

**Stock Trading Systems:
Analysis and Development of a System of Systems**

An Interactive Qualifying Project

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Abstract

The goal of this project is to gain experience with trading the stock market by experimenting with automated trading systems. The project consisted of three trading systems that operated on different time frames and rules. After each system was established, it was combined with the others into a system of systems to which simulated money was allocated based on the quality of each individual system. This paper will describe and analyze each system individually and as a system of systems.

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Table of Contents

Abstract.....	2
Acknowledgements.....	3
Table of Contents.....	4
Table of Figures.....	6
Introduction.....	8
Research and Background Information.....	9
An Introduction to Asset Classes.....	9
What are Equities?.....	9
How are Currencies Traded?.....	9
Why This Project Traded Equities.....	9
An Introduction to TradeStation.....	9
What is a Trading Platform?.....	9
What are Indicators?.....	10
Strategies and their Components.....	10
Entry Rules.....	10
Exit Rules.....	11
Benefits and Disadvantages of Automatic and Manual Trading.....	11
Types of Trades.....	12
Types of Orders.....	12
What is meant by a System of Systems?.....	13
Benefits of a System of Systems.....	13
Gap Terminology: What is a Gap?.....	13
Types of Gaps.....	14
Relative Strength Index (RSI).....	15
Trend Following Terminology.....	16
Moving Average Crossovers.....	17
Bollinger Bands.....	18
Volatility Expansion Terminology: Average True Range.....	19
Description of the Systems.....	19
Gap Strategy.....	19

Gap Up and Breakout	20
Gap Up and Gap Fill.....	21
Gap Down and Breakout	21
Gap Down and Gap Fill.....	21
Trend Following Strategy.....	22
Volatility Expansion Strategy	23
Analysis of the Systems	25
Development and Analysis of the Gap Strategy	25
Choosing a Stock.....	25
Choosing an Indicator.....	27
Back-Testing, Walk-Forward, and Analysis of the Gap Strategy	28
Evaluating the System using Expectancy, Expectunity, and System Quality	31
Monte Carlo Simulation and Position Sizing	32
Development and Analysis of the Trend Following Strategy	36
Development and Analysis of the Volatility Expansion Strategy.....	38
Technical Analysis of the System	39
How the system performs with BEAM	40
How the system performs with V	45
How the system performs with ADBE	49
System Comparison and System of Systems Analysis	53
Conclusions and Looking Forward.....	54
Works Cited	57
Appendices.....	60
Gap Strategy Code	60
Gap Up.....	60
Gap Down.....	61
Trend Following Strategy Code	62
Facebook Strategy	62
Google Strategy	63
Volatility Expansion Strategy Code.....	64

Table of Figures

Figure 1: TradeStation Account Growth.....	8
Figure 2: Gap Illustration.....	14
Figure 3: Moving Average Crossover Illustration	18
Figure 4: Bollinger Bands Illustration	18
Figure 5: Volatility Expansion Strategy	24
Figure 6: Gap Up History Summary.....	26
Figure 7: BP Back-Testing Performance Summary	29
Figure 8: BP Equity Curve	29
Figure 9: Gap Optimized Parameters	30
Figure 10: Walk-Forward Results.....	31
Figure 10a: Gap Up Longs	31
Figure 10b: Gap Up Shorts	31
Figure 10c: Gap Down Longs	31
Figure 10d: Gap Down Shorts	31
Figure 11: Gap Strategy Analysis Results	32
Figure 12: BP Monte Carlo Simulation	34
Figure 12a: BP Monte Carlo Simulation and 95% Confidence Interval	34
Figure 12b: BP Monte Carlo 95% Confidence Interval Prediction	34
Figure 12c: BP Equity Curve Before Fixed Fractional Position Sizing	35
Figure 12d: BP Equity Curve After Fixed Fractional Position Sizing	35
Figure 13: Facebook Back-Testing Performance Summary	36
Figure 14: Google Back-Testing Performance Summary	37
Figure 15: BEAM Analysis	40
Figure 15a: BEAM Optimized Parameters	40
Figure 15b: BEAM Back-Testing Performance Summary	41

Figure 15c: BEAM Efficiency	42
Figure 15d: BEAM Equity Curve	42
Figure 15e: BEAM Walk-Forward Cluster Analysis	43
Figure 15f: BEAM Walk-Forward Results	44
Figure 15g: BEAM System Quality	44
Figure 16: V Analysis	45
Figure 16a: V Optimized Parameters	45
Figure 16b: V Back-Testing Performance Summary	46
Figure 16c: V Efficiency	46
Figure 16d: V Equity Curve	47
Figure 16e: V Walk-Forward Cluster Analysis	47
Figure 16f: V Walk-Forward Results	48
Figure 16g: V System Quality	48
Figure 17: ADBE Analysis	49
Figure 17a: ADBE Optimized Parameters	49
Figure 17b: ADBE Back-Testing Performance Summary	49
Figure 17c: ADBE Efficiency	50
Figure 17d: ADBE Equity Curve	51
Figure 17e: ADBE Walk-Forward Cluster Analysis	51
Figure 16f: ADBE Walk-Forward Results	52
Figure 17g: BEAM System Quality	52
Figure 18: System Quality Comparison	54

Introduction

In today's economy, many people consider financial security to be of a paramount importance. Electronic trading platforms provide individuals with opportunities to trade in the stock market, which they would otherwise not have. Due to this, many people engage in trading without the proper background and knowledge. This exposes them to a great deal of risk as they try to enter the world of professional trading. Instead of securing their financial future, many people are putting their savings at risk.

Financial security has been a growing concern since the worldwide recession in 2008. People have started taking it upon themselves to control their personal finances, rather than relying on other institutions. For instance, 401K accounts have grown in popularity over the years. Not only are 401K accounts cheaper for employers to provide, but the employee decides where their money is invested. They provide employees more control over their personal finances (Wall Street Journal, 17 April 2014). Furthermore, personal savings are an important part of preparing for retirement. But, reinvesting money is more practical and proactive than leaving it in a bank. This, along with the availability of electronic trading, has led to the growth in the popularity of trading. Without employing a proper trading strategy, however, the stock market can be a dangerous place for everyday people to allocate their money.

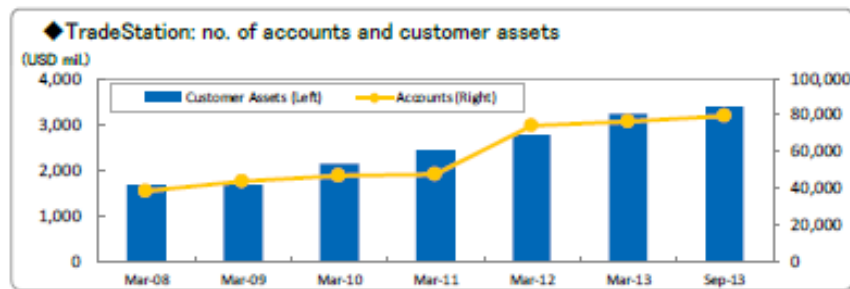


Figure 1: TradeStation Account Growth (Forex Magnates, 1 May 2014)

The primary purpose of this Interactive Qualifying Project is to create a trading system that would be able to generate a profit from the stock market. This was accomplished by experimenting with trading systems over time and studying patterns in the stock market in order to exploit them. In order to increase the chances of making a profit, each student developed a trading system individually. Each individual system was then combined into a robust system of systems.

Research and Background Information

An Introduction to Asset Classes

What are Equities?

Equities, or stocks, represent ownership in a company. They are also one of the main ways for companies to raise capital. In the United States, the two main equity markets are the New York Stock Exchange and the NASDAQ. In the United States, equity markets open at 9:30 AM and close at 4PM Eastern Time.

How are Currencies Traded?

Currencies are traded in pairs on the currency market. Unlike equities, currencies can be traded almost any time at all during the week, but the currency market does close each weekend. Additionally, currencies are not traded on a central exchange like stocks. In other words, currency trading does not have any exchange comparable to the New York Stock Exchange or the NASDAQ (Schlossberg). Another unique aspect of currency trading is that it can be highly leveraged. The amount of leverage depends on the broker, but currency trades could be as highly leveraged as fifty to one. If a trader's leverage was fifty to one, for an account of \$1000, they could trade up to \$50000 worth of currency.

Why This Project Traded Equities

This project traded equities because trading shares of stock was more comfortable than trading currency pairs. Another benefit to trading stocks is that the stock markets close every night, which relieves traders of the obligation to stay up at night watching their trades. Additionally, the fact that the stock market closes every night allows the use of different trading strategies, such as gap strategies, to trade stocks.

An Introduction to TradeStation

What is a Trading Platform?

A trading platform is software that anyone can use to buy and sell different financial assets. Trading platforms are run by brokers who buy and sell assets for customers. For this project, TradeStation was the trading platform of choice. There is usually a fee attached to having an account with a trading platform and there are also commission charges for each trade that is made. Trading platforms have helped change the trading world because now nearly anyone can be an active participant in the market. Trading platforms also are equipped with a

variety of tools that allow traders to take analytical approaches to their trades. Since this project involved using TradeStation, an explanation of some of the tools that are provided by TradeStation has been included.

What are Indicators?

An indicator is one type of tool provided by TradeStation. An indicator is a statistical measure that allows for the analysis of economic trends (TradeStation). As a trader, one looks at different indicators to try to predict the future behavior of a stock or the market as a whole. If a trader discovers that a stock moves in a predictable manner relative to what an indicator is showing, they can exploit that behavior by buying or selling that stock when the indicator exhibits that behavior. Then, the trader can take a position in the market before the price begins to move in the direction that the indicator predicted. TradeStation provides several pre-programmed indicators on its platform, but traders can also create their own indicators.

Strategies and their Components

A trading strategy is a set of rules for buying and selling financial assets. These rules are usually based on information provided by one or more indicators. TradeStation provides its own pre-programmed strategies, but its platform also allows traders to create their own strategies. Strategies are a crucial part of successful trading because they are composed of a well-defined set of rules that predict future market behaviors based on historical data. Without this knowledge it is impossible to predict the movement of the market. There are several different components in one trading strategy. For instance, in order to have a complete trading strategy, one must have entry rules, exit rules, position sizing rules, and sometimes timeframe rules.

Entry Rules

Entry rules are the part of a strategy that puts you into the market. If the entry rule conditions are met, then a buy or sell short order is placed. There are three different types of entry rules. The first are set-up rules. These are rules that prepare a trader for an upcoming trade. For instance, in a gap strategy, a set-up rule may be “If the open of the day is higher than the high of yesterday”. If this condition is met, the trader knows that a trade may be coming up in the near future. The next type of entry rule is a trigger rule. This is the rule that actually produces an order and it should be designed to get a trader into the market at the optimal time. An example of a trigger rule is “If the long-term moving average crosses over the short-term

moving average, then buy 100 shares”. The last type of entry rule is called a filter. This is a rule that prevents a trade from being executed for some specific criteria. A simple filter rule is “If there have been no trades today”. This filter rule prevents more than one trade being executed in a day. Entry rules can be a difficult thing to balance. On the one hand, a trader wants enough rules to keep them out of bad trades, but on the other hand, a trader cannot have so many rules that they only make a few trades a year.

Exit Rules

Exit rules are rules that remove a trader from the market. Ideally, exit rules end a trade while a trader is making a profit. Exit rules are also an important part of controlling losses. Some examples of exit strategies are exiting after a set number of bars, exiting after a long and a short moving average have crossed over again and exiting after a gap has been filled. Of course, different exit rules work well with different strategies and it is a matter of testing and experimentation to find rules that work with a particular trading system. Another important part of exit rules are stop losses and profit margins. These are more specific types of exit rules. Stop losses protect traders from large losses by removing them from the market if they lose a specific dollar amount on a trade or if they lose a certain percent of capital on a given trade. A stop loss is set at the largest amount that a trader is willing to lose in one trade. A profit margin is based on a similar idea. A profit margin is set at a dollar amount, or a percentage of capital that a trader would be satisfied with winning in one trade. By using a profit margin, a trader is saying that the potential benefits of staying in an already good trade do not outweigh the risks of staying in that trade. Clearly, stop losses and profit margins are important tools in managing trading risk.

Benefits and Disadvantages of Automatic and Manual Trading

Manual trading is a process in which a trader analyzes markets and assets and decides for themselves which trades to take. This is the more traditional form of trading. On the other hand, automatic trading relies on programming strategies that will alert traders when an available trade meets their criteria. This is not to say that manual trading is not scientific compared to automatic trading. In fact, traders that use both methods still need to develop rules for themselves that they believe will lead to profitable trades when followed. Though there has been a recent shift in popularity from manual to automatic trading, many traders still employ elements of manual trading. Essentially, they are trading a mix of both types of trading (Kennedy, 9 April 2014). As

one might imagine, there are benefits to both trading techniques. The benefits of automatic trading are that a computer always follows the trading rules perfectly, it will not make order mistakes, it can handle more information than a human, a computer will not miss a buy signal and computers do not get tired. On the other hand, there are also advantages to manually trading. For instance, humans can take into consideration the whole global economy when making a trade. Also, humans can sense when a trade is not going well or when a trade is not moving quickly enough and can reason to close the trade (Tucci, 7 April 2014). Traders that combine these two styles of trading are trying to get the best of both worlds by combining the precision of an automated trading system with the logic of human reasoning. For instance, a trader may set up an automatic trading system, but may choose to reject some trades that the system suggests based on the overall state of the economy, which is a factor that an automatic trading system cannot take into account. For this project, automatic trading systems have been used because of the accuracy and ease of executing trades.

Types of Trades

In stock trading, a long trade is when a trader buys shares anticipating that the value of a stock will increase. When the trader wants to get out of the trade, he/she will sell the shares that he/she bought and will earn a profit or loss based on the spread of the buy and sell prices.

A short trade in stock trading is slightly more complicated than a long trade. By shorting a stock, traders mean that they are initiating a trade by selling a stock. In order to sell a stock that they do not initially possess, a trader must borrow that stock from someone, usually a broker. After they sell the stock, they buy it back at ideally a lower price than they sold it. Then, they give the borrowed stock back to the broker. This is one way that a trader can take advantage of a decrease in price.

Types of Orders

A market order is placed when a trader wants an order filled as soon as possible. The trader will get their order filled, but not necessarily at the price that is best for them. Instead, they settle for buying or selling at market value. In contrast, a limit order is set at a specific price or better. Thus, a trader is not guaranteed that their order will be filled. There are clearly advantages to either type of order and traders sometimes just choose an order type based on their preference. Another type of order is a stop order. Stop orders are orders that trigger market or

limit orders once a specific price level is reached. Stop orders can be used as a tool to confirm the direction of the market before entering a trade.

What is meant by a System of Systems?

For this project, the final trading system was a combination of three different trading systems. Each member of the project group designed and tuned one trading system with input and advice from other members. The three systems that have been developed are a gap strategy, a trend following strategy and a volatility expansion strategy.

Benefits of a System of Systems

Trading experts agree that there is no “Holy Grail” trading system. No system works all the time and trading the stock market is never easy (Mitchell, 8 April 2014). But, one’s odds of making money in the stock market can be improved by using multiple systems. For instance, a longer term system that is resistant to market noise can work well with a shorter term system to create a more consistent and robust system of systems (Wyckoff, 6 April 2014). The major attraction of using a system of systems in trading is that it provides diversification. The three systems in this project trade using different indicators, different frequencies, and different timeframes. This type of diversification is desirable because when one strategy is performing poorly, the other systems are not exposed to the same types of risk and variance as the poorly performing strategy and should continue to perform well. This will result in more even growth over time and will help prevent large consecutive losses.

Gap Terminology: What is a Gap?

