Trading & Investing System Development:

System of Systems

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Abstract

This Interactive Qualifying Project explores stock and currency trading through the use of three different automated trading systems: a system that trades on morning gaps, trend following system, and a basic AI system.

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Chapter 1: Introduction & Overview of Research

Problem Statement

In the modern world proper management of one's personal wealth is a very important way to secure a financially comfortable future. Most people either do not invest or leave management to professionals, but this is generally a mistake that people make because they lack education on how to manage their wealth themselves. Management of one's wealth can actually be relatively easy and in many cases can give notable higher returns than that which professionals will offer. One of the best ways for a person not very experienced with finance can invest their money is through the use of automated trading systems. Because of the internet and computers automated trading has been growing in popularity both because of it's effectiveness and convenience. In this paper we discuss a few different ways that simple automated trading systems can trade stocks and currencies.

We will discuss three different systems that each approach automated trading in very different ways. First, a morning gaps system that trades on jumps in stock prices that take place at the start of a trading day. Second, there is a trend following system that identifies trends in price movements and trades them. Last, a system that decides trades with a basic neural network. These three systems complement each other by trading at very different times, evening out the performance of the three.

Chapter 2: Trading & Investing

To the average citizen without prior knowledge of the financial sector, they might think that trading and investing are the same. However this is not the case, usually an individual that identifies himself as an active investor will prefer stocks over the other assets classes. They are always considering the larger picture and always think long term when they are making investments. They also see themselves as "owners" of the companies or firms that they have invested in. Their main focus is on the dividend potential of stocks. A dividend is a cash payment from a company's earnings that is then distributed between the shareholders. The more shares you own the higher the dividend you earn. Which is one way investors makes their money back. Another characteristic of active investors is that they will never bet against the market in other words they will not sell short. They believe that betting that the price of a stock will go down goes against their principles.

On the hand we have a trader, which is a general term that encompasses the many different types of traders that you can be. You can become a flash trader that trades every microsecond, a Scalper which range from second to minutes, a day trader, etc…. However even though the time frames of their trades changes they share the same characteristics. A trader will trade all four assets classes (stocks, bonds, currency, and commodities). They don't see themselves as "owners" of the firm which they have stock. Also they don't want the assets that come with derivative contracts. Furthermore traders will take long and short positions depending on how the market is moving.

Both of the individual's attempts to profit from the financial market but each approach or ideals have its advantages and disadvantages compared to the other. Generally speaking an investor will always hold their market position for a long time. This causes your slippage and commissions cost to be smaller since you are not buy or selling stocks that frequently. Which is an advantage since you net profit is your (profit -(slippage+com). A slippage is the difference between the expected price of a trade, and the price the trade actually executes at. The longer you hold your position the more the price can fluctuate making it riskier to hold. Also your capital that is your investment is also tied-up till you decide to leave your current position. In addition the longer you hold your position the worry you need to be to follow world news that can cause a big change in the market. Using websites such as Bloomberg Calendar you are able to receive

notifications when big reports are made public. Examples of reports that are considered to be market indicators are the jobless claims, consumer sentiment, retail sales and the employment situation report. The latter one is released the first Friday of every month. On the other hand taking short positions you don't need watch the news that carefully depending how short your time frame. This is an advantage for an individual that doesn't have a lot of time to spend watching the market and the news at the same time. It may be that trading if your side project since you have work and are not able to be are station for a long time.

In addition there are two main ideas in terms being an active trader or investor. Some investors believe that the highest return on your investment will be the one that travels with the flow of the market. This means that you are not trying to to beat the market but rather the market will dictate what you do. In doing this people invest in index funds which carry very few risk in terms only money(not 100% guaranteed that you won't lose money). However if you invest in index funds your rate of return will be the around 10%-11% which is the average return of the S&P 500. If you want to achieve a better return than the average then you need to systematically beat the market and try to achieve a rate of return greater than the market average. While doing this will yield a greater profit there is a lot more risk than investing in an index fund. While trying to beat the market you are trying to predict beforehand any swings that can happen using trends or inter-market analysis to name a few prediction tools. However your prediction will never be completely accurate which can inherently cause a risk in your current market position. This is how you decide what type of investor or trader you are. Will you follow the market or try to beat it?

Macroeconomics is the broader study of the economy that focuses more on how the economy moves as whole. A lot of models used for trading and investing use trends and cycle are their bases. A trend is a pattern that it is used to predict the future of a data plot. After connecting two data plots and confirming its direction with a third data plot we can say that a trend is downwards or upwards. In theory in a stock in trending downwards it means that its price declining while an upwards trends shows the price of the stock is increasing. A market cycle is a trend or pattern that may exist in a given market environment, allowing some securities or asset classes to outperform others, given this trends you decide to trade base of the patterns you predict will happen using the cycles.

2.1 The Asset Classes

The main four asset classes are stock, bonds, commodities and currencies. A stock is a type of security that signifies ownership in a corporation and represents a claim on part of the corporation's assets and earnings. There are two main types of stock: common and preferred. Common stock usually entitles the owner to vote at shareholders' meetings and to receive dividends. Preferred stock generally does not have voting rights, but has a higher claim on assets and earnings than the common shares. A bond is a debt investment in which an investor loans money to an entity (typically corporate or governmental) which borrows the funds for a defined period of time at a variable or fixed interest rate. Bonds are used by companies, municipalities and states to raise money and have funds to do projects. For example the agricultural office needs money to funds to provide better pesticides for the farmers, they can opt for a bond that would give them access to such capital and they would need to pay back everyone that bought the bond at the interest rate states in the contract. A commodity is a basic good used in commerce that is interchangeable with other commodities of the same type. Commodities are most often used as inputs in the production of other goods or services. For example oil, natural gas, apple juice and valuable metals are all considered commodities. Finally, currencies are the accepted method of payment for different countries. They can be found as paper notes or coins which are made by their given government and circulate that country's economy. For example the Yen is the Japanese currency and it most commonly circulates in the Japanese economy.

Trading of investing in each of the assets classes carries disadvantages and advantages. When considering trading stocks, the stock market has a high liquidity which is how fast can you buy or sell the assets without affecting its price. This is beneficial because the price of the stock will likely not fluctuate a lot if there is equal numbers of seller or buyers. However if everyone is starting to sell that particular stock the price will go down. Which is a disadvantage of trading stocks, there is no guarantee that you will make profit but the amount of money that you can earn in the stock market is very large compared to the other asset classes. Also depending on the type of stock that you buy, you are eligible to exclude any profit gained for tax purposes. Depending on what type of trader you are there will be margin requirements that your account will need to have in order to able to trade. For example if you are a day-trader you need 25,000 USD of

equity in your account before the market opens for your broker to accept your trades. While the minimum equity for other securities are 2,000 USD (www.finra.org).

In terms of bonds, the main advantage is that the risk involved with stocks is almost nonexistent with bonds. You have a set interest rate that bond states and you will get your money back. However the margin for profit is very slim since the interest can be ranging from 1 to 4%. There is also the uncertainty of if the creditor will have enough money to pay people back at the right time. Bonds is assets class recommended for people that a very low risk tolerance. In addition municipal bonds which are issued by states to fund projects or services are exempt from taxes which is another benefit that bonds has over the other classes.

Furthermore, commodities which are mostly traded in the commodities futures market tend to be have a lower liquidity than stocks since there amount of volume is much lower however if you are buy commodities there is less risk involved. Since it is called futures market whereby the buyer purchases the obligation to receive a specific quantity of the commodity at a specific date and at a specific price, therefore it offers some standardized for the user and producers of that particular commodity. Hence by trading in commodities market you are essentially protecting the price of the commodity you have a contract for its duration. This gives the user some leverage during the validity of the contract.

Finally, a currency which is the asset class with the highest liquidity of all four of them has its exchange market open 24/5. Also since the volume of for the forex market is really big it is a very difficult market to get into without proper training. You need to investigate country's political and economical state by the news and make the correct judgment. In addition most long term strategies will not work with currencies because it is a very volatile market which makes its hard for indicators to accurately predict what the next trend will be.

2.2 Trends and Cycles

Many traders and investors believe that the market groups are linked creating cycles that can be exploited to their benefit. Some basic relationships between the classes are that, the U.S dollar and commodities prices will trend in opposite direction. This means that when the price of commodities is going up the strength of the U.S dollar will go down. Furthermore commodity

prices and bond prices trend in the opposite direction. Stocks and bonds prices trend in the same direction. After you know this relationship between the assets classes you build cycles that tell you if the market is behaving 'correctly'. If there is a greater chance that the trend will continue, however if the relationships are not what you expect it could be a sign of an early downward trend. Another example of a cycle is when the U.S dollar is weak which means that money will move into foreign markets, this strengthen the currencies of that particular country meaning that it will affect currency pair traded in the currency exchange. Many of the benefitted countries are manly commodities producers such as Russia and Canada. Hence if Canada and Russia benefit the most when commodities they produce have a higher price and their respective currency is stronger that U.S dollar. They are many different tools to try and analyze trend or cycles with the assets classes. One index that is very commonly known is the CRB Index/Treasury Bond ratio. If this ratio is increasing, it suggests inflation which negatively affects stocks. If the ratio is decreasing it generally is healthy for the stock market.

In the equity market or stock market it is divided into ten sectors, within each sector there are about 90 industry groups. For example The Basic Metals sectors contains industry groups such as: Aluminum, gold mining, steel, chemicals, etc.. Knowing how the stock market is structured there are different strategies that can be applied. You could find a strong industry group inside the strongest sector at that particular time and buy stock for the stronger group. While you can take the opposite approach which is short the weakest industry group in the weakest sector. In addition there is a strong relationship between interest sensitive stock groups and the bond market like banks and financial services. If bond prices are rising the stocks that pertain into any of the groups mentioned above with be trending upwards. Stock groups which underlying commodities do well will also do well. This means that it is good idea to invest into Energy companies if you see oil or natural gas prices going up.

