further Work

With more time to develop this project, our team would be interested in broadening the scope of our system. There are time intervals that we did not consider in the development of our component systems and markets that we were not interested to explore immediately. Investing in more markets is never a bad idea as diversity greatly decreases the likelihood of anomalies ruining profits. In a similar vein, longer term trading over the course of months or years would also add extra layers of diversity to the system.

Another way that we could improve the system with further work is by developing a system that determines how to best allocate funds. We did not consider market
conditions when developing our system of systems, so formalizing the distribution of assets to the component systems based on such conditions may improve robustness. This would be especially important if we increased the number of systems to include more markets. By incorporating these ideas, we can improve the security of our system and its profitability.
References


Bysshe, G. (2004). Why is the opening range (or) so important?, Trading the 10 o'clock bulls: Winning strategies for active traders (pp. 7-10). Market Gauge, LLC.


Appendix

Recommendations/Disclaimer

The capabilities of the internet revolutionized trading in the stock market with an added convenience that allows anyone with a computer, tablet, or smartphone with internet access to trade stocks. The easy accessibility of online brokers has caused many people to believe that they can walk in off the street and become a trader. In some respects this is true after proper time is invested in learning the ins and outs of the stock market as well as the strategies necessary to analyze the market.

Although there is a high potential to be a successful trader and earn substantial profits, there is an even higher chance that all money invested may be lost without proper understanding of the stock market. It is recommended that any sum of money invested by a trader is a sum of money that they can afford to lose without compromising financial stability over their everyday expenses.

For traders adamant on trading on their own without paying a money management professional, using a simulated money management system is highly recommended until a trader gains adequate experience and confidence in their abilities to trade real money without psychological factors affecting their set rules of analysis and judgement. Learning about automated trading and developing a successful automated system helps alleviate the psychological effects of trading real money and enables the trader to have more free time away from their computer.