In trading, a gap occurs when the open of one bar is at a different price level than the close of the previous bar (Seven Trading Systems, 10 January 2014). Usually, gaps are looked at on a daily scale. This means that traders say a gap occurs when the open of the day is at a different price than the close of yesterday. Naturally, there are two basic forms of gaps: gaps up and gaps down. Most traders consider a gap up as the open of the day being higher than the close of yesterday and a gap down as the open of the day being lower than the close of yesterday. However, for the gap trading system in this project, a gap up is recognized only if the open of the day is higher than the high of yesterday and a gap down is recognized only if the open of the day is lower than the low of yesterday.



Figure 2: Gap Illustration (StockCharts, 6 April 2014)

It is also important to consider what causes these gaps. Gaps occur because traders place buy and sell orders before the market opens, causing the opening price for the day to be different than the close of the previous day. But, why are so many orders being placed before the market opens? One reason is that news about a company may have been released after the close of the market on the previous day (StockCharts 6 April 2014). So, the opening stock price is trying to correct itself to reflect that news. These gaps can be analyzed and used as the basis for many different trading strategies.

Another important note is that when traders talk about gaps, they are usually referring to gaps in stock prices as opposed to currency pairs. This is simply because the stock market closes every day, which means that each morning a stock may have gapped. The currency market, however, only closes once a week. So, there can be at most one gap a week in a currency. Simply put, there are more opportunities to trade gaps with stocks than with currency pairs, so stocks are generally traded with gap strategies.

Types of Gaps

Once a stock has gapped, there are several patterns and behaviors that traders look for in the stock price. These behaviors usually become the basis for a trading system. In this project, two different behaviors have been explored: filling the gap and breakouts.

Filling the Gap

The term filling the gap usually refers to the situation in which the price of a stock that has gaped returns to the price at the close of the day before. For example, if BP had closed at 47.50 yesterday and then gapped up to 48.00 today, BP is said to have filled the gap if its price reaches 47.50 again today. So, if you were a trader and you expected BP to fill the gap, you would short BP at the open and then buy to cover once BP had filled the gap. This is just one example of how this pattern can be incorporated into a trading system.

Breakouts

A stock that has a breakout behaves the opposite of a stock that fills the gap. If a stock gaps up, then there is a breakout if the price of the stock continues to increase. If a stock gaps down, then there is a breakout if the price of the stock continues to decrease. For example, if BP closed at 47.50 yesterday and then gapped up to 48.00 today and we expected a breakout, we would buy BP at 48.00 a share at the open because we would expect the price to keep increasing. Breakouts and filling the gap are two behaviors that will be traded by the gap trading system portion of our project.

Relative Strength Index (RSI)

The Relative Strength Index was created by J. Welles Wilder in 1978 (Thygesen, 4 April 2014). The RSI is a well known and widely used indicator. This indicator measures momentum by comparing the extent of a stock's recent gains and losses by transforming this info into a number between 0 and 100 (Thygesen, 4 April 2014). There are two numbers which are important when using the RSI as an indicator. The first is the overbought level and the second is the oversold level. These levels can be used as signals to buy or sell a stock. For instance, if a stock has an RSI above the overbought level that means that there is recent momentum in the stock. But, once the RSI falls back below the overbought level, this can be taken as a sell signal because it indicates that the stock has recently lost momentum. When he created the RSI, Welles Wilder suggested that traders use a value of 70 to indicate that a stock is overbought and a value of 30 to indicate that a stock is oversold (Nathan, 9 April 2014). But, many traders deviate from this suggestion and use more restrictive overbought and oversold levels. This makes their trades more selective and more likely to be profitable. Another part of the RSI that traders can manipulate is the number of bars that the indicator looks at. Welles Wilder suggested that the indicator use a length of 14, but different traders may use different lengths based on their trading

system (StockCharts, 7 April 2014). For example, a scalping system would want to use a shorter length, since they are looking for many small, quick trades.

Trend Following Terminology

Trend Analysis is a common method used by most traders and investors. This method of trading attempts to predict trends or patterns in the market by analyzing data from the past. Based on this analysis, traders that use a trend following strategy will make predictions on future market trends. Aside from analyzing past market trends, a trend following strategy will always ride a trend until a sudden change is detected. An example of this would be, taking a long position in a bull market and then exiting that position if the strategy indicates that the market is experiencing a pullback. The terms, “bull” and “bear”, are used to describe market trends. A bull market identifies a market with an upward trend while a bear market identifies one with a downward trend (Cruset, 2005, Page 5).

Trend following strategies are popular for several reasons and are especially common among large hedge funds due to their capacity to support large amounts of equity. Given a basic understanding of trend following systems, it is likely that a trader will make a profit with the right strategy. Typically, trend following system rules are simple and can detect major trends by measuring the price variation from certain reference values. When a trend is detected, a position is established in favor of the trend. Other major advantages to trend following systems are that profitable trades are not exited until the trend changes and unprofitable trades can be detected and avoided with a predefined stop loss point. This means that once a profitable position is established, the system will hold that position, yielding consistent profits until a change is detected. Rather than trading manually, where a trader will typically hold an unprofitable position in hopes that the market will turn, automated trading systems allows the trader to set a stop loss point where, if a certain quantity of money is lost, the system will exit the position and greater losses are avoided (Cruset, 2005, Page 5).

Unfortunately, the trader does take on a certain amount of risk when using trend following systems, as a trader typically would when using any trading strategy. In the case of trend following systems, traders do need to take into account how much risk they are willing to take. Traders must determine a maximum amount of money they would be willing to lose in a

single position. It is always possible that market expectations can be wrong, which is a factor that many inexperienced traders do not take into account when trading.

There are several concepts that can be used to detect a trend. For this project, the trend following system experimented with Moving Average Crossovers and Bollinger Bands. These concepts will be explained later on. Although other trend detecting techniques exist, they are usually based on more complex indicators and require additional information in order to satisfy their rules. The complexity of the techniques, however, does not affect how profitable a system can be. Moving Average Crossovers and Bollinger Bands both use data provided by an average market day. These values are the Open, High, Low, and Close. The open and close are the prices at which a stock began and ended the day. The high refers to the highest price the stock reached during the day and the low refers to the lowest price. Neither technique takes into account volume or other intraday information.

Normally, trend following strategies will only take a few trades over the course of a year. This happens because most strategies are designed to take advantage of big market swings but this involves holding a position for a large amount of time which may lead to major losses due to noise in the market. Noise occurs when price and volume fluctuations in the market cause confusion regarding a trader's interpretation of market direction. The shorter the time frame, the more difficult it is to separate noise from meaningful market movements which can lead to major losses when holding a position that attempts to follow a trend over an extended period of time.

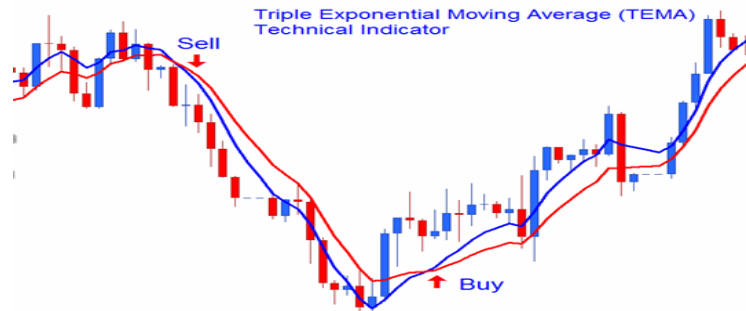
Moving Average Crossovers

A moving average or "MA" is a type of indicator, widely used in technical analysis. It helps smooth out price action by filtering out market noise from random price fluctuations. Moving averages are also trend-following indicators as they are based on past prices and they are used to identify trend direction. Moving average crossovers are a type of moving average. Crossovers occur when a faster moving average (a moving average that covers a shorter period of time) crosses either above or below a slower moving average which, covers a longer period of time. When the faster moving average crosses above the slower moving average, it is considered a bullish crossover and when the faster moving average crosses beneath the slower moving average, it is a bearish crossover. When the longer moving average is in an uptrend, it indicates that the market is strong. A buy signal is then established when the faster moving average

crosses above the slower moving average. A sell signal is also established when the faster moving average crosses below the slower moving average. Using these strategies, as stated before, involves spending a lot of time in the market. (“Moving Average Crossovers”)

Figure 3 below shows how one would trade using a moving average crossover.

Figure 3: Moving Average Crossover Illustration (Mulloy, 22 April 2014)



Bollinger Bands

Bollinger Bands, like moving averages, are a type of indicator created by John Bollinger. Bollinger Bands were created to provide a relative definition of the high and low and consist of three bands. The upper band indicates high prices, a middle band, and the lower band, which indicates low prices. The middle band is usually a type of moving average that acts as a base for the upper and lower bands. This indicator allows traders to recognize patterns in the market and is useful when comparing price activity to the action of indicators. The space above and below the middle band is determined by volatility and the volatility is normally the standard deviation of the data that is used to determine the average. Traders will use the upper and lower bands as indicators to buy and sell depending on whether a stock goes above the upper band or below the lower band. An advantage to this indicator is that the parameters and the number of standard deviations can be adjusted to work best for the trader (Bollinger, 26 April 2014).

Figure 4: Bollinger Bands Illustration (Bollinger, 26 April 2014)



Volatility Expansion Terminology: Average True Range

Volatility expansion systems, also known as volatility breakout systems, tread a path somewhat between how gap strategies and trend strategies operate. When volatility becomes high enough (due to a “volatility expansion”) and the price of a stock moves significantly outside of its normal range and noise (in a move called a “breakout”), the theory behind the system states that it will continue to move in that direction for about one to three days, usually two days. While there are many ways to measure volatility in the market, including but not limited to the VIX factor, standard deviation, variance and average true range, the only one covered in the written strategy is the average true range. An important part of the average true range naturally is the true range, which is the difference between two other variables: the true high and the true low. The true high is calculated as the higher of either today’s high or previous close. The true low, analogously calculated, is calculated as the lower of today’s low or previous close. This range helps determine a realistic range for trades on the day (Tradestation, 9 April 2014). The average true range is simply the average of the true ranges of a user-defined number of previous bar. (Tradestation, 9 April 2014).

Description of the Systems

As mentioned previously, each member of the group worked on their own individual trading system with the intention of combining systems to make a more comprehensive system of systems at the end of the project. Joshua Nottage developed a system based on a gap strategy, Joshua Levene developed a trend following system, and Justin Marcotte developed a volatility expansion system.

Gap Strategy

In a traditional gap strategy, the main focus is finding prices at the open of the market that differ from closing prices from the day before and exploiting their differences to make profit. This system is unique in that it does not look at closing prices from the day before, but instead looks at the highs and lows of yesterday. This system attempted to trade four different scenarios. The four scenarios are a gap up and a breakout, a gap up and a gap fill, a gap down and a breakout and a gap down and a gap fill. These different scenarios have slightly different trading rules associated with them, but are mostly closely related.

The main indicator used in this strategy is the Relative Strength Index, or RSI. This measures if a financial asset is currently overbought or oversold. The logic behind the strategy is that if a stock gapped, then it probably will be overbought or oversold at least for a brief period of time at the open. In that case, a buy or sell signal can be determined based on how quickly the RSI moves after the open. The other unique characteristic of this strategy is the definition of a gap. Traditionally, a gap up occurs if the open of the day is higher than the close of yesterday. However, in this strategy, a gap up only occurs if the open of the day is higher than the high of yesterday. This limits the amount of small gaps that are traded on the strategy and thus lowers the potential for stagnant trades. Also, since there is a maximum of one gap on a stock in a given day, this strategy limits the trades that can be made to one trade a day. Lastly, this strategy is traded on five minute bars because they worked well with the system. Five minute bars are short enough to show trends for a day trader, but not so short that they consist primarily of noise.

Gap Up and Breakout

For a gap up, it is expected that the RSI will be above the overbought level at the open. If there is a gap up and a breakout is expected, this means that a long position will be taken. Whether a breakout is expected or not depends on the behavior of the RSI. In order to generate a buy signal, the RSI must continue to be overbought for a good amount of time. This shows that there is momentum behind the gap up that occurred at the open. The amount of time that the RSI needs to be above the overbought level can be optimized, but a general rule is that one wants the RSI to stay above the overbought level until after 10:00AM. It is the theory of some traders that the high and lows of the day are set between the open at 9:30 and 10:00. If the RSI stays overbought after this time, it is expected that the price of the stock that gapped will break through the resistance levels created between 9:30 and 10:00. Once again, the optimal time to wait could be more than 10:00 and this optimal time can be continually changed as the system is being traded. The last condition that needs to be met is the filter condition. For this system to take a long on a gap up, the market must be moving in the right direction. This is mostly a safety net to make sure that unwise trades are not executed. This system simply requires that the current high is above the high of yesterday, which again guarantees that there is momentum in the trades that are taken.

Gap Up and Gap Fill

Once again, for a gap up, the RSI is expected to begin the day above the overbought level. If a stock is expected to fill the gap, the stock should be short sold and then bought back when the price has fallen. Whether a gap fill is expected depends on the movement of the RSI. So, if the RSI crosses under the overbought level before an optimized time (for example 10:00AM), the stock would be sold short because the stock is losing momentum and the price should go down. As before, the system included one more condition as a safety net to ensure that bad trades are not executed. This condition is that the current price must be above the high of yesterday, but below the open of today. Otherwise, a trade cannot be executed. This filter condition ensures that the stock price is moving in the correct direction, but also that the gap has not been filled yet, since the current price must be above the high of yesterday. If the gap has been filled already, then it is too late to make a trade and the system will stay out of the market.

Gap Down and Breakout

In a gap down and breakout, the price of a stock is expected to continue to decline after a gap down occurs. In this system, the RSI will help determine if a gap down is likely to breakout. In order to produce a sell short signal, the RSI needs to remain below the oversold level until a specific time of day, which can be optimized by back testing. Another condition is that the price at which a trade is taken is lower than the open of the day. This filter rule ensures that the price of the stock is moving in the correct direction. If these conditions are met, the strategy creates a sell short signal and the price of the stock should continue to decrease.

Gap Down and Gap Fill

In a gap down and gap fill, the price of a stock is expected to increase back to the low of yesterday. Sometimes, the price will rise even above the low of yesterday, creating room for more profits. In order for a buy signal to be generated on a gap down, the RSI must start the day below the oversold level and cross over the oversold level early in the day. The crossover needs to be early in the day because there needs to be time available for the stock price to change throughout the day, since this is a day trading system. Additionally, if the system only looks for crossovers early in the day, it will not interfere with the gap down and breakout rules described above. The filter rule is that the price of the stock is moving in the right direction. In order to buy shares, the current price needs to be above the open, but below the low of yesterday because the gap cannot be already filled when the purchase is made.

Trend Following Strategy

As previously mentioned, trend following strategies are designed to follow trends, detect big swings in the market, and will typically make very few, large trades over the course of a year. Given these factors, trend following strategies are very susceptible to noise, which can lead to large market losses. The trend following strategy developed for this project, attempts to avoid noise and take a larger amount of trades over the course of a year but before the strategy could be implemented, stocks needed to be chosen.

Research was conducted on stocks that were known to trend and were evaluated based on popularity and the company's activity and future plans. Of the stocks that were researched, Facebook (FB) and Google (GOOG) stood out. Both stocks were very popular and had been in an upward trend, or bull trend, for a few weeks. Facebook, Inc. had plans to incorporate many other social media applications such as WhatsApp and Instagram. Many other companies were looking towards Facebook for advertising purposes. Companies pay Facebook consistently in order to allow them to advertise on Facebook's page and phone application. Google's future plans seemed even more promising as they had an entire line of different products coming out between 2013 and 2015 such as Google Play and Google Glass. Google also made several hardware sales to Lenovo and other companies that were seeking to expand. The third stock that was chosen was Randgold Resources Limited (GOLD). This was chosen as an experimental stock used to test certain strategies and fiddle with the EasyLanguage code.