2.3 Sector Rotation

Sam Stovall of Standard & Poor's is the pioneer of the concept called sector rotation. This concept is mainly used when someone wants to diversify their portfolio. This means that an individual is using the macroeconomic cycle to move money between sectors, to the sector that is

considered to be 'hot'. In this sector rotation there are stocks that do well with all the movements that happen which are called defensive stock groups while cyclical stock groups that follow the high and lows of the cycle. It is considered that if commodities prices are strong then cyclical stock group will do better. However there is an important rule that investor and traders follow which is that the market predicts the economy not the other way around. The stock market will always turn before the economy. Some key aspects to watch out for is when energy stock or material stocks start to lag with the market which suggest the end of an economic expansion. If the interest rates, the market will turn risk averse.

2.4 Market Breadth and the Stock Market

A stock exchange is type of financial market where securities are bought or sold. The supply and demand model from economics is what dictates the prices of the securities being bought or sold. There are many different stock exchanges is the world. For a company to able to sell their stocks, they first need to do an IPO (initial public offering). With an IPO a company sells it shares to initial public shareholders which act the primary market. After time has passed by the stocks are able to be sold and bought in the exchange which is the secondary market. The stock exchange with the highest recognition is the NYSE (New York Stock Exchange). It is the biggest and companies that are listed in it gain a lot of credibility due to the strict requirements a company must follow to remain in it. The NYSE is auction based, it has people called 'specialist' on the floor which post bidding and ask prices as well as managing limit orders. They are able to do this scene each specialist holds the inventory of the stock they trade. On the other hand NASDAQ is a completely electronic stock exchange. Buyers and seller communicate via telecommunications networks and everything in handled by computer. During the early 2000's NASDAQ was considered a secondary market that was known for only having technology related stocks. However NASDAQ has being growing rapidly having on their listing prestigious technological companies such as Google, Apple, Microsoft, Facebook and Intel.

Many tools can be used to analyze and evaluate market moves and the strength of those moves. One useful tool is the breadth of the market. By the usage of different indicators investors and traders are able to have warning signals to check if a price move is supported or not by the

market participants. One way this can be achieved is to compare the number of companies moving upwards versus companies are moving downwards. If this ratio is positive it suggest that market is in a bull stage which is good for investors. However if the ratio is negative it suggest that the market will move into a bearish state which is not good for trading or investing. Other commonly used breadth indicators are volume and New High, New Lows. On Balance Volume or OBV is a running cumulative of the total volume. Depending how the market closes, the volume for that day is added or subtracted. If the market closes up, the volume is added however if closes down, it is subtract from the OBV.

In addition there are many tools that people can use to see how "the market" is doing. There are three big indices that are widely used, the DJIA, S&P500 and NASDAQ 100. The Dow Jones Industrial average, contains 30 stocks it is a price-weighted index which means that higher priced stocks have greater contribution to the index value. This is a useful index to see what type of market we are in. However the true benchmark for the overall U.S market is the S&P 500. This index is updated hourly and it is made up of the market value weighted stock price of 500 companies. Many people believe this index defines how the market is doing. A positive S&P 500 value suggest that the market is trending upwards while a negative value tell the user that market is trending negatively. The NASDAQ 100 is similar to the S&P 500 since it was made to compete with it. It contains mostly technology stocks. This index is mostly used for the technological sector which generally tells you how the market is doing. To measure the strength of the market different indices are used. The NYSE composite index measures the value of all common stocks listed on the NYSE. This index is very useful as indicator for the general market strength. For the technology sector the NASDAQ composite index is used which is the same as the NYSE composite but it is more useful for technology.

2.5 Derivatives

A derivative is a contract made by two or more parties that agree on a specific value for a security of their choice. There are many different type of contracts that can be done but the most common one are future and option contracts. Futures contracts are mainly used for commodities or financial instruments. Parties making the contract agree on a future price for the asset traded.

Future contracts can also detail the quality and quantity of the asset. Depending on the contract, it may say that you will receive the asset once the contract expires or you will get cash instead. An option contract allows the owner of the contract to buy or sell the asset at a given price. This price is commonly referred as strike price. The two different types of options contract are the pull and call options which allow you to sell or buy. An example of this is when an investor predicts the price of oil will go up from 30 to 90. He could buy the oil commodities however he can choose to make a call option and setting the strike price of his oil options contract at 70. So if oil reaches 90 he will make 20 dollars profit per share.

Chapter 3: Trading Systems

3.1 Trading Platform

A trading platform is the software that allows investors and traders to open, close, and manage market positions, as well as monitoring their own accounts. The platform allows for an electronic form of trading as opposed to the traditional method of trading on the floor or by phone. It allows the user convenience of being able to trade anywhere. In addition to electronic trading, some other features of trading platforms include chart analysis, technical indicators, and back-testing. Features can vary from trading platform to trading platform. The following IQP used the TradeStation trading platform. TradeStation provides extensive functionality with real-time data, allowing the user to manage trading accounts, perform analytics on user performance and charts, and test user designed trading systems with real-time and historical data.

To utilize the services of trading platforms, it typically requires the financial intermediary of the likes of a brokerage account. The brokerage account is through the arrangement of the investor and the brokerage firm. There are two main types of accounts, a cash account and a margin account. The cash account has the investor deposit funds with the firm and then can place orders through the brokerage. The brokerage then carries out the transaction on the behalf of the investor. The margin account provides the investor a loan in which the investor can begin to place orders with an interest rate. The user is able to spend now, but must be weary to make substantial gain in order to payback the firm. It is the opposite of the cash account when only when you have money can the investor spend to place orders through the firm. In turn the firm will place fees and commissions. Fees and commissions can vary from firm to firm. Some firms may charge per individual trade, making it so that the investor must focus on the profit of the trade including the additional fees. Other firms may reward an investor for making many trades, charging less if the investors reaches a set amount of trades per month. It can all vary, and the investor needs to determine the best brokerage firm to work with.

Financial assets are traded at stock exchanges. Notable stock exchanges include the New York Stock Exchange, the NASDQ, and the S&P 500. Here, brokers and traders can buy or sell the various financial assets. Market Makers are firms or individuals that constantly buy and sell

shares of assets. They provide liquidity for their clients and other potential customers by being partners in trades, making money off of the spread of the buying and selling prices. Specialists are Market Makers that typically focus on a specific financial asset. They ensure that their respective asset is maintained by offsetting extreme demands or supply by selling or buying more of the asset. Traditionally stock exchanges operate as a physical facility where traders and brokers would gather on the trading floor to make transactions. The trading floor, known as the pit, would involve phone calls, hand signals, and shouting in order to transfer information of the various orders. This method of communication is known as open outcry, and was popular during the early stages of stock exchanges. Electronic trading has since brought the era of electronic markets. Instead of being on the floor of an actual stock exchange, traders can now network and make transactions with others virtually anywhere. Traders can electronically send the information instantly. This has created more liquid, competitive, and efficient markets by removing the human ability in favor of the speed of technology.

3.2 Investing & Trading Styles

As a trader, there are typically different styles of investing. Investment styles determine the characteristics, allocation, and performance of financial assets. The style can be determined by the beliefs of the investor, personal traits (i.e. social status or age), financial return, and tolerance of risk. Various styles cater to the different types of traders, each with various advantages and disadvantages. It is up to the trader to determine what works best and is acceptable as a personal investment style.

One type of investment style is value investing. Value investing focuses more on the performance of the company rather than the stock. Investors believe that the market exaggerates and quickly reacts to news that do not necessarily reflect the performance of the company, thus resulting in a change of the stock. These investors then look to find companies they believe are undervalued by the market, thus purchasing stocks of those companies that they believe should be worth more. They look at the value of the company rather than the value of the stock. If and when the markets then adjust to the true value of the company, investors can then profit from the rise in price. Value investing allows investors to ignore the fluctuation and the day-to-day

changes of the market. However, it can potentially be a long term style that rewards those who are patient and heavily research companies that they believe are intrinsic valuable. Once a bull, rising market is in place, it may tough to buy at a low price of devalued companies.

As opposed to value investing, there is the style of growth investing. Growth investing looks for companies that would grow potentially faster than the economy and inflation. Thus looking for companies to have expected earnings grow at an above-average rate than the market. A notable variation of this is the CANSLIM method. The essence of the system is to evaluate high growing stocks for quantitative and qualitative criteria, then recognizing price patterns on charts of the stock. The acronym can be broken down into the following:

> C – Current Quarterly Earning:
> - The amount of profit a company earned in the quarter compared to quarters of years prior, looking for growth, ideally 20%.
> A – Annual Earnings:
> - The amount of annual earnings should also be moving at a rapid pace.
> N – New:
> - Looking for something new within or outside the company that would affect performance. These could include new products, new management, or new highs for prices could all be factors.
> S – Supply and Demand:
> - Ideally looking for high demand, to ensure there are plentiful willing buyers for the stock.
> L – Leader or Laggard:
> - Investors are looking for stocks that have won previously as the will tend to continue you on as so (leaders), as opposed to stocks that have historically performed poorly and are less likely to do well(laggards).
> I – Institutional Support:
> - Investors are looking to see if the stock has intrigued the likes of multiple institutional owners, so that there is strong likely that the sock is making an impact to the eyes of others.
> M – Market Direction:

- Market direction will determine when to buy or sell the stock. In a bull market it is best to buy into the stock, as opposed to selling when the market is bear.

This method as well as growth investing in general is best in a bull market. In this type of market, companies can be better evaluated in terms of their growth.

There is also a hybrid variation of the two investment styles. This style looks for companies with growth potential, while also being undervalued by the current market. However, this strategy tends to favor lesser extremes of the two systems. It does not look for 20% growth, and may lower that number for a more realistic evaluation. It is a subjective system of evaluation that borrows from both styles and allows the investor to see returns from a bull and bear market, though not as much as one of the other two strategies.

Like investment styles, there many different types of styles of trading financial assets. Each style has advantages and disadvantages that should be assessed and conformed to be acceptable based on the trader. There are different types of logic for trading styles that determine the behavior of how to trade. Each reflect and cater towards different types of trading styles.

3.3 Trading Logic

One of the variations of trading logic is Support and Resistance. Support and Resistance uses two calculated metrics of price that are meant to determine bounds that a stock would not fall or rise past. Support represents the lowest levels the asset would trade at, while Resistance represents the highest level the asset would trade at. Each of these would be marked as indicators for the trader to determine when to buy or sell an asset. Volume of the asset then shows the strength of how it is trading by meeting or going past these levels. However, a downside to this is that these levels are not exact and may have to be calculated depending on if the asset breaks through or does not reach the levels at all.

There are also trend following strategies that use analysis of an asset's strength and direction in order to capitalize on profit. The strategy identifies a trend in the market, a pattern that can predicted and identified through analysis of the asset, then make orders accordingly to follow the trend until it ends. A breakout can be sign to begin trend following. A breakout occurs

when an asset breaks through a defined high price, a resistance level. Thus traders will look to trade in the direction of the breakout in order to profit usually during a bull market, until the asset re-establishes its price. The breakdown typically occurs in a bear market. It is the opposite of a breakout in which the asset breaches a point of support, a calculated defined low point. Traders will look to go short here until the asset reestablishes itself. Some well known trend following systems include Turtle Systems, 10 O'Clock Bulls, Regression Channels and Bollinger Bands/Keltner Channels. The Turtle System is a longer term strategy that uses past days' highs and lows to determine parameters of buying and selling. Volatility calculated by average true range, determines the position size when going long or short. The 10 O'Clock Bulls utilizes an opening range approach to trading. The opening range is the allocated amount of time of the opening of the market that defines the high and low prices for the system. These support and resistance levels are not permanent and must be observed to be determined if they are the true levels. In this case the opening range would be determined in the first 30 minutes of the market open. The system would long breaking out and short during a breakdown. Regression Channels uses a set of linear regression lines to identify how the strategy would trade. A regression line is drawn through the asset points, with an upper and lower regression line drawn one or two standard deviations away. With these sets of lines, a channel is created. This channel references contains most of the prices, depending on the standard deviation, thus the trader can identify to buy or sell depending if the asset breaks either of the regression channels. This type of implemented strategy is known for precision trading system, in which the system requires and can determine precise numbers that the regression lines are producing in order to calculate and determine the proper order to place. Bollinger Bands are calculated indicators consisted of a moving average band, an upper standard deviation band, and a lower standard deviation band. The bands represent an area of notable breakouts or breakdowns in order to buy or sell. Based on the number of bands, certain zones or area between two bands can be designated as a buy or sell zone for traders. Keltner Channels are similar to Bollinger Bands except for how the calculations of the bands are performed. Keltner Channels use average true range instead of standard deviation. Trend Following strategies are good for capitalizing of market movement, however this also is its weakness. The mentioned strategies require a trend of some sort. If a trend does not occur, not indicators will signal a buy or sell. Thus, the strategies are very dependent on the existence of a trend in the market.

Stop and Reverse Strategies uses an indicator to determine momentum in the market. When the market momentum changes the trade changes position from long to short or short to long. This type of strategy can be applied to the likes of the 10 O'clock Bulls, Regression Channels, and Bollinger Bands/Keltner Channels. In each system similar with the fact that they must be adjusted to be able to frequently change positions. This trading style is good for capitalizing on markets that are seeing new frequent highs and lows, however will struggle in markets that show minimal substantial movement in either direction.

Volatility Expansion Strategies focus on gauging the change in price from day to day. As opposed to the Trend Following where the trader trades in direction of the market, Volatility Expansion looks at price changes and assumes that there will be continuation of that direction based on market momentum. Following the momentum of the market, the trader must be willing to commit to the direction the market is going. This style of system is good for when the market is unstable, however in a stable market it is difficult to gauge the direction the market is going.

There are also many specialized strategies that focus more on certain behaviors of the market. Gap strategies specialize in markets where the asset has a difference in opening and closing price levels for two consecutive days. Traders will look for the high volume at the opening of the day from the gap and look to make trades to profit as the price levels adjust for the opening day offset. Rocket Strategies focus on stocks that jump high percentages with little to no reliable warnings. Once these assets begin their ascension, investors look to enter and profit off of the spike in price. However, the unpredictability can trick traders into thinking the asset will continue its direction. It is an unreliable strategy that can prove to be profitable but requires caution. Neural Networks in trading strategies have been used as an automated system to reliably predict the market. The system uses machine learning to adapt and coordinate trades, using past performance and historical data to correct and potentially predict future trades for higher profits. With the market already difficult to predict, the challenge in this system is reliably having the system to adapt to change and progress.

3.4 Trading Time Frames

For trading there are many different time frames to be in and out of the market. Some these time frames include scalping, day trading, swing trading, intermediate term position trading, long-term position trading, and active investing. Scalping is quick short term style where the trader almost immediately pulls out of the market once a trade is profitable. This prevents any risk of long term positions. However, a scalper must make frequent transactions in order to net substantial profit. Commissions then must be factored into the net profit since there would be many trades to be entered. Day trading is also a short term trading style that sees a trader enter positions during the day, and then exit all those positions by the end of the day. It is another form of quicker and smaller profits, where ideally there would be some net gains by the end of the day. It prevents trade positions from being held overnight, a concern for some traders as they are not actively monitoring their trades at this time. Swing trading is another short term trading style that looks to profit from a day to a week. Swing traders looking at trends in patterns of price levels in order to position themselves to enter the market and profit off the trends. Though it can make substantial profits off of trending markets, it is highly dependent on if the market trends, in which without it swing traders find difficult to identity how to enter and exit. It also can require positions to be held overnight. At this point traders may stress not knowing the direction of the price level by morning, concerning the trader of the safety of their position by the close of the day. Position trading is one of the long term forms of trading. Intermediate term position trading can range from 3-6 months, while long term position trading can range from 6 months to a year. Position traders look at the longer term movement of weekly or monthly charts. They hope to make large profits with long term investment, and are unconcerned with short term deviations and losses as ideally the long term general direction will smooth out for a profit. It is convenient for traders as they do not have to actively be monitoring their positions on a daily basis. Also the commissions are low since a trader is not making frequent trades. However, immediate profit will not be seen and money will be invested for longer periods of time. Active investing is another short term form of trading. Active investors constantly manage their portfolios. They do not tend to buy and hold, instead actively adjusting their positions typically to reach a profit goal, a benchmark that the investors must meet or beat in terms of return. They are typically seeking the market trends instead of passively waiting for it to happen then entering. This requires high

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dedication and attentiveness as the investors must be aware of the market and news at all times. Significant market downturns also prevent active investors from trading as it is rather difficult to stay profitable, thus they must be disciplined to stay out of the market at this time and be patient.

To make trades, a trader has the option of entering trades manually or using algorithmic trading. Manual trading has the trader analyze, enter, exit, and manage trades through the trader's own observation. Manual trading ensures that trades are entered the way the trader desires, and can allow a trader to quickly rationalize and make decisions based on intuition rather than a formula. The trader may use automated indicators, however ultimately the trades are based on user input. Algorithmic trading or automated trading is the use of an automated system programmed designed by the user to analyze, enter, exit, and manage trades without user input. The trader would create a set of trading rules and guidelines for the automated system to follow, in which the system would follow exactly. It is convenient for the trader, as the trader does not need actively engage in executing the trade itself. Automated systems have the benefit of performing advanced calculation and analysis faster than human can, and can quickly capitalize. Though it is quicker than any human, some argue it lacks rationale to evaluate outside factors and risks to make judgment based trades. Others argue that this is a benefit and that removing the human factor of emotion and intuition creates a reliable and consistent system that will not deviate from its rule set. It depends on the trader about which approach to take when making trades.

There are two major methods of evaluating assets, Fundamental Trading and Technical Trading. Fundamental trading looks to evaluate an asset based on its intrinsic value. It mainly focuses on the company itself and other macroeconomic factors that could affect the company's value. This analysis would provide a value that traders can compare to its actual current price on the market. Traders are mainly looking for high intrinsically valued companies with undervalued price levels, expecting to buy in hopes that the market will eventually reevaluate the price and its value will rise. Technical traders are more focused on charts and other analytics to predict future prices and evaluate it to its current price. They are not as concerned about the company itself, rather its actual performance in the market and any patterns that could potentially help predict its future movement. Technical analysis provides numbers that can back claims of performance, which sometimes fundamental analysis misses. However, fundamental analysis may see

undervalued companies that are doing well, in which technical analysts miss due to lack of numeric and apparent proof. Each provides different approaches to how assets are to be selected and evaluated for future investment.

3.5 Personal Objectives

In addition to having a particular style in trading or investing, system should reflect personal objectives of the traders. These objectives are a set of expectations on how the system should behave in accordance to the trader. Many of the following should be considered when developing a system for trading:

- High winning percentages: The trader has preference for winning trades and requires the system to win the majority of the time regardless of the amounts of profit. It is a sort of comfort knowing the system is not losing many trades, though profits per trade may be low.
- High annual return: The return at the end of a yearly timeframe to determine if the system is making enough considering the trader's time and effort put into the system.
- Low draw-down: Draw-downs are drops from peak to trough price levels. During this time traders' orders are put at risk, thus draw-downs are a form of risk assessment. Risk is how much a trader is comfortable potentially losing. A low draw-down would be for a trader that is less tolerant of losing money, looking for safer trades rather than high risk with high reward trades.
- Robust across different markets: If a system is robust and applicable across many different markets, traders become more confident in that system's performance. Having a robust system brings a sense of reliability that the system will act efficiently in a given market.
- Low time commitment: A trader's time is valuable, and the trader may not have time to devote from opening to close. A system that requires minimal user presence would be reliable and reflect the user's tendencies. It can be short term so the user may only have to trade for a very short time or long term where the user may monitor the system every so often.

- Small amount of time in market: The longer a system is in the market, the more risk it is exposed to. Traders may feel more comfortable with systems that are only in the market for short periods of time, reaping the benefit in that time period before unexpected reversals can cause losses.

- No held trades overnight: Trades overnight have a potential to dramatically change by the next morning's opening bell. Some traders may be uncomfortable not knowing the status of their trades overnight when they are not actively monitoring them. For these types of traders who need to know the status of their trades at all times, it may be best to avoid holding trades overnight.