The trend following strategies that were developed to trade Google and Facebook were very similar in order to maintain a certain degree of consistency when testing. Both strategies used intra-day intervals and were tested for a year of trading. The last date was set to March 26, 2014 and they were tested over the course of one year previous to this date. On March 27, Google split its stock. The stock was split 2-for-1. This means that, the company's board of directors decided to increase the number of shares outstanding by issuing more shares to current shareholders. The 2-for-1 split means that for every share that a shareholder has, they were issued one more additional share. Basically, the number of shares doubled and the value of each share was cut in half. Now, there are two separate symbols that can be traded for the same company. In the case of Google (GOOG) there is a GOOG and a GOOGL symbol and one is favored over the other.

In the case of Google, the strategy that was used traded over 120-minute bars, which proved to be the most profitable way to trade this stock. The same strategy was used for Facebook and Randgold. Facebook was traded over 60 to 90-minute bars and 45-minute bars were used for Randgold. These strategies will be explained in more detail in the Data Analysis section for the Trend Following Strategy.

Volatility Expansion Strategy

The volatility expansion strategy shown for this project makes use of a great number of inputs, which in turn determine values for variables of the strategy. First of which is the low volume breakout fraction for longs, marked simply as $FrLv0$. Similarly, for high volume, is the high volume breakout fraction for longs, similarly marked as $FrLv1$. The next of which is referred to as $MMFrL$, a volatility multiplier for money management on longs. Next, $V0$ and $V1$ are low and high volatility measurements, respectively. Finally, $AvData$ is how many previous bars of data are used for the average true range. While some of these were “variables” in the original code, they were moved to the input section based on that they were constant. While having so many variables makes optimization difficult, it also allows for greater customization.

The inputs are channeled into variables. ATR , the average true range, takes into account the true range over $AvData$ amounts of data. ML and BL create a breakout line for longs, with slope ML and intercept BL . The slope ML is calculated by dividing the difference between $FrLv1$ and $FrLv0$ by the difference between $V1$ and $V0$. The intercept BL is calculated by subtracting $FrLv0$ by the product of ML and $V0$. The entry fraction for longs, FrL , is determined by multiplying the slope of the breakout fraction line by ATR and adding the intercept.

Note that the ML and BL are essentially constant, due to all of their components being constant. However, ATR can change every bar, and as such, so may FrL . These two variables determine the long and one of the two sell signals.

```
Buy next bar at  $H + FrL * ATR$  stop;  
  
If  $MarketPosition = 1$  and  $C > EntryPrice$  and  $BarsSinceEntry \geq 1$  then  
    Sell this bar at close;  
  
If  $MarketPosition = 1$  then  
    Sell next bar at  $EntryPrice - MMFrL * ATR$  stop;
```

Figure 5: Volatility Expansion Trading Rules

The trading system has three simple rules for its operations. The buy signal says to buy at the High plus the product of the bar plus the product of the FrL and the ATR. This accounts for regular noise in the market and applies a tough boundary to get past for both regularly noisy stocks and for softer-working stocks.

There are two ways of leaving a trade: with a profit, and with a loss. The first exit rule applies for wins: if the close is higher than the entry price and at least 1 bar has passed. This works on the basis that, if a trade is still going up a day after it was bought, it will still likely be going up tomorrow, since that is a general pattern of volatility expansions. After two days, it is unpredictable which direction it will be going, and on day bars, it can be safer to take the money and run rather than wait it out. The second exit works for losses: it will sell the stock at the entry price, minus the product of the MMFrL and the ATR. The MMFrL has no consequence throughout the rest of the strategy other than to be set to the user's risk tolerance (Mike Bryant, "Breakout Bulletin – February 2003").

Analysis of the Systems

Development and Analysis of the Gap Strategy

Choosing a Stock

In order to experiment with gap strategies, a trader must be trading stocks that gap often and gap predictably. Finding these stocks can be a challenge, but once a trader has found the right stock, they can create an effective gap strategy for trading that stock. For this project, finding the right stock was a tricky process that required time and creative thinking. The first step in this process was using a stock screener to narrow down the world of stocks to a more manageable number. The tricky aspect of using a stock screener is deciding what criteria to screen by. It would make sense that stocks that gap have a high volume of trades, since the price needs to move quickly to have a gap and the only way for this to happen is with a high number of trades. Stocks that gap may also have increasing volatility, since a gap requires the price of a stock to have a higher high or a lower low than past prices. So, the criteria for this screen were that the volume one day ago was above 1,000,000, that the volatility was increasing and that the price per share was between 50 and 70. The volatility measurement was that the implied volatility of a day ago was higher than the implied volatility of two days ago. Implied volatility is measured by an option-pricing model. The last criterion was to prevent too many stocks for appearing on the scan. The scan provided a list of 65 stocks that had the potential to be viable options for a gap trading strategy.

Still, the list of tradable stocks needed to be narrowed down further. The next logically step was to look at each stock on the list individually to see if it gapped enough to build a strategy around. To analyze the number of gaps and how each gap behaved, a special tool was required. The tool of choice was a Tradestation indicator that looked at the historical data of a stock and recorded the number of gaps and whether or not the gap was filled. This strategy was used on the list of 65 stocks as well as on some other stocks, which were not from the stock screen, but which seemed to gap frequently including some members of the DOW Jones Industrial Average. The results are in Figure 5. It is important to note that only stocks that had at least 70 gaps in the period of two years that was analyzed were included in this table. The results are quite revealing. Almost every stock filled a gap down more than 50% of the time. Additionally, almost every stock did not fill a gap up more than 50% of the time. This

information suggests that most of my trades on both gaps up and gaps down should be long trades.

While many of the stocks from Figure 5 could be traded as part of a gap strategy, for the purposes of this project, one stock was picked to build a gap strategy around. The chosen stock was British Petroleum (BP). This stock gapped very frequently and predictably based on the analysis performed on historical data. While the strategy was applied to other stocks, it was created and tested on BP. The system was then applied to J.P. Morgan (JPM) and CVS, since these symbols seemed to fill gaps down consistently and had a higher potential for breakout on gaps up.

Figure 6: Gap History Summary

Symbol	Gap Up Filled	Gap Down Filled
ABBV	16.67%	97.35%
BP	25.68%	62.41%
BBL	20.79%	58.82%
CAM	30.30%	62.86%
CVS	16.67%	75%
EBAY	25%	69.77%
GOLD	24.53%	48.03%
JCI	12.82%	65.28%
JPM	25%	66.67%
KSS	15%	58.14%
RHT	20.83%	62.5%
RIO	19%	58.67%
XLI	10%	80.47%
AXP	10.26%	76.19%
BA	22.86%	65.43%
GS	16.13%	69.12%
IBM	15.38%	57.41%
JNJ	16%	68.75%

Choosing an Indicator

At first, this gap strategy took trades simply based on the price movement of a stock after a gap. In particular, the strategy looked at the price at 10:00AM after the highs and lows of the day had supposedly been set. If the price broke out of the high or low of the day after 10:00AM, a trade would be executed. This worked to some extent, but there were a variety of problems. First, the criteria that the strategy traded on worked somewhat well for breakouts, but it said nothing in particular about when a stock was expected to fill the gap. Another problem was inconsistency. Without any sort of real indicator, the strategy took too many trades that were bad and the winning percentage of the system was not high enough to make money consistently. Clearly, an indicator needed to be introduced to increase the consistency of the system.

A number of different indicators were tried on the system including volume and momentum. The idea behind including volume in the strategy is that in order for something to gap and then have continuing price change, there must be a large number of trades that occur on that stock. So, if the volume was not very high, it could be taken as a sign to not take a trade since the price was probably not going to move much. In practice, volume did not work as an indicator for this strategy because alone it does not provide enough information behind the movement of a stock. Another indicator that was tried in this system was momentum. The idea was that if a stock gapped and continued to move, it would have momentum and then could be traded profitably. If there was not enough momentum in the stock, no action need be taken. This indicator did improve the system, but there was not enough correlation between movements after a gap and momentum to build a successful system around. Even more indicators were tried in the strategy, but none proved to be a good indicator for this system until the Relative Strength Index was tried.

The Relative Strength Index (RSI) is a different indicator that measures momentum on a scale of 0 to 100. If a stock has had a large number of recent gains, then the RSI will increase and the opposite is also true. There are two important numbers to look at when using the RSI as an indicator. The first is the overbought level. The overbought level is generally considered to be an RSI over 70. If an RSI is over 70, then it is likely to correct itself and the stock price will decrease along with the RSI. The other important number is the oversold level. This is generally considered an RSI of under 30. If an RSI is under 30, then it is likely to correct itself and the

stock price will increase along with the RSI. But, the optimal overbought and oversold levels may change from stock to stock and can be checked and adjusted by back testing, which will be covered later.

When it came to picking an exit, the process was one of trial and error. Originally, the strategy would exit after a gap was filled (if a gap fill was expected). For breakouts, the strategy would only exit a position at the end of the day, or when profit targets or stop losses were met. But, the strategy was missing out on potential profit if a stock filled the gap and then kept moving in a favorable way for the strategy. Additionally, the strategy was not locking in profits on breakouts that would turn around throughout the course of the day. So, after trying several exit strategies, the one that worked the best in this system was an ATR exit strategy. This strategy generates a stop order at the highest price since the entry of the trade minus a number of average true ranges. The number of average true ranges can be optimized through back testing. This exit worked well because as new higher prices are obtained, the stop order is scaled up, which means that this type of exit leaves room for a more profitable trade, while still helping to lock in some level of profits. There was also a stop loss on this strategy. This stop loss closed any position that was losing more than one and a half percent of the equity risked.

Back-Testing, Walk-Forward, and Analysis of the Gap Strategy

The back testing and walk-forward analysis for this system had to be done in four parts. These four parts being gap up breakout, gap up fill, gap down breakout and gap down fill. In any trading system, the optimal parameters for the system change over time. But by back testing, a system can find the best parameters for a given period of time. For this gap strategy, the best parameters for the period from 2009 to 2012 are summarized in Figure 8. The parameters that are found by back testing are used for live trading, but only for a certain period of time. This length of time is determined by a walk-forward analysis.

The results from the back-testing of this trading system are shown below. There are several things to note about the performance of this system. First, the long trades performed fairly well. The total net profit of \$10,525 and a profit factor of 1.75 shows that this gap strategy could become a viable strategy with more adjustments. Part of the adjustments would involve improving the performance of the short trades. The short trades were profitable, but the gross loss is too high and leaves only a small net profit on short trades. This is reflected in the poor

profit factor of 1.18. Other important statistics in this performance summary are the high number of trades, which was expected of this system, and the maximum consecutive losing trades of six. This is important because a system that does not lose a lot of consecutive trades is psychologically easier to trade. The equity curve for the back-testing shows that there were a few poorly performing periods for the system, but it continued to make profits over time.

TradeStation Performance Summary Expand ▾			
	All Trades	Long Trades	Short Trades
Total Net Profit	\$12,925.00	\$10,525.00	\$2,400.00
Gross Profit	\$40,455.00	\$24,505.00	\$15,950.00
Gross Loss	(\$27,530.00)	(\$13,980.00)	(\$13,550.00)
Profit Factor	1.47	1.75	1.18
Total Number of Trades	411	240	171
Percent Profitable	51.34%	52.92%	49.12%
Winning Trades	211	127	84
Losing Trades	195	112	83
Even Trades	5	1	4
Avg. Trade Net Profit	\$31.45	\$43.85	\$14.04
Avg. Winning Trade	\$191.73	\$192.95	\$189.88
Avg. Losing Trade	(\$141.18)	(\$124.82)	(\$163.25)
Ratio Avg. Win:Avg. Loss	1.36	1.55	1.16
Largest Winning Trade	\$2,115.00	\$820.00	\$2,115.00
Largest Losing Trade	(\$745.00)	(\$545.00)	(\$745.00)
Max. Consecutive Winning Trades	9	7	6
Max. Consecutive Losing Trades	6	8	6
Avg. Bars in Winning Trades	64.83	68.34	59.54
Avg. Bars in Losing Trades	49.56	45.60	54.92
Avg. Bars in Even Trades	60.80	71.00	58.25

Figure 7: BP Back-testing Performance Summary

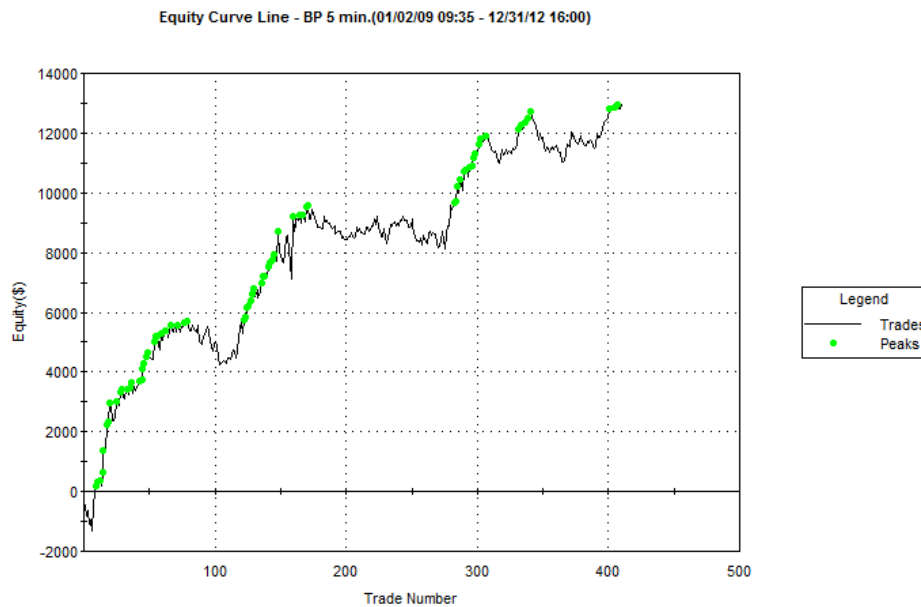


Figure 8: BP Equity Curve

	BP	CVS	JPM
Gap Up Overbought	69	87	72
Gap Up Oversold	15	20	20
Gap Down Overbought	60	60	60
Gap Down Oversold	27	35	38
RSI Length	8	8	8
Number of ATR for Trailing LX	7	7	7
ATR Length	8	8	8

Figure 9: Gap Optimized Parameters

A walk-forward analysis is used to determine the best amount of historical data to use when determining parameters for a trading system. It will also determine how long these parameters can be used for before they need to be recalculated. For this system, four separate walk-forward analyses needed to be used. The results are provided in Figure 9a through Figure 9d. Of the four walk-forward tests, three were failures and only one was a pass. This may seem discouraging, but there are some reasons why this may not be devastating news. First of all, the gap system as a whole is made up of the four smaller strategies. But, it was not possible to perform a walk-forward analysis on the system as a whole. Just because each smaller strategy failed the walk-forward test that does not necessarily mean that the system as a whole would fail a walk-forward analysis. The system as a whole would be more robust than each individual strategy. Another reason why the walk-forward analysis may not have been conclusive is because there may not have been enough tests in each walk-forward. The test may not have been comprehensive enough to be conclusive.

OOS% \ Runs	5	10	15	20	25	30
10	FAILED	FAILED	PASS	FAILED	PASS	FAILED
15	FAILED	PASS	PASS	FAILED	FAILED	FAILED
20	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
25	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
30	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED

OOS% \ Runs	5	10	15	20	25	30
10	FAILED	PASS	PASS	PASS	PASS	PASS
15	PASS	PASS	PASS	PASS	PASS	PASS
20	FAILED	PASS **	PASS	PASS	PASS	PASS
25	PASS	PASS **	PASS	PASS	PASS	PASS
30	PASS	PASS	PASS	PASS	PASS	FAILED

Figure 10a: Walk-Forward Gap Up Longs (Top)

Figure 10b: Walk-Forward Gap Up Shorts (Bottom)

OOS% \ Runs	5	10	15	20	25	30
10	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
15	FAILED	FAILED	FAILED	FAILED	FAILED	PASS
20	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
25	FAILED	FAILED	FAILED	PASS	FAILED	FAILED
30	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED

OOS% \ Runs	5	10	15	20	25	30
10	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
15	FAILED	FAILED	PASS	FAILED	FAILED	FAILED
20	FAILED	PASS	FAILED	FAILED	FAILED	PASS
25	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED
30	FAILED	FAILED	FAILED	FAILED	FAILED	FAILED

Figure 10c: Walk-Forward Gap Down Longs (Top)

Figure 10d: Walk-Forward Gap Down Shorts (Bottom)

Evaluating the System using Expectancy, Expectunity, and System Quality

There are three measurements of the effectiveness of a trading system that are used in this paper. The three technical analysis methods that are used are expectancy, expectunity, and system quality (Van Tharp Institute, 9 May 2014). The gap trading system was applied to three stocks and then these measures were calculated for the system's performance on each stock.

In any profitable trading system, a positive expectancy is necessary. Expectancy is a measure of how much a system will make per dollar risked (Tharp 59). A positive expectancy

means that the system is expected to make a positive profit over the course of several trades. In this system, the expectancy is positive for each stock to which the system was applied, which means that it is expected to make a profit over time. Obviously this is good news, but a higher expectancy is always better and the expectancy of this system could be improved. The next statistic that was measured was expectunity. Expectunity was created by Van Tharp as a way to incorporate trading opportunities and timeframe into the expectancy of a system. Expectunity makes it possible to compare systems that operate on different timeframes. A system that trades more frequently will have more opportunities to trade and therefore will have a higher expectancy. Since the gap strategy is a day strategy and is open to taking a trade every day (given the conditions are right), it has a high number of opportunities to trade and its expectancy is much higher than its expectancy. However, the system's expectancy on BP was much higher than its expectancy on CVS or JPM. The last statistic that is used to analyze this system is system quality. System quality is calculated by adjusting expectancy by the standard deviation of the R-multiples used in calculating the system's expectancy and is used as a way to allocate money to each individual system in the overall system of systems. So, if a system has a high system quality, it will be given a larger portion of funds to trade with. The system quality for the gap strategy is consistent across all three stocks that it was traded on and is relatively high at around eighteen. These statistical measures have been included below and will be used later to compare the three systems and to allocate funds in the system of systems.

	Stocks		
	BP	CVS	JPM
Expectancy	0.2228	0.2229	0.0429
Expectunity	23.0295	10.6359	8.9453
System Quality	18.1196	18.4688	18.5103

Figure 11: Gap Up Analysis Results

Monte Carlo Simulation and Position Sizing

Another analysis technique that was used to evaluate this system was Monte Carlo simulation. Basically, Monte Carlo simulation takes all of the trades a system makes, randomly sequences them and then calculates the rate of return and the max drawdown. This process is then repeated many times to explore the characteristics of the trading system. This is useful for many reasons. First of all, it can be used to monitor the performance of a trading system. Using

information from the trials of the Monte Carlo analysis, a 95% confidence interval can be created for the drawdown of the system. In Figure 11a, the 95% confidence intervals are illustrated along with the actual equity curve from back testing. From this analysis it can be determined that there is 95% confidence that our rate of return will be at least 12.93% and that the max drawdown will be at most 3.447%. Confidence intervals can also be created for future trades. An example of this is Figure 11b. This is useful because if future trades are outside of the predicted 95% confidence interval, it is an indication that the trading system needs to be adjusted or even abandoned. Without confidence that the system is behaving normally, it does not make sense to continue trading it. Figure 11b shows that this system stayed within our projected confidence interval. This means that the system was behaving normally and could continue to be traded. Position sizing strategy refers to how large a position will be taken throughout the course of a trade (Van Tharp Institute, 9 May 2014). Fixed fractional position sizing is a position sizing technique that scales the amount of money risked on each trade based on the total equity in a trading account. So, if an account with \$100,000 has a fixed fractional position sizing of 20%, it will risk \$20,000 on the next trade. If that trade goes well, and the account then has \$110,000, the next trade will risk \$22,000. Position size also scales down if an account is losing money. Using optimization with a different fixed fractional each time, the optimal fixed fraction can be discovered. Using optimization, an equity curve using the optimal fixed fractional position sizing was created and is included in Figure 11d. According to the simulation, the optimal fixed fractional is one hundred percent. This means that the gap system had its best performance when it risked all of its equity on each trade. This fixed fractional did significantly improve the equity curve, but it is not wise for any trader to risk all of their equity on one trade.



Figure 12a: BP Monte Carlo Simulation with 95% Confidence Interval

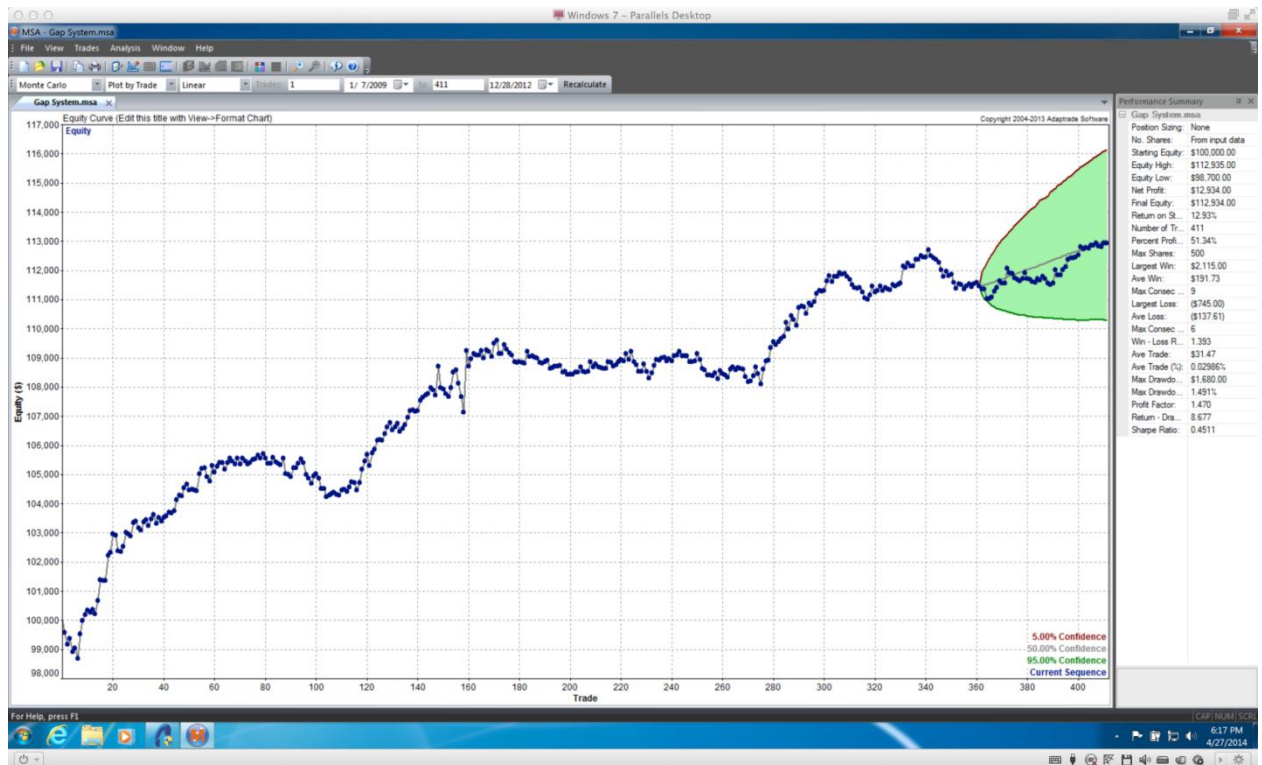


Figure 12b: BP Monte Carlo 95% Confidence Interval Prediction

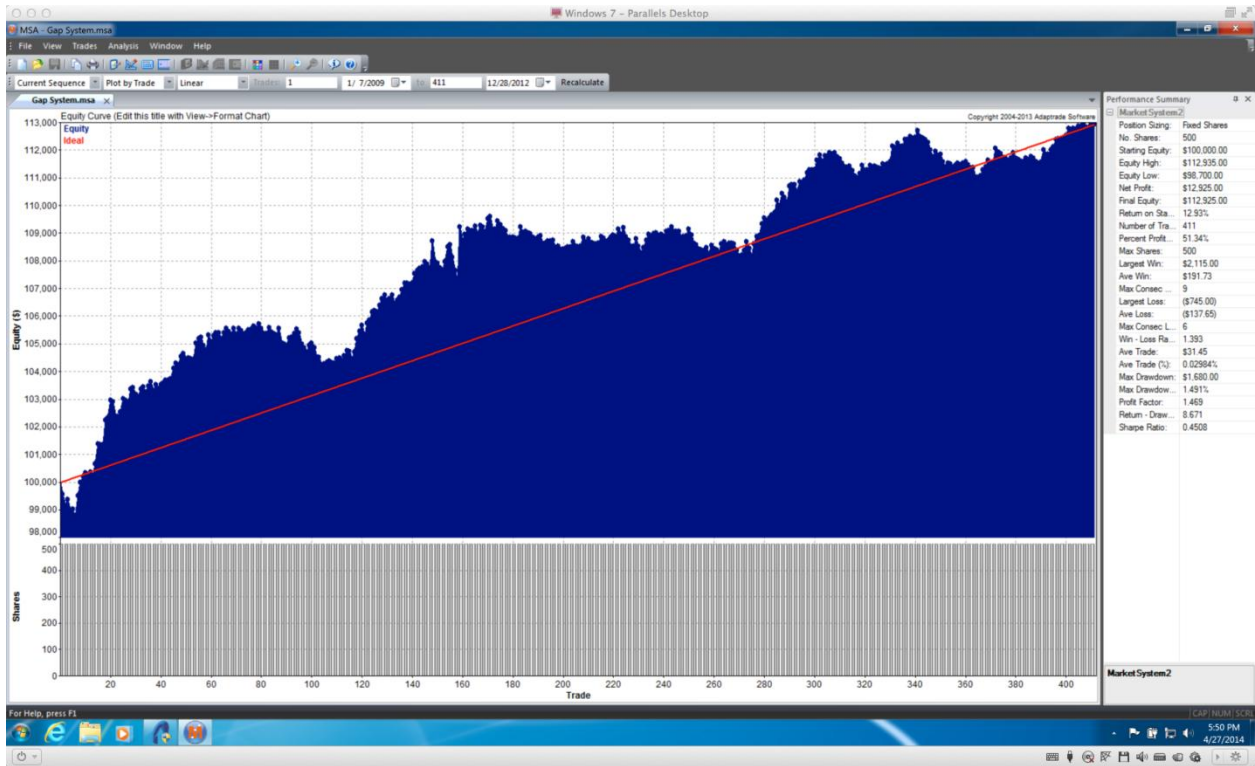


Figure 12c: BP Equity Curve Before Fixed Fractional Position Sizing

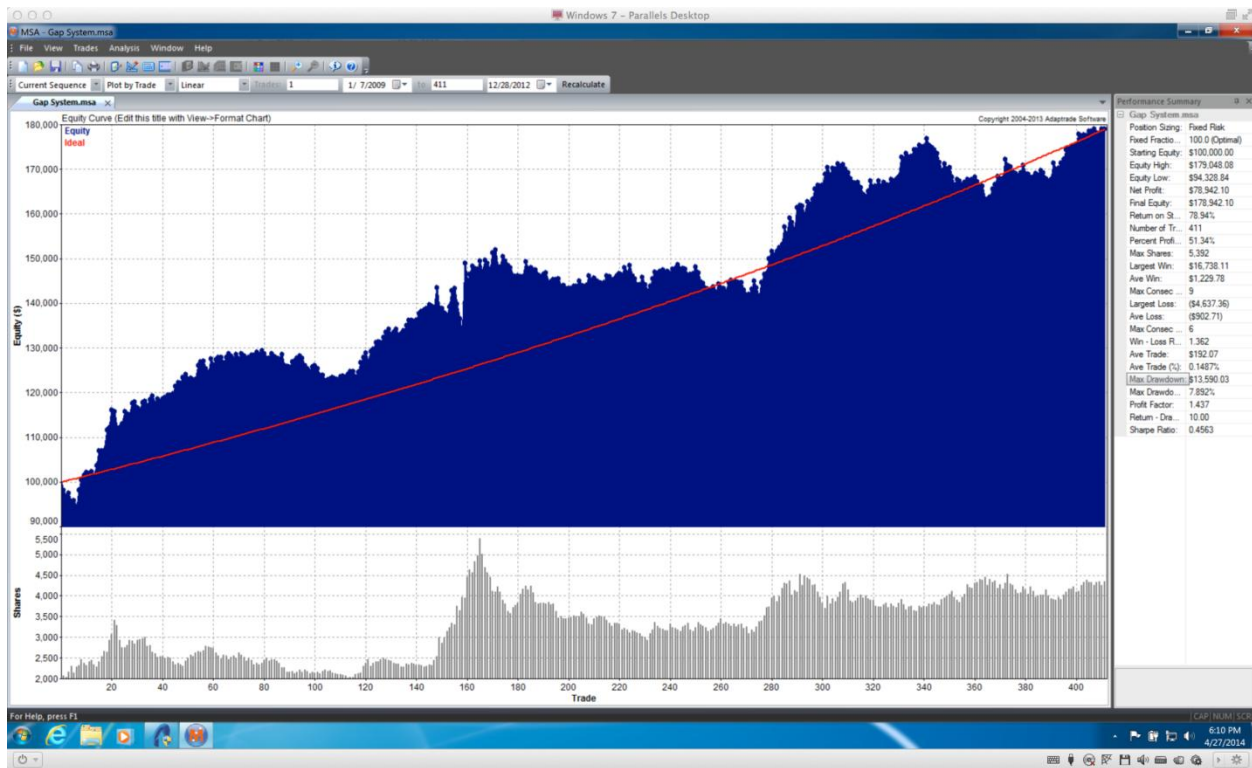


Figure 12d: BP Equity Curve After Fixed Fractional Position Sizing

Development and Analysis of the Trend Following Strategy

There were two very similar strategies that were developed to trade Google and Facebook but both strategies have slight differences based on the stock's trend. It was observed that Google very rarely deviated from a bull state which means that it was in a constant up trend. This makes for a perfect situation to take long positions. The strategy used moving average crossovers long entry and long exit as indicators. Facebook proved to be more volatile than Google. Due to this, Facebook also used short entry and short exit indicators, aside from the longs. Also, as previously mentioned, Google was traded using intra-day 120- minute bars while Facebook used 60 to 90- minute bars in order to account for slight volatility. Figures 12 and 13 present the performance summaries for both stocks.