- Small account size: The trader may have access or may prefer to allocate a small account to the system. System should reflect that preference by allocating money differently in trades, or using stricter stop losses to prevent the loss of the entire account.

- Small maximum adverse excursions: Maximum Adverse Excursion (MAE) is the largest loss of a single trade. A high MAE may represent a flaw in the system, in which the system can easily be exposed to during unpredictable markets. A small MAE can help assure that in the worst case scenario the ideal amount of loss.

- Profit Factor >2: The profit factor is the dollar amount made per dollar risked. In this case with a profit factor of 2, a trader is earning at least 2 dollars for every one dollar risked. This results in a 1 dollar net profit.

TradeStation also provides metrics from a system's strategy performance report. Some of these objectives can be calculated and viewed from this report. Other notable metrics include total net profit, which is the net profit of all trades, and percent profitable, the percentage of profitable trades. These metrics are a good way to evaluate if the system is performing to the trader's liking and personal objectives.

Adhering to the many constraints a trader may have for system, there will be trade-offs to these personal trading objectives. The Fundamental Law of trading Strategies are a set of general guidelines for strategy behavior and results. It states that as the profit factor rises and/or the average trade ratio falls, the required winning percentage of a system rises. Thus when it comes to trading objectives, each may have a positive or negative impact on profit factor or average trade ratio. When personalizing a system, a trader must be willing to accept the associated profit

factor and trade ratio that results from the desired preference of winning trade percentages. Not all objectives affect the statistics the same, thus not all personalized systems will result in the same profit factor.

3.6 System Rules

Trading systems are a collections of rules that work together harmoniously in order to produce results. The rules include an entry, exit, position sizing, order types, and selecting appropriate stocks for the system. Each rule should be individually tested as well as tested in a complete system in order to truly measure its effectiveness and results.

Entry rules essentially determine the frequency a system trades. They are rules that allow a system to enter the market. Entry rules contain filters. Filters help the trader to narrow down the search of assets. Filters can use technical analysis or observe patterns in the market give the trader a smaller selection of particular performing financial assets. These trade filters can help identify the set-up conditions of an asset. The set-up rules identify conditions that signal the time is favorable for entering a position in the market. It should be based on a premise or theory on the asset or market. Alternatively there are trigger rules as opposed to set-up rules. Trigger rules identify conditions that indicate that the time to enter a position in the market is now. It typically involves a price move the same direction indicated by the set-up, but may also include other variables and information to confirm the direction. The trigger essentially confirms the set-up. It also usually specifies a particular order type, which can influence slippage. Slippage is the difference between the expected trading price versus the trading price when the order is executed. Details of how to identify entry rules traditionally can be determined through fundamental or technical analysis, as well as more modern techniques such as data mining. Data mining filters using algorithms to improve and learn from historical data ideal entry conditions. Also price patterns can be observed to identify when and how to enter the market, taking note of common trends that can be predicted. Additionally the use of indicators calculates and identifies timing of when a position is to be entered. Properly designed entry rules will identify and initiate all trades that a system is designed to make, ensuring no big moves are missed.

Exit rules influence the expectancy of a system. These rules must be designed towards the philosophy and objectives of the trader. Exit rules typically operate and execute under the condition of being with a profit or with a loss. There are numerous types of exit rules with a profit. A system can exit after a set number of bars, limiting the time in the market before a loss can occur. There can be an exit at the end of the day, where no positions would be held overnight. There are also trailing stops which are calculated as the trade remains profitable, and exits once there are signs that the trade will begin to lose before becoming unprofitable. There are also profit targets in which once a trade has reached the desired profit level, it exits the trade. Also indicators can automatically analyze and determine ideal conditions when it is best to exit, signaling potential unfavorable conditions that can result in a loss in the market. Exit rules can also be executed with a loss. Typically a trader will set a number willing to lose in any trade with stop losses. One a trade reaches a certain amount of loss; the system will exit the trade at that number. This is to prevent further losses. Stop losses are based on the trader's risk and philosophy of how much is deemed acceptable to lose. There are also end of day stops, where the system will automatically close all position by market close. However, not all trades will be profitable at this time. This prevents the system from staying in the market at unpredictable times overnight when the trader cannot monitor it. There is also a third condition of how exit rules are executed. A trade may at times experience constant profit or loss or neither of the two. In this case the trade is not showing any substantial movement. At this point the system may exit a trade as there is no clear sign for the trade to be profitable, thus exiting without profit or loss.

Position sizing rules specify how much money is risked on each trade and on all open trades in total. Thus, it specifies how many shares or contracts are traded. They essentially determine the size of the reward per trade, as well as the risk for reaching a system's maximum allowable drawdown. If there is too much money at risk on a single or set of trades, the trader may reach the max drawdown and be forced to stop trading before a system reaches positive expectancy. If too little money is risked, a trader may not earn enough than could be potentially earned with the amount of money. The Martingale Technique is a cost-averaging strategy used for position sizing. The concept of the Martingale is that for every losing trade, the trader should double the size of the next trade to compensate for the loss of the previous. This process would be repeated ideally evening out profits and losses. In addition there is the Anti-Martingale Technique that takes the reverse approach to position sizing. For every losing trade, the next

trade would halve its position size. In addition every winning trade would result in the next trade to double its position size. The concept for this is Fixed Fractional Position Sizing, in which a trader bases the number of contracts or shares based on the risk of the trade. However, position sizing is very system and portfolio dependent. Thus different position sizing rules should be tested for the best fit of a system.

Systems also need to specify types of orders when entering positions into the market. There are many different types of orders including, market orders, stop orders, and limit orders. Market orders are buy or sell orders which are to be executed immediately at the current market price. These types of orders are used when certainty of placing the order is more of a priority than the price order. A stop order is a buy or sell order that is executed after a certain price is reached defined by a trader. It can be used to limit a loss or reach a certain profit target. Once the price surpassed this predefined entry point, the stop order becomes a market order. Limit orders designate an order to buy or sell at specific price or better. Buy limit orders can be executed at the limit price or lower, conversely sell limit orders are executed at the limit price or higher. Limit orders are not guaranteed to execute since a price level must be met. There are also conditional orders, based on predefined set of criteria set by the trader, and duration orders, which designate how long a trade is entered before exiting.

All of the mentioned rules must be carefully selected, as there is no universal rule set that can be applied for every trading system. In addition appropriate stock must also be selected for the correct system. Some stocks are more ideal for particular systems; this term can be referred to as "Smoothies". These stocks would have the ideal characteristics and behavior that particular system is looking for in order to trade. For example in the 10'Oclock Bull system, the system is looking for a wide range between high and low prices. To identify which stock would be most applicable, the trader should look into the pre-market, where the trader should identify stocks that are showing strong movement before the opening. This increases the chance of reaching the ideal conditions for the trading system, making it easier for the system to identify how to trade. It is important to select appropriate stocks; otherwise the system may not perform as expected. (7)

Chapter 4: Optimizing and Analyzing Trading Systems

When one is creating a trading system there are two conflicting forces that must be considered: the profit factor and the risk. Generally speaking, in trading and investing things which provide a higher profit factor have greater risk. One way the profit factor can be expressed is as the expectancy of a trade which is the average profit of a trade divided by investment for that trade. From this Van Tharp's expectunity measure is derived which is the expectancy multiplied by the number of opportunities to trade in a given time span. It is important that when computing these that things like spread costs enforced by one's trading platform are considered because they can have large effects on the performance of a system so ignoring them could lead to misleading values for expectancy and expectunity. Next we define R (Risk) as the amount we are willing to lose in a trade. Every trade a system makes can now be expressed in terms of R, so an R-multiple is the profit of a trade divided by R. From this one can compare a system's ability to perform at a target R by computing the standard deviation of the R-multiples. Last we compute the system quality by dividing the expectunity by the standard deviation of the R-multiples. This is by no means the only way to determine the quality of a system, but this considers both how profitable the system is and how risky the system is.

Optimization of a trading system is a very important part of making a successful system, but there are pitfalls involved in this process that must be avoided. The most important thing to avoid is overfitting. Overfitting is a phenomenon in which some method or system that attempts to model and predict based on a data set becomes very good at predicting on that limited data set, but this performance does not reflect the method or system's ability to accurately predict. It is very easy to overfit a system without even realizing that it has happened. If a system is found to be able to successfully win all of its trades with few small losses it most likely is overfit. This sort of problem is generally dangerous because after seeing a system's success in during backtesting one may be blinded by the success and not consider overfitting as a possibility.

The easiest way to avoid overfitting is to test and optimize on a larger data set. Thankfully because of the internet programs like TradeStation can quickly provide massive amounts of data to test on. Sometimes the problem of overfitting is most easily thwarted by looking through the trades a system made in backtesting. If a few of those trades were unusually profitable then they might be the source of the overfitting and expanding the data set would not

remove those trades but just lessen the effect of those trades, but in such a way that could be convincing as proof that the system is not overfit. This can often happen because of the jumps between trading days. The best way to confirm that a system is not overfit it to cross validate, which is to optimize with only some of the data set and then observe performance on the rest of the data. After cross validating multiple times one can be fairly confident that their system is not overfit.

Chapter 5: Literature Review

5.1 Literature Review on Gaps

Gap trading strategies indicate trades performed on the basis of the occurrence of a gap. A gap is an occurrence on a price chart where no trading occurred. Gaps can be filled when the price reaches the point where the gap occurred. Gaps can occur on all type of timeframes including weekly and daily. They occur frequently enough that it can reliably be focused into a strategy. They also work well in bear and bull markets, thus making it less of a need to predict the performance of the market.

In terms of Gap strategies there are many general indications on how to trade gaps. Typically the strategies are based on the type of gap. There are many different types of gaps. Breakaway gaps occur after a price pattern occurs, the price will then gap immediately after, which breaks the pattern. Continuation gaps or runaway gaps occur in the middle of a strong price movement. Exhaustion gaps occur towards the end of strong price movement, typically signaling the final point of the trend and the near end of the price movement. All these gaps are typically forms of indicators to traders to look for trades, especially when expecting the gap to fill. In an ideal situation all gaps will fill, however this not always the case. Some gaps fill weeks or months later, while other gaps never fill at all. This project's intended gap strategy will not specifically look to trade when gaps fill. Instead it will look for morning gaps as indicators.

Morning gaps occur as the price gap between the opening of the current day and the close, high, and low price levels of the previous day. Typically these types of gaps are a sign of an imbalance between buying and selling. Orders are placed before the market opens. Thus to accommodate and create balance, the price will gap to fulfill and represent the orders on the chart with a gap. News can play a pivotal role in the cause of gaps. This signals an influx of buyers and sellers, which traders can look to take advantage of with the change in price levels. This gears towards a daily strategy, with the set-up condition being the occurrence of a morning gap. Daily strategies typically focus on identifying set-ups on a daily basis, entering the market, and then exiting the market before the day closes.

Most systems use the same strategy for set-up conditions by identifying the occurrence and type of gap in the morning. Some systems will wait until the price approaches the point of filling the gap, and then proceed to trade in the direction of filling the gap. Others will use the morning as the timeframe for the strategy. Systems will typically wait the first hour in order to establish support and resistance levels. From there the system will identify if the price breaks either of these two price levels later in the day and then enter a trade.

For this project the gap system will operate within the opening hour. The opening hour typically sees strong liquidity in most stocks. Most traders tend to stay out of this timeslot due to unpredictability. However, this provides an opportune time with the large volume of liquidity to make a quick profit. Thus this project's gap strategy looks to take advantage of this trend also. Instead of waiting for the gap and establishing support and resistance within the hour, it looks to make the support and resistance levels in the first 15-20 minutes. The objective behind the system is to be out of the market by the end of the opening hour at 10:30am. This is typically the end of high liquidity in stocks. It also is in accordance with a personal objective for the system of limiting time in the market and leaving the market before the close of the day, to convenience the trader. This system can potentially profit in this timeframe with idea of high liquidity in the first hour and predicted movement indicated by the gap. (3)

5.2 Literature Review on Daily Trends

Trend is term that it is widely used in many different areas of sciences and math. Many investors and traders try to follow trends in the market and use them as their trading guidelines. A system that follows a trend can be used in a long term or short term strategy it all depends on what type of investor or trader a person is. The basic idea of trend following system is to buy when the price is trending upwards and hold your position. After you expect there will be a downward trend you start selling. This is the most simplified version of the system however the entry and exit conditions need to be well thought and researched to able to maximize profit when your are shorting or taking longer positions.

Applying a trend following strategy will work in most assets classes however it will be harder to apply to assets classes that are known to have a high volatility. This is because if you

are in a higher volatility market it is very hard to have strong upward or downward trend that last a significant amount of time in order to make profit. For a trend following system you are using past data and using different indicators and analysis technique to able to see if there is a pattern that can be followed. After you have found patterns in the past data, they will be applied as a means of prediction for future data sets. This trading ideal has been applied throughout the years with a lot of success.

Indicators are a huge part of your system success since they will provide you with the entry and exits signals. The entry and exit signal will make or break your system. The most common indicators used for trend following are Moving Averages, MACD (Moving Average Convergence Divergence), RSI (Relative Strength Index), and OBV (On Balance Volume).

Moving Averages attempt to create a straight line from the price graph of each stock. They do this by taking the average price over a period of time. There are many different types of averages that are classified by their time frame. You have 50,100, 200 day moving averages that are used by investors and long term traders.

Moving Average Convergence Divergence is an oscillating indicator that moves above or below the zero line. An entry signal when used MACD might be to buy when it crosses over the zero line. If line keeps above the zero line a long period of time is suggest an upward trend and you might want to hold for longer to see how high the price goes. The exit strategy would to sell when MACD goes below zero. If the indicator never goes above zero for a period of time it suggests a downward trend.

Relative Strength Index is another oscillating indicator that moves between 0 and 100. This indicator provided different information than MACD. RSI helps to find scenarios where the price of a stock has reached an overbought or oversold stage. Generally if RSI is above 70 it tells you that the stock is overbought which one approach suggest that you should start shorting since the price is likely to go down. When the value reaches 30 it suggest that the stock is oversold which means you should look to buy. If the stock price if oscillating between 30 and 70 it suggest an upward trend since everyone is buying the oversold stock. However, once it reaches above 70 the trend will most likely be downwards.

Each indicators has it usefulness however they only offer guidelines, the trader ultimately is the one setting the entry and exit rules. Some indicators may offer a higher complexity than others but this doesn't mean that using more complex indicators will yield more than using the

simpler ones. You are limited by your imagination in terms of the uses of indicators. Many trend following strategies use more than two indicators to look for entry or exit scenarios. There is no magical indicator that will always be correct, sometimes it might be wrong which means that having a wider range of warning signals if a very good starting point.

The time frame for a trend following system will ultimately depend on the user preferences. A trend following system can follow a long term strategy and a short term strategy too. One could apply "shooting for the fences strategy" which looks for big swings in the market to make most of their profit. A strategy of this type generally is long term since the conditions for a big swing are needed to be met perfectly by the market. However applying this idea will generally make the system trade a couple of times a year. The big swing that they're looking for generally doesn't happen that often. On the other hand one might try to apply a daily trend trading system. This system will trade a lot, and generally make small profits that will eventually add up and give good amounts of profit. This type of system is looking for trend in the current stocks. Generally someone trading a daily system will wait at least 30 minutes after the market opens because now it have enough past data to analyze. A daily trend system will almost never leave overnight positions and will close all its positions once the market closes.

Finally, past IQP groups that have done trend following strategies have taken the approach of a long term strategy with the usage of different indicators of the ones mentioned above. There are a large numbers of indicators that can be applied to trend following systems; it is not limited to ones mentioned above. Indicators such as bollinger band, support and resistance are also very helpful to determine your entry and exit rules.

5.3 Literature Review on Neural Networks

One very recent way to approach trading is to use artificial intelligence (AI) based analysis to decide trades. The most popular way to do this is with artificial neural networks (ANN). At an essential level an ANN is a computational model that is used to create predictions through emulating the computational structure of neurons in animals. This is achieved through creating a number of connected digital neurons called perceptrons. A perceptron is a single computation node that takes in several numeric input values that are multiplied by some weight

values, sums those values and feeds that sum into an algebraic function, often a sigmoid function, and outputs that result. An ANN is therefore a large number of perceptrons that feed their outputs into each other. By using sample data an ANN can be "taught" how to predict by modifying the weights of input values to better model the data. With this structure in mind there are three considerations that must be made in order to implement an ANN to analyse trading data: (8)

- ANN structure - There are many different ways to arrange perceptions to create characteristically different networks.
- Training method - Choosing an intelligent way to teach an ANN is essential to creating an effective predicting network.
- Implementation - Just as there are many ways to trade through traditional means, there are many ways to trade using a neural network.

There are fundamentally two kinds of ANN structures: networks with cycles and networks without cycles, often called a feed-forward network. Networks with cycles are generally considered to be much more complex than networks without cycles. This is because in a feed-forward network every node needs to be visited exactly once and there is a clear order in which this can be done without any conflicts, but a network with cycles could have perceptrons send information that could feed back into themselves so they would have to be run more than once and recursive computation could also lead to feedback loops. Because of this it is much more practical to use a feed-forward network. The most simple of these kinds of networks is called a multilayer perceptron in which there is an input layer, some number of hidden layers, and an output layer and each node of one layer feed into the nodes of the next layer.(6) An input layer is simply perceptron nodes that output the data input values. The hidden layers contain the bulk of the "processing" nodes. Last, the output layer takes in all the values up to this point and outputs the desired output prediction values.(8)

How a network is trained is a complex discussion, but there is a well established method for training a multilayer perceptron called back propagation. This method changes weights a small amount in order to minimize the squared error of the output value to the known result values. This method works well mostly because the structure of network makes training reasonably fast and effective.(8)

Implementation of an ANN for trading is of course the focus of this section, but it is just as complex of a subject as the creation and structure of an ANN to begin with. There have been many different approaches to both how to use the output of an ANN and what data is best to feed into an ANN. The sort of predictions that an ANN should produce should reflect the way that one intends to be trading. For example, if a trading system is designed to predict sudden jumps in prices then both the data that the ANN should make predictions from and the kind of output will be fairly different from a system that is designed to be in market most of the time. One of the most straightforward and common ways to handle the output of an ANN is to simply have the ANN predict whether prices will be up or down in some amount of time.

From looking at previous work we can easily see some general guidelines on what to do to create a successful ANN. (2) found that one of the most important factors in an ANN's performance is the amount of data used to train the network. This is not surprising as ANNs are known to perform better with larger training sets, but as (10) points out, ANNs that analyse trading data can be very sensitive to changes in the size of data sets, even relatively small ones such as a 24 week data set and a 25 week data set. When it comes to what data should be used to make predictions with an ANN it has been generally found that raw bar data is not particularly effective, but technical indicators such as RSI and Willaim's %R may do little to improve the performance of the ANN system and in some cases worsen the performance (5). Indicators such as moving averages on the other hand were very effective as tools for an ANN to make predictions.

There have been many different approaches to implementing an ANN for trading that have had some unusual results. One experiment attempted to use a convolutional neural network (CNN). A CNN is a kind of network that uses images as input. These networks have shown great effectiveness in areas of image recognition. This particular network was given the input of stock movement images, but because of the way that the network had to parse data from an image and process it, the network was not able to perform well. (9)

(1)'s system to trade on the Istanbul Stock Exchange is a very good example of how an ANN is unable to make system improve. ANNs are not a magical tool that will not necessarily make better predictions than humans can with simple indicators. In the system created by (1) it was found that the system they had created would generally perform worse the more hidden layers were used in the network. This means that the raw data and indicators given to the

network to make predictions with were most effectively used in straightforward ways and that increasing the decision process of the network only obscured the effectiveness of the network. This is a very important insight to keep in mind because with this observation, it is clear that when creating an ANN a clear understanding of what is helping and hurting that ANN's performance is essential.