Figure 13: Facebook Back-Testing Performance Summary

TradeStation Performance Summary			
	All Trades	Long Trades	Short Trades
Total Net Profit	\$11,914.00	\$2,163.00	\$9,751.00
Gross Profit	\$19,320.00	\$5,558.00	\$13,762.00
Gross Loss	(\$7,406.00)	(\$3,395.00)	(\$4,011.00)
Profit Factor	2.61	1.64	3.43
Roll Over Credit	\$0.00	\$0.00	\$0.00
Open Position P/L	\$35.00	\$35.00	\$0.00
Select Total Net Profit	\$11,914.00	\$2,163.00	\$9,751.00
Select Gross Profit	\$19,320.00	\$5,558.00	\$13,762.00
Select Gross Loss	(\$7,406.00)	(\$3,395.00)	(\$4,011.00)
Select Profit Factor	2.61	1.64	3.43
Adjusted Total Net Profit	\$5,782.64	(\$1,138.04)	\$4,568.89
Adjusted Gross Profit	\$14,887.69	\$3,457.27	\$9,789.25
Adjusted Gross Loss	(\$9,105.05)	(\$4,595.31)	(\$5,220.36)
Adjusted Profit Factor	1.64	0.75	1.88
Total Number of Trades	38	15	23
Percent Profitable	50.00%	46.67%	52.17%
Winning Trades	19	7	12
Losing Trades	19	8	11
Even Trades	0	0	0
Avg. Trade Net Profit	\$313.53	\$144.20	\$423.96
Avg. Winning Trade	\$1,016.84	\$794.00	\$1,146.83
Avg. Losing Trade	(\$389.79)	(\$424.37)	(\$364.64)
Ratio Avg. Win:Avg. Loss	2.61	1.87	3.15
Largest Winning Trade	\$4,102.00	\$2,254.00	\$4,102.00
Largest Losing Trade	(\$1,085.00)	(\$903.00)	(\$1,085.00)
Largest Winner as % of Gross Profit	21.23%	40.55%	29.81%
Largest Loser as % of Gross Loss	14.65%	26.60%	27.05%
Net Profit as % of Largest Loss	1098.06%	239.53%	898.71%
Select Net Profit as % of Largest Profit	1098.06%	239.53%	898.71%
Adjusted Net Profit as % of Largest Loss	532.96%	(126.03%)	421.10%
Max. Consecutive Winning Trades	5	3	3
Max. Consecutive Losing Trades	4	3	3
Avg. Bars in Total Trades	9.24	9.67	8.96
Avg. Bars in Winning Trades	13.37	14.00	13.00
Avg. Bars in Losing Trades	5.11	5.88	4.55

The performance summary in Figure 12 shows the results of the trend following strategy used to trade Facebook. Although the percent profitability is 50% and the number of winning trades is equal to that of the losing trades, it is worth mentioning that the total net profit is very strong at \$11,914.00 and a profit factor of 2.61 is favorable. Profit factor is another way to measure the attractiveness of a trade set-up. It is calculated by dividing the historical net profits by the historical net losses and a profit factor greater than one means that the strategy is making money. The average winning trade for this strategy is also much higher than the average losing trade.

Figure 14: Google Back-Testing Performance Summary

	All Trades	Long Trades	Short Trades
Total Net Profit	\$13,414.00	\$13,414.00	\$0.00
Gross Profit	\$23,532.00	\$23,532.00	\$0.00
Gross Loss	(\$10,118.00)	(\$10,118.00)	\$0.00
Profit Factor	2.33	2.33	n/a
Roll Over Credit	\$0.00	\$0.00	\$0.00
Open Position P/L	\$0.00	\$0.00	\$0.00
Select Total Net Profit	\$11,548.00	\$11,548.00	\$0.00
Select Gross Profit	\$20,573.00	\$20,573.00	\$0.00
Select Gross Loss	(\$9,025.00)	(\$9,025.00)	\$0.00
Select Profit Factor	2.28	2.28	n/a
Adjusted Total Net Profit	\$7,380.83	\$7,380.83	\$0.00
Adjusted Gross Profit	\$19,162.22	\$19,162.22	\$0.00
Adjusted Gross Loss	(\$11,781.39)	(\$11,781.39)	\$0.00
Adjusted Profit Factor	1.63	1.63	n/a
Total Number of Trades	66	66	0
Percent Profitable	43.94%	43.94%	0.00%
Winning Trades	29	29	0
Losing Trades	37	37	0
Even Trades	0	0	0
Avg. Trade Net Profit	\$203.24	\$203.24	\$0.00
Avg. Winning Trade	\$811.45	\$811.45	\$0.00
Avg. Losing Trade	(\$273.46)	(\$273.46)	\$0.00
Ratio Avg. Win:Avg. Loss	2.97	2.97	n/a
Largest Winning Trade	\$2,959.00	\$2,959.00	\$0.00
Largest Losing Trade	(\$1,093.00)	(\$1,093.00)	\$0.00
Largest Winner as % of Gross Profit	12.57%	12.57%	n/a
Largest Loser as % of Gross Loss	10.80%	10.80%	n/a
Net Profit as % of Largest Loss	1227.26%	1227.26%	n/a
Select Net Profit as % of Largest Loss	1056.54%	1056.54%	n/a
Adjusted Net Profit as % of Largest Loss	675.28%	675.28%	n/a
Max. Consecutive Winning Trades	6	6	0
Max. Consecutive Losing Trades	4	4	0
Avg. Bars in Total Trades	8.88	8.88	0.00
Avg. Bars in Winning Trades	14.45	14.45	0.00
Avg. Bars in Losing Trades	4.51	4.51	0.00

In the performance summary for Google (shown in Figure 13) one of the main values worth noting is the quantity of losing trades versus winning trades. It can be inferred that there is a noticeable amount of risk taken due to the quantity of losing trades observed above. Although total net profit is high, gross loss must also be taken into account since more than \$10,000 was lost. Despite the percent profitability being below 50% and the number of losing trades exceeding that of winning trades, it is still a profitable strategy with a strong profit factor of 2.33. This means that although there were more losing trades, these were probably for small losses caused by noise, but losses could have been much greater if not for a good exit strategy.

Development and Analysis of the Volatility Expansion Strategy

After deciding to work with a volatility expansion system, the next step was to figure out exactly how one worked. Luckily, TradeStation had an example system pre-built among four different small strategies, all of which marked volatility expansion. Next, stocks needed to be selected. To start off, Twitter seemed like a fine choice. It had been moving dramatically, so using its volatility seemed like a strong venture. However, this proved not true on any bar length – small bars caught all the noise, while longer bars missed most moves. Whether the system made too many trades, many of which were not profitable, or it made too few trades, one thing was true: the system was not making money. Twitter was not going to make money with this idea, but maybe WalMart or Hess would. Using a volatility expansion strategy, both WalMart and Hess were on the way to making profit, their profit factors only reached to about 1.09, which, while profitable, will not make money very fast. Something new needed to be tried.

Shorting and short-covering proved to not be particularly profitable. In the interest of pure profit, the shorting side of the strategy was removed. This also tied in to an idea not having to owe anyone stocks or money, which adds the interest problem. However, V (Visa) traded very well on the system and, as time went on, the system grew more and more into making V into the most profitable stock for the system.

The current TradeStation codes prove ineffective in most cases. A 2002 November issue of the Breakout Bulletin, which is a trading newsletter, proved to have a similar but more refined strategy, designed to show the impact of a volatility filter. While the breakout function was simple, it seemed much more self-integrated than the modular interchangeable codes of TradeStation. As one may naturally expect, the integrated system, while only designed for an

example, proved a better quality. Although another result was, perhaps a bit counter intuitively, the volatility filter sometimes proved more inhibitive than helpful. This could also be due to the removal of context: the system was designed to trade the S&P 500 with \$75 commission and daily bars, while the current written strategy was using \$7 commission and ten-minute bars on V. It would be naturally expected that it would not quite perform as good as the reported results shown in the magazine. In order to attempt to reproduce similar results, the system was switched to daily bars. V instantly worked much better on such a timeframe, and such daily bars were kept to the end of the project. However, optimizations of the strategy as written resulted in very few trades, and in addition the profit factors proved either very poorly or scarily well. One such optimization led to a profit factor of 643, but this proved to be a fluke and didn't work for any other timeframe other than the one it was back-tested for (Bryant, 20 April 2014).

The 2002 article system proved simple and relatively inefficient. One found in a February 2003 article proved much more complex. The first process was to remove the short and short-cover mechanisms: these have always proven to be unreliable and much more trouble than they are worth. Next in the list of alterations was to make into inputs any solid numbers. While 22 has context in terms of average number of trading days in a month, replacing it with an AvData would allow for further customization and optimization (Bryant, 24 April 2014).

After configuration of inputs and variables, the next step was to find more stocks on which to trade the system. Most stock filters would provide the option to find high volume (3,000,000 shares per day or higher) and smaller range betas (0.5 to 2). Many stocks popped up even under this filter, so the filter for beta was converged to closer and closer towards V until it led to a small, manageable list of stocks to test. Of those stocks, the best-proving ones were BEAM and ADBE.

Technical Analysis of the System

For this project, the stocks chosen were Beam Inc. (BEAM), Adobe Systems Incorporated (ADBE), and Visa (V).

How the system performs with BEAM

TradeStation Strategy Performance Report - BEAM Daily (1/2/1998-12/31/2012)	
Symbol	BEAM
Description	Beam Inc.
Interval	Daily
Start Date/Time	1/2/1998 4:00:00 PM
End Date/Time	12/31/2012 4:00:00 PM
TradeStation Strategies Applied	
Bryant Variable Breakout System(On)	
JM_MJR_WriteTrades(On)	
TradeStation Strategy Inputs	
Description	Value
Bryant Variable Breakout System - FrLv0	1.15
Bryant Variable Breakout System - FrLv1	2.14
Bryant Variable Breakout System - MMFrL	20
Bryant Variable Breakout System - V0	7
Bryant Variable Breakout System - V1	28
Bryant Variable Breakout System - AvData	21
TradeStation Strategy Settings	
Costs/Capitalization	
Initial Capital	\$100,000.00
Commission	\$10.00 per Trade
Slippage	\$0.00 per Trade
Interest Rate	2.00%

Figure 15a: BEAM Optimized Parameters

For the sake of reproducibility, these are the variables, which were described earlier, and the initial capital that the system used. This back-testing included a commission of \$10 per trade. The \$10 commission is unusual, given that most basic trading platforms have \$7 commission. However, TradeStation's commission has occasionally been known to approach \$10, and this prepares for the worst. Besides, that means the system saves more money than it thought it would spend, resulting indirectly in more net profit.

TradeStation Strategy Performance Report - BEAM Daily (1/2/1998-12/31/2012)

Account (US Dollar) All data

TradeStation Performance Summary Collapse

	All Trades	Long Trades	Short Trades
Total Net Profit	\$5,242.00	\$5,242.00	\$0.00
Gross Profit	\$7,594.00	\$7,594.00	\$0.00
Gross Loss	(\$2,352.00)	(\$2,352.00)	\$0.00
Profit Factor	3.23	3.23	n/a
Roll Over Credit	\$0.00	\$0.00	\$0.00
Open Position P/L	\$0.00	\$0.00	\$0.00
Select Total Net Profit	\$6,645.00	\$6,645.00	\$0.00
Select Gross Profit	\$6,976.00	\$6,976.00	\$0.00
Select Gross Loss	(\$331.00)	(\$331.00)	\$0.00
Select Profit Factor	21.08	21.08	n/a
Adjusted Total Net Profit	\$4,136.30	\$4,136.30	\$0.00
Adjusted Gross Profit	\$6,885.86	\$6,885.86	\$0.00
Adjusted Gross Loss	(\$2,749.56)	(\$2,749.56)	\$0.00
Adjusted Profit Factor	2.50	2.50	n/a
Total Number of Trades	150	150	0
Percent Profitable	76.67%	76.67%	0.00%
Winning Trades	115	115	0
Losing Trades	35	35	0

Performance Summary Trade Analysis Trades List Periodical Returns Performance Graphs Trade Graphs Settings

Figure 15b: BEAM Back-Testing Performance Summary

As noted here, on the trading interval used to test BEAM, it has made a 3.23 profit factor, which means that, for every dollar lost in it, it has gained 3.23 dollars. Out of 150 trades, it won a resounding 115 of them and lost 35 of them, accounting that 76.67% of its trades were profitable. However, the timeframe was from 1/2/1998 to 12/31/2012, showing that it only took 150 trades over about 15 years, an average of 10 trades per year. The select profit factor “removes the trades further than standard deviations away from the average trade”, as such removing all the outliers. (Select Profit Factor). Noting that, the Select profit Factor increases dramatically, with most of the loss being removed. Meanwhile, the Adjusted Profit Factor “displays the amount made in relation to the amount lost, for a worst case scenario during the specified period.” (Adjusted Profit Factor). Even in this worst case scenario, the system still trades at a reasonable profit factor level, vouching for the viability of the system.

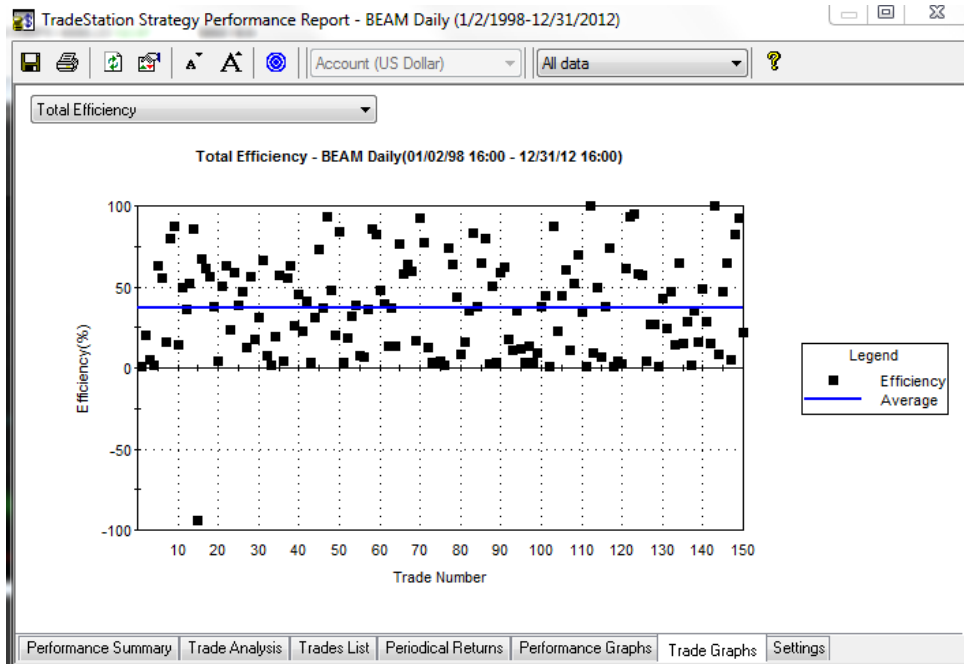


Figure 15c: BEAM Efficiency

This chart shows the efficiency of each trade, going from -100 to 100. While one of the trades is a huge hiccup and many trades approach zero efficiency, the average trade estimates 37.5% efficiency.

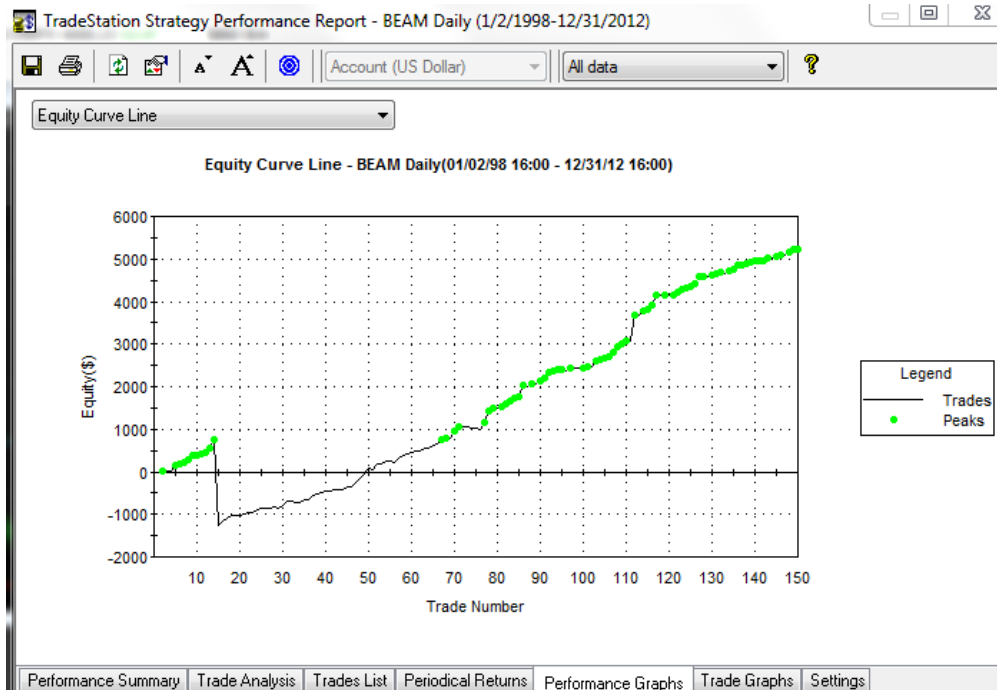


Figure 15d: BEAM Equity Curve

Perhaps one of these most important graphs is the Equity Curve. A perfect equity curve is a straight line, meaning that every trade was perfectly executed. Such a system is likely not possible, however it is the goal of every trading system to have a perfect equity curve. The curve for this volatility expansion strategy takes a dip right at the beginning but is able to somewhat manage a straight line after such a dip. This remarks hope for the system.