Chapter 6: Trading System - Morning Gaps

The following automatic trading system uses gaps in the market as identifiers for entering the market. Gaps can be classified into the following basic types, Full Gap Ups, Full Gap Downs, Partial Gap Ups, and Partial Gap Downs.

A Full Gap Up occurs when the current day's opening price is greater than the previous day's high price.

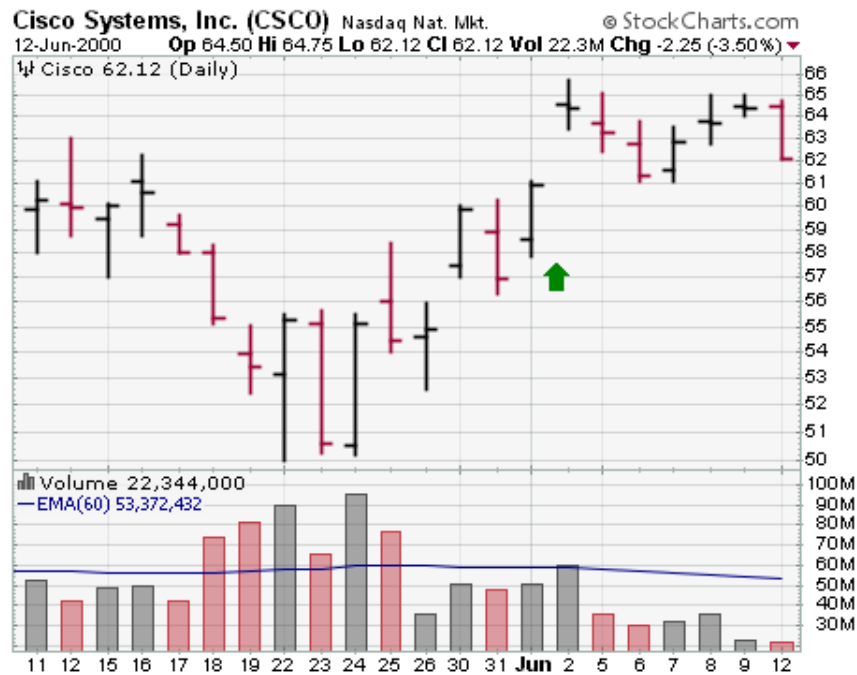Figure 1: Full Gap Up indicated with green arrow

A Full Gap Down occurs when the current day's opening price is less than the previous day's low price.

Figure 2: Figure 2: Full Gap Down indicated with red arrow

A Partial Gap Up occurs when the current day's opening price is higher than the previous day's close, and lower than the previous day's high.

Figure 3: Partial Gap Up indicated with red arrow

A Partial Gap Down occurs when the current day's opening price is less than the previous day's close, and greater than the previous day's low.

Figure 4: Partial Gap Down indicated with red arrow

The concept with this gap strategy is that at some point the price level will look to fill the gapped price. In the case of a gap up, the price eventually will decrease back down to the price that was gapped. Though not all gaps will fill or take long periods of time to fill, there seems to be correlation of extreme movement in the market after the occurrence of the gap.

The objective for this system is to be a daily trading system that spends little time in the market, and requires minimal monitoring by the user. Although profit is always a major objective for every system, this system looks to make smaller profits in favor of time convenience for the trader. The timeframe of the system will be in the morning for the first hour after the opening bell which starts at 9:30 am. Ideally a trade would be entered once per stock, with multiples stocks being traded simultaneously. Since the system may be limited in profits in such a short timeframe, monitoring multiple stocks seemed to be an approach to compensate. The system is to close all positions by 10:30 am, this prevents any positions from being held without the active monitoring of the trader. The system also uses 5 minute bars as the form of monitoring prices.

With a system that functions within an hour, it seemed ideal to get as much information as possible in terms of price movement. Using 1 minute bars would produce too much noise; in which there would be too much information to accurately depict any sort of behavior or patterns. Thus, 5 minute bars seemed to be the best in terms of displaying pertinent clear information as well as displaying relatively frequently.

Based on these objectives and criteria for the system, entry conditions can be determined in order for the system to identity when and how to trade. The set-up rules are mainly based on the system objectives. This system would begin monitoring a stock at 9:30 am. The system checks for no open positions, ideally this should never happen at this point. Next is the set of trigger rules. The trigger rules begin by identifying after the open whether one of the mentioned types of gaps occurred. The system was simplified to group Full Gap Ups and Partial Gap Ups together, as well as Full Gap Downs and Partial Gap Downs. Once the system identifies that a gap has occurred, it begins to monitor the first 4 bars. The first 4 bars represent 20 minutes, from 9:30 – 9:50am. The system is looking for a specific pattern to show definitive signs of movement. For this system it looks for each bar if the price level is continually increasing or continually decreasing, showing clear signs of increase or decrease within those 20 minutes. After those first 20 minutes, at the next bar the system would place an order. The system will look to long in the case of signs showing increasing price levels, or short in the case of decreasing price levels. Currently the system defaults to purchasing 500 shares of the stock.

There are a few scenarios that cause the system to exit a trade. The first two scenarios require hitting the profit target or stop loss target. The profit target is the satisfactory amount of profit earned in a trade where the trade can be acceptably exited. The stop loss is the price point in which a trade is losing in which the trader does not want to further lose, thus exiting the position. Both of these price points are dependent on the stock. Each is calculated through the optimization feature in TradeStation that allows a trader to simulate various values of each, to determine the optimal value to be applied when actually implemented. Additionally the final rule for exit is once the clock reaches 10:30am. In this case all positions would be closed whether profiting, losing, or neither. This adheres to the objective of limiting the time in the market by setting a set timeframe as well as not holding positions overnight by closing positions early in the day.

In order for the system to function properly, stocks had to be properly selected that would fit the conditions of the system. Stocks had to show potential to gap in the morning, as well as having regularly high volatility. This would ensure the system would be able to identity that the stock is tradable. TradeStation provides a scanner system that narrows down the search for stocks for criteria such as volatility and average volume. Though the search for stocks began with the scanner, eventually it was replaced by using the filter system provided by busystock.com. Busystock provides a screener with a variety of different basic and advanced filters. One filter in particular is the option called '% Morning Gap'. This screen looks at stocks that gapped in the morning, whether up or down, at certain percentage. The system typically used stocks that gapped at 3% or above. The stocks had to be searched before the opening, typically the hour before during the pre-market. Using the pre-market, stocks can be observed for movement and volume, giving a strong sense of how it will act once the market opens. No one stock was specifically tested, the stocks were selected based on criteria daily, thus the system could be trading different stocks from a day to day basis.

Testing and Optimization

Once the system was devolved in TradeStation using the EasyLanguage programming language, it became time to test performance. TradeStation provides users with extensive historical data to allow back testing with systems. Through this type of testing the trader can simulate how the system would perform in real time.

The first version of the system used a different set of trigger rules. Instead of identifying direction within the first four bars, it identified support and resistance levels by taking the highest and lowest price levels. The system would then long or short depending on if the price rose above the resistance or below the support. Through back testing, it was discovered that it was difficult at times to gauge whether these define price levels would be accurate for the duration of the time frame. Most strategies would redefine support and resistance levels, however the short timeframe would allow limited time to trade if this was done. Thus, the strategy was revised to its current implementation where the bars need to indicate a majority direction of price going up or down before the system enters a trade.

Back testing then continued with this version of the system. Testing moved on to begin testing different types of stocks. Since the system requires specific characteristics from stocks, mainly stocks that gap in the morning, screeners were used as mentioned to identify those stocks.

The system could then be applied to those stocks to see if it properly traded or not. Though a system can be perfected to handle historical data, a trader cannot guarantee the same performance on real time data. Thus back testing has its limitations and the system required real time trading.

6.1 System Analysis

The following is part of the strategy performance report of all trades for all versions of the system.

	All Trades	Long Trades	Short Trades
Total Net Profit	($2,230.00)	($315.00)	($1,915.00)
Gross Profit	$7,240.00	$4,390.00	$2,850.00
Gross Loss	($9,470.00)	($4,705.00)	($4,765.00)
Profit Factor	0.76	0.93	0.60
Total Number of Trades	42	20	22
Percent Profitable	45.24%	40.00%	50.00%
Winning Trades	19	8	11
Losing Trades	18	7	11
Even Trades	5	5	0

Figure 5: Gap System Strategy Performance

As can be seen the system is not profitable. The system makes a fairly even amount of winning and losing trades. However, just fewer than 50% of those trades are profitable. Thus, the trades that the system loses result in major losses even if there are as many winning trades. As noted by the profit factor, it slightly loses money. Thus, the system requires more robust testing and edits in the logic of identifying trades. Possible issues in the system are that the price movement quickly changes direction once the system has entered a trade. Thus the system may enter long and then the price starts to decline, resulting in losses. Thus it currently would not be ready for real life application with actual money.

System Quality

A system quality check was performed to look at the analytical performance of the system. There was a measure for expectancy, expectunity, and system quality. For these calculations not all of the data was used, mainly the data from the final version of the system was used instead of all the versions. Thus about a third of the total trades were disregarded for the

purpose of identifying what the potential system quality measures of the most updated system would be.

	Morning Gap
Expectancy	0.77
Annualized Expectancy	2.61
System Quality	2.413657974

Figure 6: Morning Gap System quality values

The expectancy, profit or loss per dollar risked per trade, is very low but still positive at 0.77. The annualized expectancy is expectunity per year instead of per trade, at 2.61. The system quality at 2.41 will be factored when evaluating the system combined as a system of systems. The positive values indicate the profit the system can make over time, however higher values would be ideal. Thus it can still make money, however it is not very sustainable. As seen in the strategy performance report the system has roughly 50% chance to win or lose, thus making very little or losing money.

Monte Carlo

The Monte Carlo experiments are performed on the system to get an accurate understanding of performance of the system. The system would be put under repeated algorithmic random sampling based on the trade data of the system.

Average Trade: $92.74   Win/Loss Ratio: 1.895
Average Trade (%): 8.128%   Win/Loss Ratio (%/%): 1.703
Trade Standard Deviation: $213.93   Max Consecutive Wins: 4
Trade Standard Deviation (%): 68.97%   Max Consecutive Losses: 4

Worst Case Drawdown: ($620.00)   Return/Drawdown Ratio: 9.914
Worst Case Drawdown (%): 74.36%   Modified Sharpe Ratio: 0.2400
Average Drawdown: ($308.33)
Average Drawdown (%): 31.72%

Figure 7: Gap System Monte Carlo Result at 95%

As can be seen, there is a high draw down in the worst case scenario, thus the system is not fully equipped for the many possibilities and behaviors of an actual market. Additionally through the

analysis it can be seen that at most the system can bring 4 consecutive trades as well as 4 consecutive losses.

6.2 Conclusion & Future Work

The system is far from ready to being profitable using real money. It requires work in terms of distinguishing indicators of when to enter the market. Improvements to the system should include additional scans for signs of when to go long or short. Some possible indications could be looking at the previous day's closing behavior. If there is some sort of behavior towards the end of the day, it is possible that behavior could translate over in some capacity. Also position sizing in terms of adjusting shares with winning and losing trades should also be considered. However, in the case of partial gaps, they tend to be more risky than full gaps. Thus, possibly identifying these partial gaps and adjusting trade logic as well as the amount of shares to be decreased is a feature that could be explored. Also the timeframe of the opening hour may be a flaw of not allowing enough time to analyze the market as well as perform the trade. This time in the market is difficult to gauge direction of price levels. Typically traders stay out of this hour to avoid the fluctuations in price. However, this is a good opportunity make a quick profit and leave before too much loss occurs. The system has potential and should be used as a base to be improved for actual implementation.

Chapter 7: Trading System - Daily Trending System

The following automated trading system was created to perform a daily trend strategy. The system utilizes indicators to create the entry and exit rules for a trade. The starting point for this system was to choose which indicators would be used.

The starting idea for the system was to make use Moving Averages as the main entry signal. The moving average used would be calculated using the past 32 bars. EasyLanguage provides the moving average function with two parameter which is the price is being used and the period of time. After calculating the moving average, if the system is currently out of the market and the closing price is greater that the moving average and the low is the lowest low of the last 3 bars then buy at the next bar. The figure below illustrates this concept more clearly.

Figure 8: Moving Average Indicator 1

The last closing price is bigger than the moving average value which the blue oscillating line. Also we can see above that the current lowest price is the lowest of the last 3 bars which triggers the system to buy into the market labeled as 'TrendLE'. The other entry rule is when the closing price is less than the moving average. If this condition is met then we check the opposite from the first entry, we check if the current high if the highest 3 bars back. Since it is an and

statement both condition must be met for the system to buy in. The second condition is clearly illustrated below.

Figure 9: Moving Average Indicator 2

As you can see above the moving average has a higher value than the last closing price which makes our first condition true. Also the second condition is met and we buy into the market with the label 'Trend SE'. This means there is a downwards trend that we can use to our favor.

The exit strategies for this system are mainly based on profit and stop loss. This means that after the system has reached the desired profit while the market position states that we are in the market we leave. The other exit condition is the stop loss which is used to limit the amount of money the system will loose for a given trade. The current system stop loss is set to 300 dollars. After losing this amount it will exit the current position. In addition there is also a bar limit set, that also acts as an exit rule after a position has been hold for a particular bar limit amount set by the user. For example the bar limit below is set to 23 bars.

Figure 10: Bar Limit

It clearly shows that after buying into the market and being 23 bars in it reaches the bar limit and it will exit the market. This approach yielded some positive results however after looking at the Strategy Performance Report.

Display: |Column View ∨|

TradeStation Performance Summary			Collapse ⌃
	All Trades	**Long Trades**	**Short Trades**
Total Net Profit	$3,298.00	$3,112.00	$186.00
Gross Profit	$11,674.00	$5,930.00	$5,744.00
Gross Loss	($8,376.00)	($2,818.00)	($5,558.00)
Profit Factor	1.39	2.10	1.03
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	($63.00)	$0.00	($63.00)
Select Total Net Profit	$3,298.00	$3,112.00	$186.00
Select Gross Profit	$11,674.00	$5,930.00	$5,744.00
Select Gross Loss	($8,376.00)	($2,818.00)	($5,558.00)
Select Profit Factor	1.39	2.10	1.03
Adjusted Total Net Profit	($125.01)	$1,004.48	($2,517.16)
Adjusted Gross Profit	$9,780.23	$4,635.97	$4,350.88
Adjusted Gross Loss	($9,905.24)	($3,631.49)	($6,868.03)
Adjusted Profit Factor	0.99	1.28	0.63
Total Number of Trades	69	33	36
Percent Profitable	55.07%	63.64%	47.22%
Winning Trades	38	21	17
Losing Trades	30	12	18
Even Trades	1	0	1

Figure 11: Moving Average Performance

There is a problem with the short trades. We are losing more than we would want to. There is a lot of improvements that can be done. After thinking about some improvements the latest system was created.

The newer system which is called Daily Trend Following 2.0 uses two indicators for the entry signals. It felt like the older system needed another condition that would tell the strength of a trend of a stock. To achieve this RSI (Relative Strength Index) was used. RSI is an oscillating indicator that moves between 0 and 100. Once the RSI crosses over an oversold threshold which

is most cases it's 30 it suggest that the stock will have an upward trend. If a stock is oversold its buying price will be low and it eventually will start to rise up again. This follows the idea of supply and demand. The new condition is added as an or statement instead of an and statement. This is the case because if an and statement was used it will limit the number of trades since all three conditions must be met at the same time. RSI is being used to show the strength of trend since if it passes the 30 mark the price of that stock will go up. On the hand, if a stock is overbought it will cross under the 70 RSI mark which suggest that the price will go down since the stock is being overvalued. Both this threshold are very useful to help the system exit at the right time and continue holding if the trend is strong.

An example of the usage of RSI is given below:

Figure 12: RSI

The green lines represent the overbought and oversold threshold. The RSI is the oscillating curve in white. Every time there is a crossover or cross under it is highlighted in red. This will trigger a buy or a sell. As shown below we can see how RSI shows the strength of a trend.

Figure 13: More RSI

The system performs better when shorting. Other idea that can be done to fix either short or longing is to have to two different strategy files each one for shorting and longing. This will help find out which part of your system is not working as intended.

7.1 System Optimization

Since all the functions used for this system use variables as inputs by using TradeStation optimization tool you're able to find the data inputs that will give the highest profit. Each time you are using the strategy for a different stock you need to run the optimization rule again. TradeStation uses a brute force algorithm to optimize your code. This simply means that it will try all the combinations that you inputted. For example the current system uses a bar limit to calculate the moving average and RSI. By optimization the bar limit variable you are testing all possible input from a given range. The picture shown below illustrates this tool.
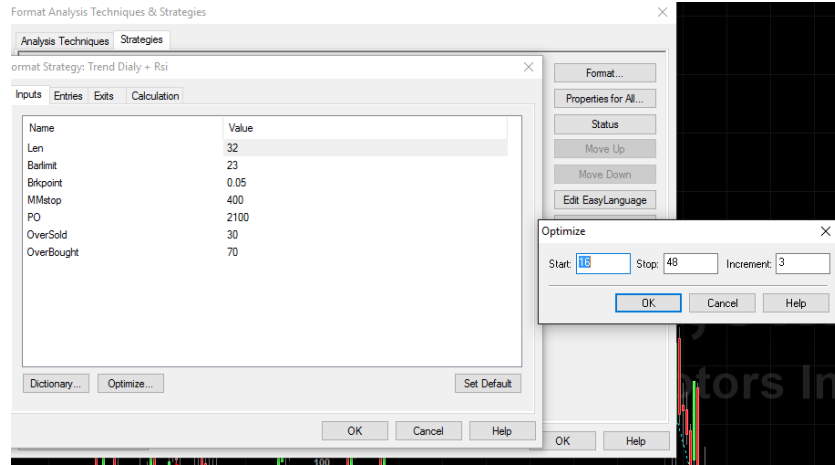
Figure 14: Optimization TradeStation Menu

After running the optimization the following report will be generated:

Figure 15: Optimization TradeStation Report

The report shows, how the input were chosen. It clearly shows a brute force approach which again simply generates all possible output with the given input range and displays the highest profit. This was done for Tesla Corporation stock. The performance report before the optimization is shown below

Figure 16: Performance Report before Optimization

The newest version with the updated inputs is shown below.

Figure 17: Performance Report After Optimization

After comparing both output we can see that a system that has used the TradeStation optimization tool will perform better. However the only disadvantage of this optimization is that

you need access to past data and you need to run the optimization for any new stock that you are trying to trade.

7.2 System Analysis

The Strategy Performance Report shown on Figure 17 summarizes the outcomes of the system. Overall the Annual Rate of return is 38% which is better than the market average of 11%. This means that this current system is beating the market. In addition we see that the system if winning more trades than it is losing which is very promising. These results also take into consideration the commissioner that you have to pay per trade. In the case of TradeStation they take $5 per trade. This is very important because even though you system on paper might seem to be profitable, commissions is something people sometimes overlook. On average the winning trade neted $262.81, while on average each losing lost neted a loss of $228.21.