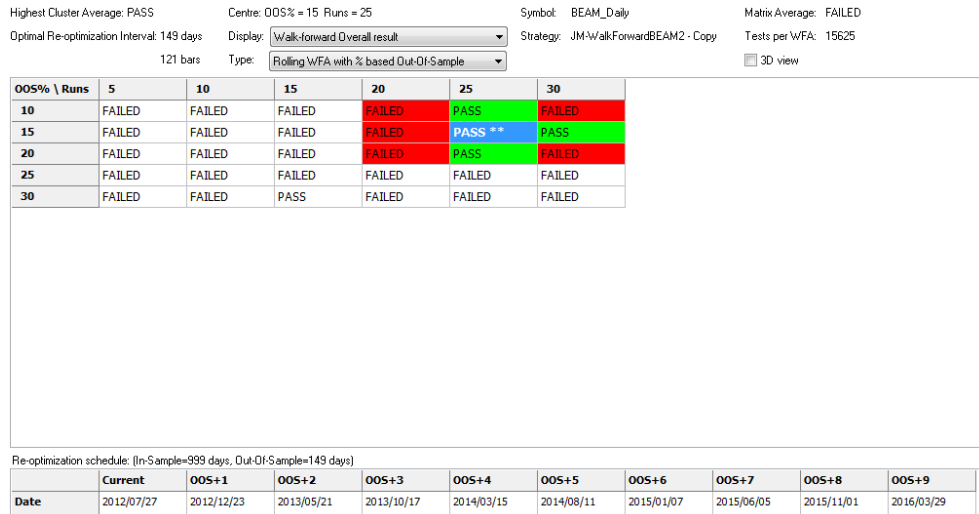


Figure 15e: BEAM Walk-Forward Cluster Analysis

The system works fine in its own time frame, but how is it projected to work outside of its own time frame? For this, a Walk-Forward Optimization is in order. As shown by the above graph, there is a small sideways T of PASS outside a PASS**. While the system passed under the test provided at OOS% 15 and 25 Runs, it's standing on a telephone pole with little support, meaning that if the market shifts even by a small bit, this system's viability could be devastated. It is best to have a 9x9 square on this chart with the one in the middle being the most viable. On such a note, a minor change in the market will not likely disrupt how the system works. These results not only show that the system has a long way to go before it reaches its maximum profit, but they also remark that the system is on the right track.

Walk-Forward Analysis Results : OOS=15% WFRuns=25

Symbol: BEAM_Daily Strategy: JM-WalkForwardBEAM2 - Copy

	Test Criteria	Result	Comment
1	Overall Profitability	Pass	Total Profit > 0. System is likely to perform profitable on unseen data
2	Walk-Forward Efficiency	Pass **	Walk-Forward Efficiency >= 100%. System is likely to perform in future at a rate similar to those achieved during optimization
3	Consistency of Profits	Pass ***	80%+ of walk-forward runs were profitable. System is most likely to be successful in future.
4	Distribution of Profits	Pass	No individual time period contributed more than 50% of Total Net Profit.
5	Maximum Drawdown	Pass	No individual run had a drawdown of more than 40% of initial capital.
	OVERALL RESULT	PASS **	Walk-Forward Efficiency >= 0%. System is likely to perform in future

Figure 15f: BEAM Walk-Forward Results

On the block with the PASS**, it shows a result of all PASS or PASS** on this square. These Walk-Forward settings will work tremendously while the market stays in a similar arrangement to a pattern shown in the last 15 years of the market.

Av. Win	66.61404		1st Trade	3/30/1998	Expectancy	0.52004	0.017292
			Last Trade	12/11/2012			
St.Dev Wins	74.13913		# Days	5370	Opportunities	10.19553	
			# Trades	150	Expectancy	5.302081	0.176299
System Quality	11.00434						

Figure 15g: BEAM System Quality Analysis

To calculate the expectancy, expectunity and system quality of this system, a function called *writetrades* was used to transfer the data about trades that the system took into Excel (shown in the Appendices section). The trade data was then used to calculate expectancy, expectunity and system quality. The expectancy, or how much money the system expects to make per trade, is 0.52004 when accounting for the average loss (the average scenario) and .017292 when accounting for the worst loss in the system's data set of trades, so as to account for a worst case scenario. A negative expectancy shows invalidity of a system, due to it indicating that, over the long run, the system loses money. While a smaller expectancy is worse than a larger expectancy given the same number of trades and time frame, a smaller expectancy may be an indication of either a poor system or a scalping system, a trading system designed to make

many trades each with a small profit. To account for this, opportunities of trades per year gets accounted. As mentioned previously, the system makes about 10 trades per year. The expectancy is an annualized expectancy, meaning it is used to analyze money made per year. Here, the result is 5.302081 on an average year or 0.176299 in the worst year possible.

The last statistic calculated was system quality, which simply is determined by the product of the average winning trade and the square root of the number of trades, divided by the standard deviation of the winning trades. Given the numbers accounted here, the system quality is determined to be 11.00434. This statistic was used for money allocation for the system of systems.

How the system performs with V

TradeStation Strategy Performance Report - V Daily (1/2/2009-12/31/2012)	
Symbol	V
Description	Visa Inc
Interval	Daily
Start Date/Time	1/2/2009 4:00:00 PM
End Date/Time	12/31/2012 4:00:00 PM
TradeStation Strategies Applied	
Bryant Variable Breakout System(On)	
JM_MJR_WriteTrades(On)	
TradeStation Strategy Inputs	
Description	Value
Bryant Variable Breakout System - FrLv0	0.43
Bryant Variable Breakout System - FrLv1	1.84
Bryant Variable Breakout System - MMFrL	16
Bryant Variable Breakout System - V0	16
Bryant Variable Breakout System - V1	47
Bryant Variable Breakout System - AvData	24
TradeStation Strategy Settings	
Costs/Capitalization	
Initial Capital	\$100,000.00
Commission	\$10.00 per Trade
Slippage	\$0.00 per Trade
Interest Rate	2.00%

Figure 16a: V Optimized Parameters

	All Trades	Long Trades	Short Trades
Total Net Profit	\$10,579.00	\$10,579.00	\$0.00
Gross Profit	\$13,378.00	\$13,378.00	\$0.00
Gross Loss	(\$2,799.00)	(\$2,799.00)	\$0.00
Profit Factor	4.78	4.78	n/a
Roll Over Credit	\$0.00	\$0.00	\$0.00
Open Position P/L	(\$10.00)	(\$10.00)	\$0.00
Select Total Net Profit	\$11,951.00	\$11,951.00	\$0.00
Select Gross Profit	\$12,145.00	\$12,145.00	\$0.00
Select Gross Loss	(\$194.00)	(\$194.00)	\$0.00
Select Profit Factor	62.60	62.60	n/a
Adjusted Total Net Profit	\$8,736.94	\$8,736.94	\$0.00
Adjusted Gross Profit	\$12,161.82	\$12,161.82	\$0.00
Adjusted Gross Loss	(\$3,424.88)	(\$3,424.88)	\$0.00
Adjusted Profit Factor	3.55	3.55	n/a
Total Number of Trades	141	141	0
Percent Profitable	85.82%	85.82%	0.00%
Winning Trades	121	121	0
Losing Trades	20	20	0

Figure 16b: V Back-Testing Performance Summary

A profit factor of 4.78 showed great promise. The select profit factor of 62.60 showed potential of very high gains, while the adjusted profit factor being 3.55 showed that, no matter what, V would make a lot of money on this strategy.

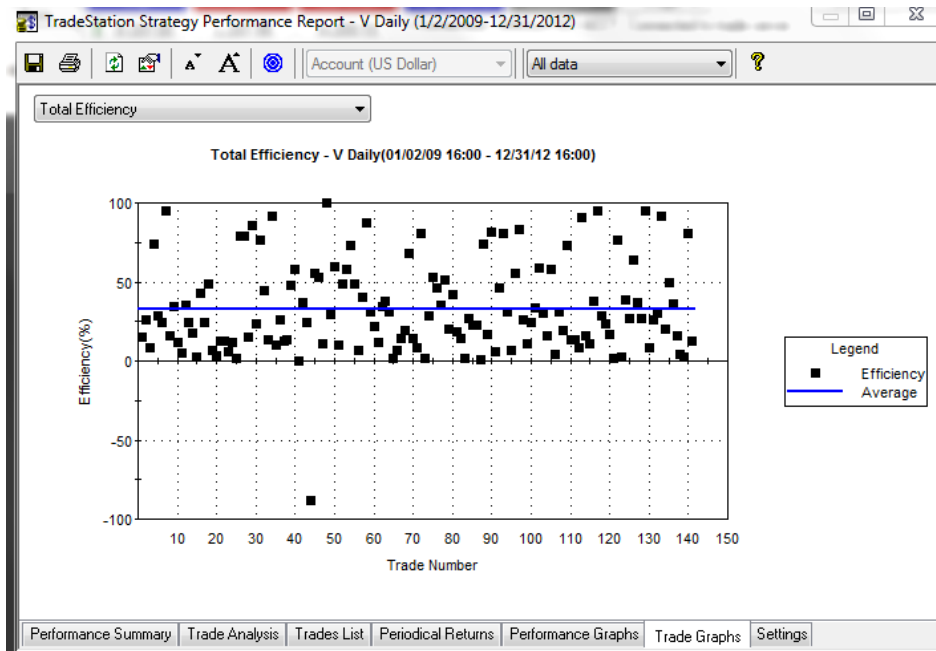


Figure 16c: V Efficiency

Unfortunately, the efficiency appeared to be under 37.5%. However, there seemed to only be one big outlier.

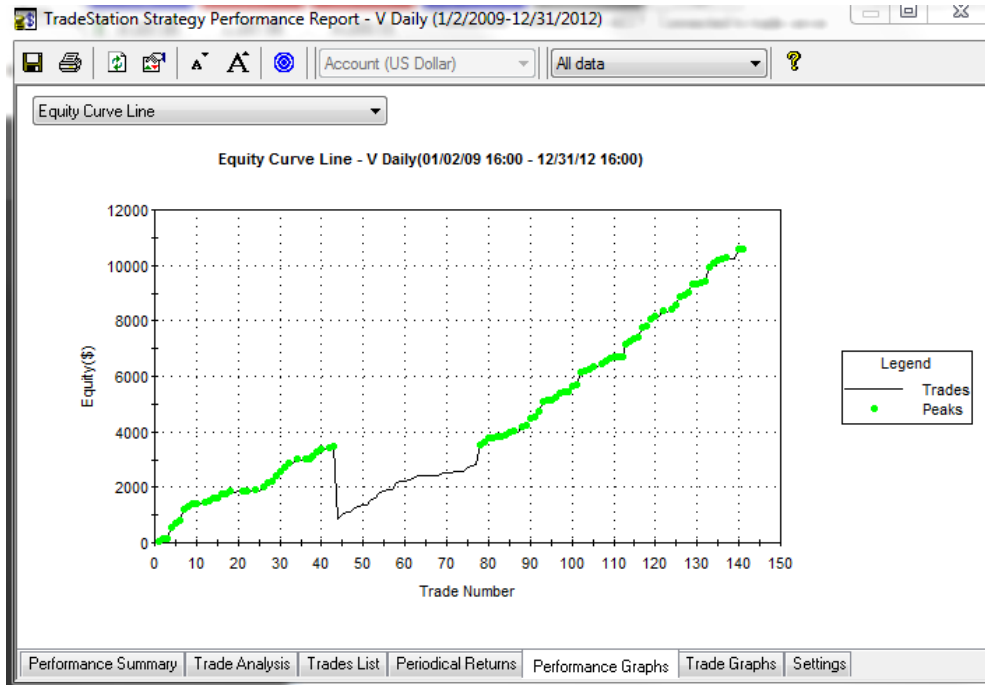


Figure 16d: V Equity Curve

The equity curve isn't perfect, particularly from about 40 to 80. The line proved a bit rigid. This carries hope but still is far from an ideal.

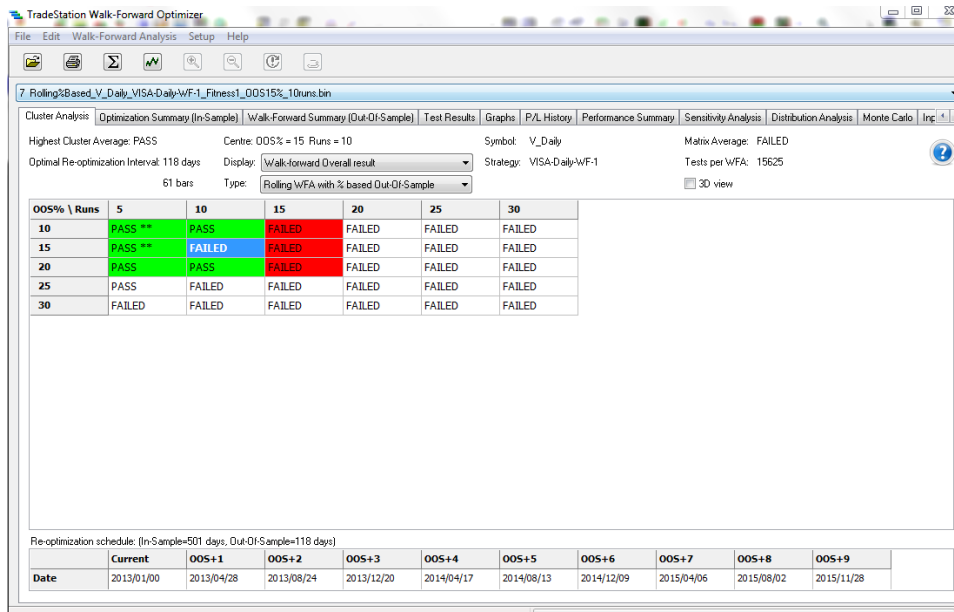


Figure 16e: Walk-Forward Cluster Analysis

Interestingly, for this walk-forward analysis, the passes form a C pattern and not a T. In addition, the most recommended spot is a failure spot. Much work could be done on the system to make it much more robust.

Walk-Forward Analysis Results : OOS=15% WFRuns=10
 Symbol: V_Daily Strategy: VISA-Daily-WF-1

	Test Criteria	Result	Comment
1	Overall Profitability	Pass	Total Profit > 0. System is likely to perform profitable on unseen data
2	Walk-Forward Efficiency	Failed	Walk-Forward Efficiency < 50%. System is likely to perform in future at a rate of less than 50% of those achieved during optimization
3	Consistency of Profits	Pass **	80%+ of walk-forward runs were profitable. System is most likely to be successful in future.
4	Distribution of Profits	Failed	Walk-forward run #7 contributed more than 50% of Total Net Profit.
5	Maximum Drawdown	Pass	No individual run had a drawdown of more than 40% of initial capital.
	OVERALL RESULT	FAILED	Walk-Forward Efficiency >= 0%. System is likely to perform in future

Figure 16f: V Walk-Forward Results

For some reason, the failures of only the walk-forward efficiency and the distribution of profits were enough to send this test into a failure result. However, the message on the right of the main failure message still states that the system is likely to perform in the future.

Av. Win	110.561984			1st trade	3/18/2009	Expectancy	0.536108	0.028802
				Last trade	12/21/2012			
St.Dv Win	117.01502			Strategy Calendar Days	1374	Opportunities	37.45633	
				Number of Trades	141			
System Quality	11.2195068					Expectunity	20.08065	1.078805

Figure 16g: V System Quality Analysis

The expectancy was found to be .536108, expectunity 20.08065, and average win 110.561984. However, due to a comparative lack of trades (only 141) and a high standard deviation of wins, the system quality of this strategy on V proved to be only 11.2195068.

How the system performs with ADBE

TradeStation Strategy Performance Report - ADBE Daily (1/4/1988-12/31/2012)	
Symbol	ADBE
Description	Adobe Systems
Interval	Daily
Start Date/Time	1/4/1988 4:00:00 PM
End Date/Time	12/31/2012 4:00:00 PM
TradeStation Strategies Applied	
Bryant Variable Breakout System(On)	
JM_MJR_WriteTrades(On)	
TradeStation Strategy Inputs	
Description	Value
Bryant Variable Breakout System - FrLv0	0.65
Bryant Variable Breakout System - FrLv1	0.68
Bryant Variable Breakout System - MMFrL	19
Bryant Variable Breakout System - V0	3
Bryant Variable Breakout System - V1	27
Bryant Variable Breakout System - AvData	27
TradeStation Strategy Settings	
Costs/Capitalization	
Initial Capital	\$100,000.00
Commission	\$10.00 per Trade
Slippage	\$0.00 per Trade
Interest Rate	2.00%

Figure 17a: ADBE Optimized Parameters

As mentioned in the BEAM section, these are the variables used for the rest of the graphs. As a reminder, with commissions less than \$10, the system can be expected to work better.

TradeStation Performance Summary			
	All Trades	Long Trades	Short Trades
Total Net Profit	\$3,999.00	\$3,999.00	\$0.00
Gross Profit	\$7,705.00	\$7,705.00	\$0.00
Gross Loss	(\$3,706.00)	(\$3,706.00)	\$0.00
Profit Factor	2.08	2.08	n/a
Roll Over Credit	\$0.00	\$0.00	\$0.00
Open Position P/L	\$0.00	\$0.00	\$0.00
Select Total Net Profit	\$5,357.00	\$5,357.00	\$0.00
Select Gross Profit	\$7,153.00	\$7,153.00	\$0.00
Select Gross Loss	(\$1,796.00)	(\$1,796.00)	\$0.00
Select Profit Factor	3.98	3.98	n/a
Adjusted Total Net Profit	\$3,008.33	\$3,008.33	\$0.00
Adjusted Gross Profit	\$7,036.89	\$7,036.89	\$0.00
Adjusted Gross Loss	(\$4,028.57)	(\$4,028.57)	\$0.00
Adjusted Profit Factor	1.75	1.75	n/a
Total Number of Trades	269	269	0
Percent Profitable	49.44%	49.44%	0.00%
Winning Trades	133	133	0
Losing Trades	132	132	0

Figure 17b: ADBE Back-Testing Performance Summary

Here, the profit factor is much lower than with BEAM at only 2.08. However, its select profit factor doesn't expand very largely, nor does its adjusted profit factor drop much. This proves much more stability in its patterns.

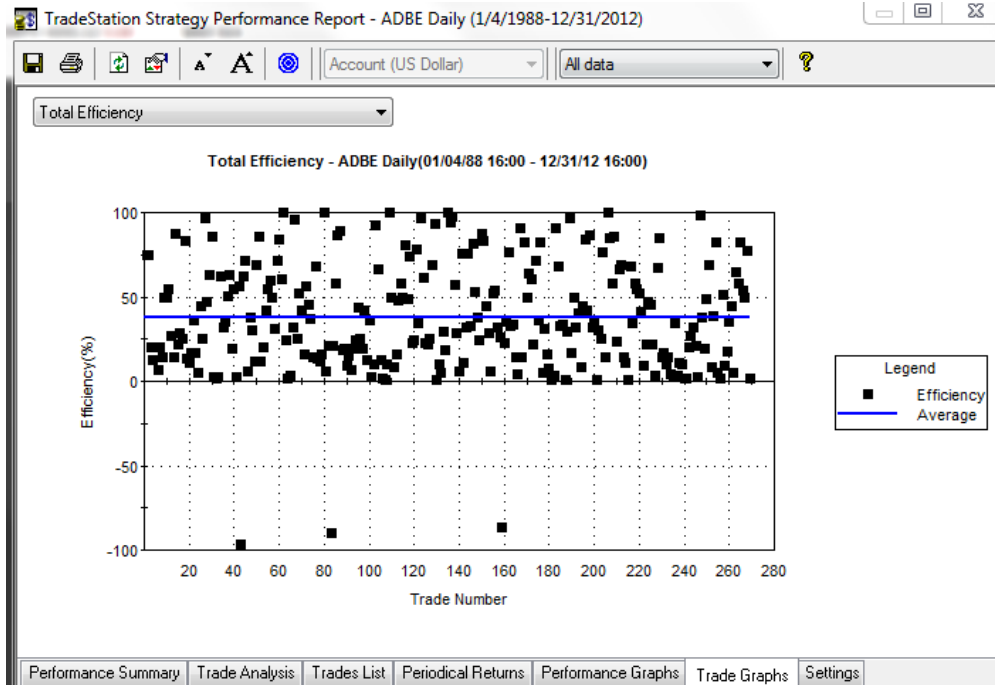


Figure 17c: ADBE Efficiency

Even accounting for the super-low outliers in this example, the efficiency still proves around 37.5% at a glance.

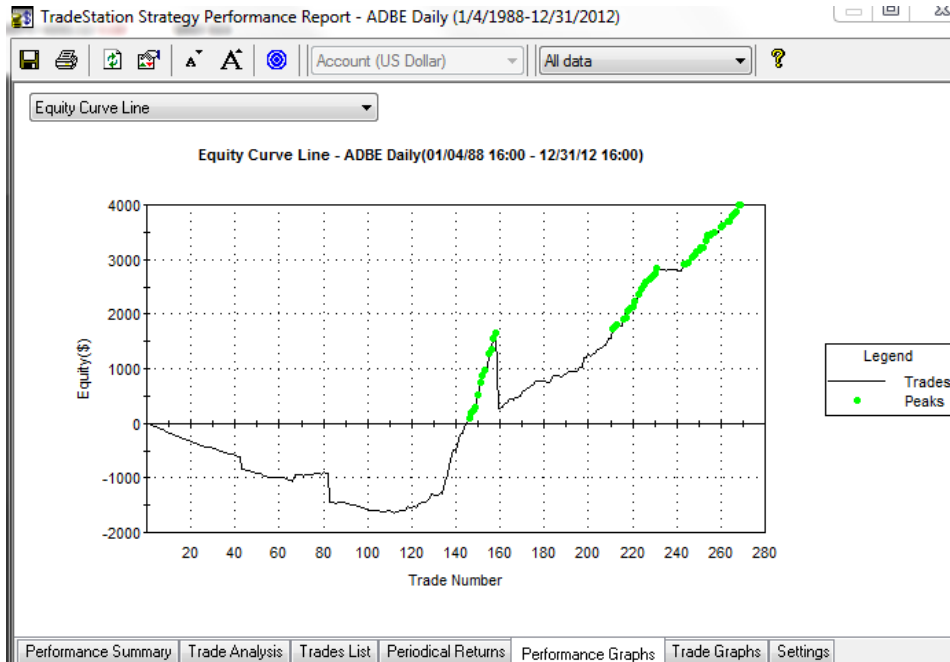


Figure 17d: ADBE Equity Curve

This equity curve has quite some trouble starting up. After trade number 140, however, the system really picked up and, after the next twenty, started on an upward slope. Even so, the system will not look convincing to most.

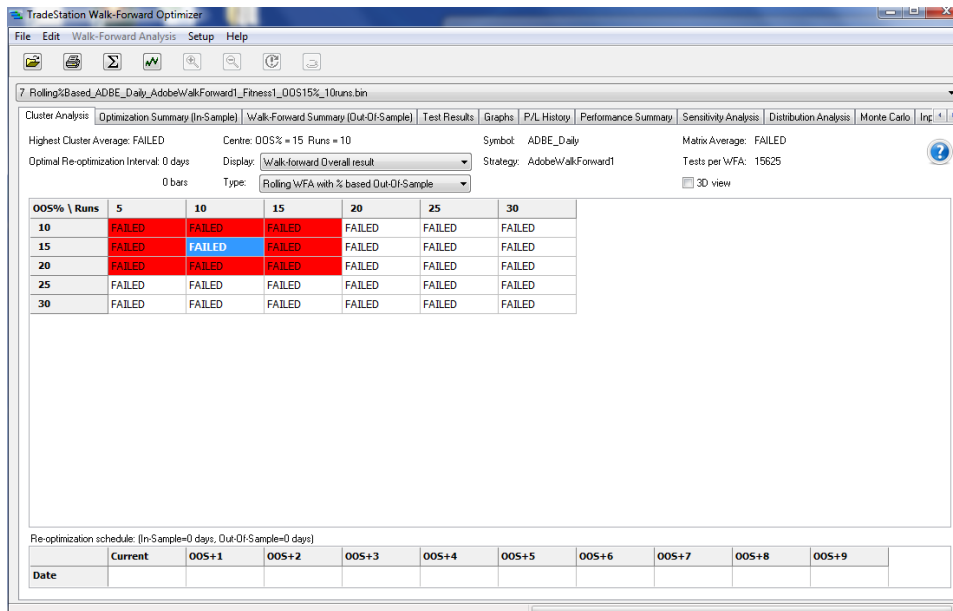


Figure 17e: ADBE Walk-Forward Cluster Analysis

And this chart is very disappointing – not a single pass in this chart. At this sign of a chart, most professionals would stop the process here and work a different stock or even just remove the entire strategy from their repertoire.

Walk-Forward Analysis Results : OOS=15% WFRuns=10

Symbol: ADBE_Daily Strategy: AdobeWalkForward1

	Test Criteria	Result	Comment
1	Overall Profitability	Pass	Total Profit > 0. System is likely to perform profitable on unseen data
2	Walk-Forward Efficiency	Failed	Walk-Forward Efficiency < 50%. System is likely to perform in future at a rate of less than 50% of those achieved during optimization
3	Consistency of Profits	Pass	50%+ of walk-forward runs were profitable. System is likely to be successful in future.
4	Distribution of Profits	Failed	Walk-forward run #8 contributed more than 50% of Total Net Profit.
5	Maximum Drawdown	Pass	No individual run had a drawdown of more than 40% of initial capital.
	OVERALL RESULT	FAILED	

Figure 17f: ADBE Walk-Forward Results

However, even that whole grid of failure had a silver lining. Overall Profitability analysis states that the system is likely to perform profitable on unseen data and Consistency of Profits analysis states that the profits are consistent.

Av. Win	57.93233	1st trade	3/21/1988	Expectancy	0.069119	0.001406
		Last Trade	1/5/2010			
St.Dev Wins	59.31122	# Days	7960	Opportunities	12.3348	
System Quality	16.01992	# Trades	269	Expectunity	0.852573	0.01734

Figure 17g: ADBE System Quality Analysis

All of expectancy, expectunity, and average win are small (0.069119, 0.852573, and 57.93233, respectively), yet it has the largest system quality from among all three (in this case, 16.01992). Why would such be, after all the previous analysis? The answer lies in the consistency. While this volatility expansion strategy may deliver small amounts of money with ADBE, it does so more consistently than it does with BEAM and V.

System Comparison and System of Systems Analysis

From the analysis that was done on all three systems, we were able to find three important statistical values for each system. These three values are expectancy, expectunity, and system quality. These three values were found for the three different stocks that each system was traded on and are provided in Figure 17. One thing that is notable is the difference in expectancy and expectunity between the three systems. The expectancy for the gap strategy is generally lower than that of the volatility strategy. This may be due to the fact that the gap strategy works on a shorter timeframe than the volatility system. This leaves less time for the trade to make profits and thus a lower expectancy. However, since there are many opportunities for trades in this gap strategy, its expectunity measures more favorably relative to the volatility expansion system. A similar pattern occurred with the trend-following system. Since this system was designed to trade on a shorter timeframe than a traditional trend-following system, it had many opportunities to trade and had very good expectunity values. In fact, this system had the most consistent expectunity across its stocks. But, the last statistic that was calculated, system quality, was the statistical value that determined how much money would be allocated to each system for trading.

System quality is often used as a way to compare trading systems that operate on different indicators, timeframes and other criteria. System quality is calculated by taking the square root of the number of trades, multiplying by the average winning trade and then dividing by the standard deviation of winning trades. This takes not only the size of winning trades into account, but also the consistency of the size of winning trades. In this system of systems, the gap strategy had the most consistent and highest system qualities, which is an indication that the systems winning trades are not only sizable, but consistent. When allocating money to a system of systems, comparing system quality is a good indicator of how much money should be invested into each system. For this system of systems, a weighted average of system quality was used to allocate money. Therefore, the percentage of total system quality that each system contributed was also the percentage of money that they were given. Since the total amount of simulated trading money between the three traders was \$300,000, that total was split up by the percentages given in Figure 17.

Figure 18: System Quality Comparison Table

	Volatility			Gap			Trend-Following		
	V	ADBE	BEAM	BP	CVS	JPM	GOOG	FB	GOLD
Expectancy	0.5361	0.0691	0.5200	0.2228	0.2229	0.0429	0.7402	0.2850	0.0968
Expectunity	20.0807	0.8526	5.3021	23.0295	10.6359	8.9453	23.1856	17.0862	19.3593
System Quality	11.2195	16.0199	11.0043	18.1196	18.4688	18.5103	16.9234	10.3490	11.3284
% Money Allocated	8.5033	12.1415	8.3402	13.7329	13.9976	14.0290	12.8263	7.8435	8.5858
Amount of Money	\$25,510	\$36,425	\$25,021	\$41,199	\$41,993	\$42,087	\$38,479	\$23,531	\$25,757

Conclusions and Looking Forward

The gap strategy that was developed for this project is probably not ready to be traded using real money. The system had a positive expectancy, but the rate of return was just not high enough to make it worthwhile to trade. An investor would be better off investing their money in an exchange traded fund that mimics the S&P 500. The S&P 500 had a return on investment of 15.89% in 2012 and 32.15% in 2013 (New York University, 9 May 2014). These returns are higher than the returns of the gap strategy and the exchange traded fund is less risky than the gap strategy. Therefore, there is no incentive to trade the gap strategy. Given more time, one of the first things that would be improved about the system is its exit rules. The exit rules that were used are not very impressive based on results, but they are the best rules that were found for the system. With more time, more exit rules could be tested and the system would be vastly improved. An alternative way to improve the system is to find a better stock to trade. BP does gap frequently and its behavior is predictable, but its price does not move much in any given day, which means that a lot of money needs to be invested per trade to really see a good return. By picking a different stock that is perhaps more volatile during the day, higher profits could be earned without risking too much money on any given trade.

The purpose of the trend following strategy that was developed for this system of systems was fulfilled but only to a certain extent. Typically, trend following strategies are developed to take advantage of big market swings and will only make about five to seven trades over the course of a year. The trend following strategy for this project was designed to increase the number of trades and was used with intra-day bars rather than monthly or yearly bars in an

attempt to avoid noise. The number of trades definitely increased and both strategies for Google and Facebook were profitable. It can be observed though, that noise affected the profitability of the strategy used to trade Google, which suggests that, for future projects, more research should be conducted on noise and how noise affects the market. Also, more experimentation should be conducted with exit strategies and a wider range of trending stocks.

Overall, the volatility expansion system proved moderately well in current testing, and, even relative to the other systems in the overall system, it held its own very well. However, overall for future testing, the figures show that the system isn't quite robust enough yet. While it could be traded and one could make money using it, it may not generate the alpha needed consistently enough and without any worries to the prospective user of the system to overall be more worthwhile to said prospective user. However, since the code is so simple, a great number of modifications could be made to the code to improve it. The most important one to tackle would likely to be to reinstate and rework the shorting and cover code. While such code was found detrimental for these tests, removing it proved overall detrimental for the final tests of the system. To further experiment, one could try adjusting the role of the volatility to play a bigger role than just a breakout measurer for entries and exits. A large quirk in the code that could cut down profits is the "exit after 2 bars" strategy. While this gets the strategy out when the breakout usually ends, what if it keeps going? A trailing stop could in theory be used instead, but it could also reduce the gains of some profitable trades. Finally, the last avenue to check out from observations here was that ADBE took a two-year trade. An inactivity stop could prove reliable to ensure such does not happen, but at the same time, offers high chance of failure. Such a parameter for how many bars until exit could probably be optimized as well.

The overall system of systems achieved its goal. By allocating money to several unique strategies and stocks, the system became more robust and consistent. Based on how the money was allocated to each individual system, an overall expectancy and expectunity was calculated. The overall expectancy of this system of systems is 0.29075 and the overall expectunity is 14.1357. As designed, the overall system of systems sacrifices higher returns for consistency and robustness. If one individual strategy is performing poorly, the other systems will balance this loss out. With additional time, the next step in this project would have been to further analyze the system of systems to get a better understanding of how the systems worked together

compared to how they work individually. This could include a Monte Carlo simulation taking into account all trades of the system of systems to better understand the expected performance of the system. Something that was discovered during the completion of this project was that in a system of systems, it is important to keep the systems diverse to avoid failure during poor markets. In other words, if two systems are too much alike, they will be affected by the same news and same market trends. In order to diversify systems, a trading system developer must have a comprehensive knowledge of how markets relate and move in relation to one another.

Works Cited

- "A Gap Strategy for the E-mini S&P". *Seven Trading Systems*. 16 July 2010. Web. 10 January 2014. <<http://seventradingsystems.com/day-trade-strategy.php>>.
- "Adjusted Profit Factor." *Adjusted Profit Factor (Report Field)*. TradeStation. Web. 16 Apr. 2014.<http://help.tradestation.com/08_08/tradestationhelp/mergedprojects/spr_topics/report/adjusted_profit_factor__strategy_performance_report_.htm>.
- "Annual Returns on Stock, T.Bonds and T.Bills: 1928 – Current". *New York University*. Web. 9 May 2014.
<http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/histretSP.html>.
- "Average True Range." *Average True Range*. TradeStation. Web. 20 Apr. 2014.
<http://help.tradestation.com/09_00/tradestationhelp/commentary/average_true_range.htm>.
- Bollinger, John. "Bollinger Bands Introduction." *BollingerBands*. Bollinger Capital Management, Inc.. Web. 7 Apr 2014. <<http://www.bollingerbands.com/>>.
- Bollinger, John. *Bollinger Bands Introduction*. N.d. Photograph. BollingerBand. Web. 26 Apr 2014. <<http://www.bollingerbands.com/>>.
- Bryant, Mike. "Breakout Bulletin - February 2003." *Breakout Bulletin - February 2003*. Breakout Futures, Feb. 2003. Web. 20 Apr. 2014.
<<http://www.adaptrade.com/BreakoutFutures/Newsletters/Newsletter0203.htm>>.
- Bryant, Mike. "Breakout Bulletin - November 2002." *Breakout Bulletin - November 2002*. Breakout Futures. Web. 25 Apr. 2014.
<<http://www.adaptrade.com/BreakoutFutures/Newsletters/Newsletter1102.htm>>.
- Cruset, José. "Analysis of Trend Following Systems." . N.p., n.d. Web. 3 Apr 2014.
<<http://www.cruset.com/systemtrader/download/trendfollowing.pdf>>.
- F., Andreas. "Trading System Rules." *Following The Trend*. N.p., 1 Jan. 2014. Web. 7 Apr. 2014. <<http://www.followingthetrend.com/the-trading-system/trading-system-rules/>>.

- “Gaps and Gap Analysis”. *StockCharts*. Web. 6 April 2014.
<http://stockcharts.com/school/doku.php?id=chart_school:chart_analysis:gaps_and_gap_analysi>.
- “Indicators”. *TradeStation*. Web. 10 April 2014.
<<http://www.tradestation.com/en/education/university/markets-and-trading-resource-center/articles/technical-analysis/indicators>>.
- Kennedy, Rory. “Autotrading vs. Manual Trading”. *Wealth Creator*. Web. 9 April 2014.
<<http://www.wealthcreator.com.au/invest/advice/autotrading-vs.-manual-trading>>.
- Mitchell, Todd. “In Search of the Holy Grail Trading System”. *Trading Concepts*. 10 April 2013. Web. 8 April 2014. <<http://www.tradingconceptsinc.com/5564/search-holy-grail-trading-system/>>.
- “MONEX Group Releases Full Financial Results For H1 Of Fiscal Year: Flying Start Curtailed.” *Forex Magnates*. Chart. 31 Oct 2014. Web. 1 May 2014. <<http://forexmagnates.com/monex-group-releases-full-financial-results-for-h1-of-fiscal-year-flying-start-curtailed/>>.
- "Moving Average Crossovers." *Online Trading Concepts*. OnlineTradingConcepts.com, n.d. Web. 3 Apr 2014.
<<http://www.onlinetradingconcepts.com/TechnicalAnalysis/MASimple2.html>>.
- Mulloy, Patrick. *Triple Exponential Moving Average (TEMA) Technical Indicator*. N.d. Chart. Trade Forex TradingWeb. 22 Apr 2014.
<<http://www.tradeforextrading.com/index.php/tema-moving-average>>.
- Nathan, Narendra. “How to Use RSI Indicator to take Decisions on Buying and Selling Stocks”. 8 April 2013. Web. 9 April 2014. <http://articles.economictimes.indiatimes.com/2013-04-08/news/38374193_1_rsi-overbought-zone-swing>.
- “Relative Strength Index”. *StockCharts*. Web. 7 April 2014.
<http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:relative_strength_in>.

- Schlossberg, Boris. "Top 7 Questions About Currency Trading Answered". *Investopedia*. 7 May 2014. Web. 8 May 2014.
<<http://www.investopedia.com/articles/forex/06/sevenfxfaqs.asp>>.
- "Select Profit Factor." *Select Profit Factor (Report Field)*. TradeStation. Web. 16 Apr. 2014.
<http://help.tradestation.com/08_08/tradestationhelp/mergedprojects/spr_topics/report/select_profit_factor_strategy_performance_report.htm>.
- "Strategies for Trading Relative Strength Index- RSI Technical Indicator". Web. 6 April 2014.
<<http://www.stock-market-strategy.com/relative-strength-index-rsi/>>.
- Tharp, Van. *Trade Your Way to Financial Freedom*. New York: McGraw-Hill, 1998. Print.
- Thygesen, Philip. "Relative Strength Index – RSI". *Stock Market Strategy*. 9 April 2010. Web. 4 April 2014. <<http://www.stock-market-strategy.com/relative-strength-index-rsi/>>.
- "True Range." *True Range*. TradeStation. Web. 20 Apr. 2014.
<http://help.tradestation.com/09_01/tradestationhelp/charting_definitions/true_range.htm>.
- Tucci, Nathan. "Manual Trading vs Automated Trading". *Winner's Edge Trading*. 1 June 2012. Web. 7 April 2014. <<http://www.winnersedgetrading.com/manual-trading-or-automated-trading/>>.
- "Van Tharp's Glossary of Terms". *Van Tharp Institute*. Web. 9 May 2014.
<<http://www.vantharp.com/glossary.asp>>.
- "What is a 401(k)?" *Wall Street Journal*. Web. 17 April 2014. <<http://guides.wsj.com/personal-finance/retirement/what-is-a-401k/>>.
- Wyckoff, Jim. "Kaufman: Multiple Trading Methods and Market 'Noise'". *Action Forex*. Web. 6 April 2014. <<http://www.actionforex.com/articles-library/general-trading-articles/kaufman:-multiple-trading-methods-and-market-%22noise%22-2007112632430/>>.

Appendices

Gap Strategy Code

Gap Up

Inputs: Price(Low), Length(14), Oversold(30), Overbought(70), psize(500), ProfitTargetPct(.10), { pass in 0 if you don't want a profit target }

StopLossPct(.05); { pass in 0 if you don't want a stop loss }

Variables: JNRSI(0);

JNRSI = RSI(Price, Length);

If OpenD(0)>HighD(1) and entriestoday(date)=0
and time <1000

and High<OpenD(0) and High>LowD(1)

And JNRSI crosses under Overbought

Then sellshort psize contracts next bar at market;

If OpenD(0)> HighD(1) and entriestoday(date)=0

And time >1000 and time < 1010

And JNRSI>Oversold

And High>High[1]

Then buy psize contracts next bar at market;

SetStopShare ;

if MarketPosition <> 0 then { set regular profit-target and stop-loss }

begin

if ProfitTargetPct > 0 then

SetProfitTarget(EntryPrice * ProfitTargetPct) ;

if StopLossPct > 0 then

SetStopLoss(EntryPrice * StopLossPct) ;

end

else { set entry-bar profit-target and stop-loss }

begin

if ProfitTargetPct > 0 then

SetProfitTarget(Close * ProfitTargetPct) ;

if StopLossPct > 0 then

SetStopLoss(Close * StopLossPct) ;

end ;

SetExitOnClose ;

Gap Down

Inputs: Price(Low), Length(14), Oversold(30), Overbought(70), psize(500), ProfitTargetPct(.10), { pass in 0 if you don't want a profit target }

StopLossPct(.05) ; { pass in 0 if you don't want a stop loss }

Variables: JNRSI(0);

JNRSI = RSI(Price, Length);

If OpenD(0)<LowD(1) and entriestoday(date)=0

and time <1030

and High>OpenD(0) and High<LowD(1)

And JNRSI crosses over Oversold

Then buy psize contracts next bar at market;

If OpenD(0)<LowD(1) and entriestoday(date)=0

And time>1030

And JNRSI < Oversold

{ and High<OpenD(0) } And High<High[1] and High[1]<High[2]

Then sellshort psize contracts next bar at market;

SetStopShare ;

if MarketPosition <> 0 then { set regular profit-target and stop-loss }

begin

if ProfitTargetPct > 0 then

SetProfitTarget(EntryPrice * ProfitTargetPct) ;

if StopLossPct > 0 then

SetStopLoss(EntryPrice * StopLossPct) ;

end

else { set entry-bar profit-target and stop-loss }

begin

if ProfitTargetPct > 0 then

SetProfitTarget(Close * ProfitTargetPct) ;

if StopLossPct > 0 then

SetStopLoss(Close * StopLossPct) ;

end ;

Trend Following Strategy Code

Facebook Strategy

{ Buys if Price crosses over Avg and then stays above Avg for one or more bars }

inputs: Price(Close), Length(9), ConfirmBars(1);

variables: Counter(0), Avg(0);

Avg = AverageFC(Price, Length);

if Price > Avg then

 Counter = Counter + 1

else

 Counter = 0 ;

if CurrentBar > ConfirmBars and Counter = ConfirmBars then

{ CB > ConfirmBars check used to avoid spurious cross confirmation
at CB = ConfirmBars }

 Buy ("MACrossLE") next bar at market ;

if CurrentBar > 1 and Price crosses under Avg then

{ CB > 1 check used to avoid spurious cross confirmation at CB = 1 }

 Sell ("MACrossLX") next bar at market ;

Google Strategy

```
{ Buys if Price crosses over Avg and then stays above Avg for one or more bars }
```

```
inputs: Price( Close ), Length( 9 ), ConfirmBars( 1 );
```

```
variables: Counter( 0 ), Avg( 0 );
```

```
Avg = AverageFC( Price, Length );
```

```
if Price > Avg then
```

```
    Counter = Counter + 1
```

```
else
```

```
    Counter = 0 ;
```

```
if CurrentBar > ConfirmBars and Counter = ConfirmBars then
```

```
{ CB > ConfirmBars check used to avoid spurious cross confirmation  
  at CB = ConfirmBars }
```

```
    Buy ( "MACrossLE" ) next bar at market ;
```

```
if CurrentBar > 1 and Price crosses under Avg then
```

```
{ CB > 1 check used to avoid spurious cross confirmation at CB = 1 }
```

```
    Sell ( "MACrossLX" ) next bar at market ;
```

```
if Price < AverageFC( Price, Length ) then
```

```
    Counter = Counter + 1
```

```
else
```

```
    Counter = 0 ;
```

```
if CurrentBar > ConfirmBars and Counter = ConfirmBars then
```

```
{ CB > ConfirmBars check used to avoid spurious cross confirmation  
  at CB = ConfirmBars }
```

```
    Sell Short ( "MACrossSE" ) next bar at market ;
```

```
if CurrentBar > 1 and Price crosses over Avg then
```

```
{ CB > 1 check used to avoid spurious cross confirmation at CB = 1 }
```

```
    Buy To Cover ( "MACrossSX" ) next bar at market ;
```

```
{ ** Copyright (c) 2001 - 2010 TradeStation Technologies, Inc. All rights reserved. **
```

```
  ** TradeStation reserves the right to modify or overwrite this strategy component  
  with each release. ** }
```

Volatility Expansion Strategy Code

Input: FrLv0 (.8), {Breakout fraction, Low vol, longs}
FrLv1 (0.3), {Breakout fraction, high vol, longs}
{FrSv0 (.8), {breakout fraction, Low vol, shorts}
FrSv1 (0.3), {breakout fraction, high vol, shorts}}
MMFrL (2.0), {Volatility multiplier For exit, longs}
{MMFrS (2.0), {Volatility multiplier for exit, shorts}}
V0 (16), {Low volatility}
V1 (30), {high volatility}
AvData (22); {number of bar to look back in average true range}

Var: ATR (0), {Average true range}
ML (0), {Slope of B/O fraction curve, longs}
BL (0), {y-intercept, longs}
{MS (0), {slope of b/O fraction curve, shorts}
BS (0), {y-intercept, shorts}}
FrL (0); {Entry fraction For longs}
{FrS (0); {Entry fraction For shorts}}

ATR = Average(TrueRange, AvData);
ML = (FrLv1 - FrLv0)/(V1 - V0);
BL = FrLv0 - ML * V0;
{MS = (FrSv1 - FrSv0)/(V1 - V0);
BS = FrSv0 - MS * V0;}
FrL = ML * ATR + BL;
{FrS = MS * ATR + BS;}

Buy next bar at H + FrL * ATR stop;
{Sell short next bar at L - FrS * ATR stop;}

If MarketPosition = 1 and C > EntryPrice and BarsSinceEntry >= 1 then
 Sell this bar at close;
{If MarketPosition = -1 and C < EntryPrice and BarsSinceEntry >= 1 then
 Buy to cover this bar at close;}
If MarketPosition = 1 then
 Sell next bar at EntryPrice - MMFrL * ATR stop;
{If MarketPosition = -1 then
 Buy to Cover next bar at EntryPrice + MMFrS * ATR stop;}