To further analyze the system, some system quality measures were done. The first measure was to calculate the Expectancy of the system. The Expectancy of a system is the Profit or Loss per Dollar Risked Per Trade. Also the Expectunity was calculated which the Annualized Expectancy. The table below shows the results after the calculations were done:

Entry Date	Entry Price	Exit Date	Exit Price	Long/Short	Profit/Loss	Number of Shares	Average Loss	Largest Loss	R Mult 1	R Mult 2
3/18/2016 13:50	232.74	3/18/2016 15:30	233.95	1	121	100	$141.00	$258.00	$0.86	$0.47
3/21/2016 9:55	238.74	3/21/2016 11:35	239.39	1	65	100	$141.00	$258.00	$0.46	$0.25
3/21/2016 12:00	237.91	3/21/2016 13:40	238.44	1	53	100	$141.00	$258.00	$0.38	$0.21
3/21/2016 13:55	238.46	3/21/2016 15:35	236.84	1	-162	100	$141.00	$258.00	-$1.15	-$0.63
3/22/2016 10:45	234.88	3/22/2016 12:25	237.46	-1	-258	100	$141.00	$258.00	-$1.83	-$1.00
3/22/2016 12:35	237.86	3/22/2016 14:15	238.36	1	50	100	$141.00	$258.00	$0.35	$0.19
3/22/2016 14:50	236.67	3/23/2016 10:00	232.62	-1	405	100	$141.00	$258.00	$2.87	$1.57
3/23/2016 10:30	232.45	3/23/2016 12:10	226.81	-1	564	100	$141.00	$258.00	$4.00	$2.19
3/23/2016 12:40	226.69	3/23/2016 14:20	227.41	-1	-72	100	$141.00	$258.00	-$0.51	-$0.28
3/24/2016 9:45	221.01	3/24/2016 11:25	225.69	1	468	100	$141.00	$258.00	$3.32	$1.81
3/24/2016 12:35	225.36	3/24/2016 14:15	227.8	1	244	100	$141.00	$258.00	$1.73	$0.95
3/24/2016 15:25	227.78	3/28/2016 10:35	228.84	1	106	100	$141.00	$258.00	$0.75	$0.41
3/28/2016 10:50	228.45	3/28/2016 12:30	234.07	1	562	100	$141.00	$258.00	$3.99	$2.18
3/28/2016 12:50	234.01	3/28/2016 14:30	231.88	-1	213	100	$141.00	$258.00	$1.51	$0.83
3/28/2016 14:45	232.29	3/29/2016 9:55	228.07	-1	422	100	$141.00	$258.00	$2.99	$1.64
3/29/2016 11:30	226.87	3/29/2016 13:10	227.59	-1	-72	100	$141.00	$258.00	-$0.51	-$0.28
3/29/2016 13:35	228.25	3/29/2016 15:15	230.14	1	189	100	$141.00	$258.00	$1.34	$0.73
3/29/2016 15:50	229.8	3/30/2016 11:00	229.8	-1	0	100	$141.00	$258.00	$0.00	$0.00

Figure 18: Trade List

					Expectancy (Profit or Loss Per Dollar Risked Per Trade)	1.14	0.62			
			1st Trade	3/18/2016 13:50						
			Last Trade	3/24/2016 14:15						
Days Per Year	365	Strategy Calendar Days (Days)	6.017361111		Opportunities (Trades/Year)	1,091.84		Std Dev R Multiples	1.72673	
		Number of Trades (Trades)	18		Annualized Expectancy (Expectunity) (Profit or Loss Per Dollar Risked Per Year)	1246.71	681.34	System Quality	2.80556	Total profit/loss per dollar risked relative to the total variability of the profit/loss per dollar risked => Dimensionless

Figure 19: Calculation of the Trading Data

The higher the value for the Expectancy, the better the system performance. Having an expectancy of 1.41 suggest that every trade the system makes it is making 1.41 dollars which show a system that is profitable. The goal is to have a positive expectancy but having more is definitely better. For a whole year the system is expected to trade 1,091 times which follows the starting philosophy of a day trader. It is to trade as much as possible and closing every position at the end of the day.

Another tool that it is used to analyze a trading system is called Monte Carlo Analysis. To be able to apply this analysis to the system Market System Analyzer software was used. After inputted the trading data the following graph and tables were produced.
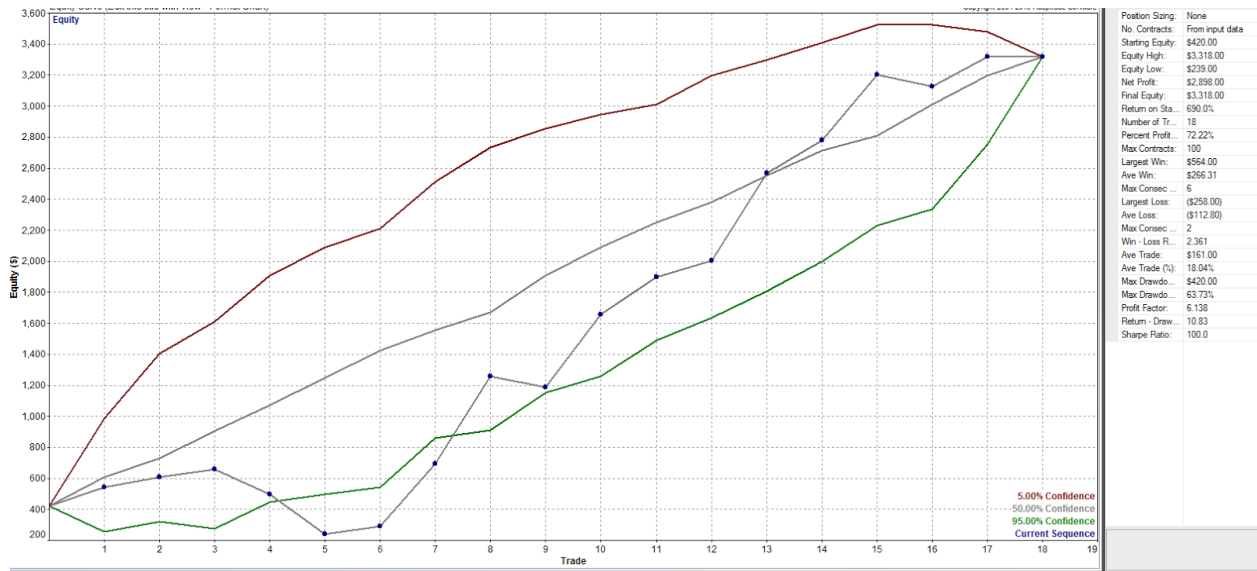
Figure 20: Equity Curve using Market System Analyzer (no position sizing applied)

Monte Carlo Results at 95.00% Confidence

Total Net Profit: $2,898.00   Max Number of Contracts: 100

Final Account Equity: $3,318.00   Minimum Number of Contracts: 100

Return on Starting Equity: 690.0%   Average Number of Contracts: 100

Profit Factor: 6.138

Largest Winning Trade: $564.00   Largest Losing Trade: ($258.00)

Largest Winning Trade (%): 51.75%   Largest Losing Trade (%): -61.43%

Average Winning Trade: $266.31   Average Losing Trade: ($112.80)

Average Winning Trade (%): 20.47%   Average Losing Trade (%): -17.14%

Average Trade: $161.00   Win/Loss Ratio: 2.361

Average Trade (%): 13.48%   Win/Loss Ratio (%/%): 1.900

Trade Standard Deviation: $243.47   Max Consecutive Wins: 4

Trade Standard Deviation (%): 63.75%   Max Consecutive Losses: 3

Worst Case Drawdown: ($492.00)   Return/Drawdown Ratio: 11.23

Worst Case Drawdown (%): 61.43%   Modified Sharpe Ratio: 0.3477

Average Drawdown: ($282.00)

Average Drawdown (%): 28.51%

Figure 21: Monte Analysis Results

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7.3 Monte Carlo Analysis

Very useful information was obtained after performing Monte Carlos Analysis to system. As shown below we can expect 3 consecutive losing trades without starting to worry if something is wrong with that a day of trading. On the other hand the system will at most win 4 consecutive times which are things to watch out for when trading. In addition we can see the maximum drawdown of $492 which is basically the largest amount of money lost before making a profit. This means that if the system will go to maximum of $-492 before making profit. This seems to be slightly above the stop loss set the by the system at $400.

7.4 Conclusion and Future Work

The system is profitable and can be used to trade in the stock market. After trading for 4 months the final account balance was $321,287.11. The starting balance was $100,000. It is a very significant profit. The system works as intended. You are able to turn the system on at the start of the trading day which is 9:30 am EST and exit at 4:00 pm EST. After trading for 4 months a lot of things were learned in the process. The first thing that I learned was that to turn off the system during lunch hour time around 12:00 pm since the volume of trades decreases a lot and there's little trends that can be spotted. In addition there are some times of year such as spring break where again the volume of trades is greatly reduced. Trying to avoid holidays is very crucial time frame to avoid. Furthermore trading on a Friday can also yield less successful trades. The weekend is right on the corner and the number of trades is lower compared to all the other days. However the system is far from perfect. To be able to diversify the current system a future implementation would be to try and trade a different assets class like the forex market. Even Though the forex market is more volatile than the stock market there is some trends that can be used. In addition, there could be more experimentation with other trend indicators for make the exit and entry rules are crisp as possible. There is a lot of potential in the forex market to make profit since it is the market with highest liquidity however it is also the market where you can loose your money the fastest.

Chapter 8: Trading System - Neural Networks

8.1 General Setup

The third system we used to balance out our collective portfolio is a neural network system that is always in the market. Our neural network is run by outputting data from TradeStation, preprocessing it with a python script and then training and simulating a neural network with Weka. The network was usually trained with the last 10000 bars on a network with 10 hidden layers and a 10 fold cross validations process to prevent overfitting. The results from the neural network simulation are used to determine whether a trade should be made and whether a buy or sell should be made. Most of the testing was done on the EUR/USD currency pair because it is very liquid and less likely to be affected by news and politics. This way could be tested independent of needing fundamental analysis. An important detail of how this neural network was trained is that it is not being actively re-trained by new data so generally the outcome of the previous immediate trades have no effect on the network's predictions. The system went through four main versions which built on each other.

8.2 Version 1

The first iteration of the neural network system traded on 1 minute bars and it was quickly discarded due to a major problem. The data entries that the system was the present time, high, low, open, and close and the number of consecutive bars that have gone in the same direction where the value was negative if the price had gone down. This network was designed to predict whether the price will be up or down in five bars. To go with this prediction, this basic network would always get out of the market after five minutes. With these parameters the network was able to predict with about 60% accuracy. These are great results for such a simple setup, but after simulating the network it was quickly identified that the network could not make a profit because the spread costs outweighed any gains the system made because the prices move too little in the span of 5 minutes.
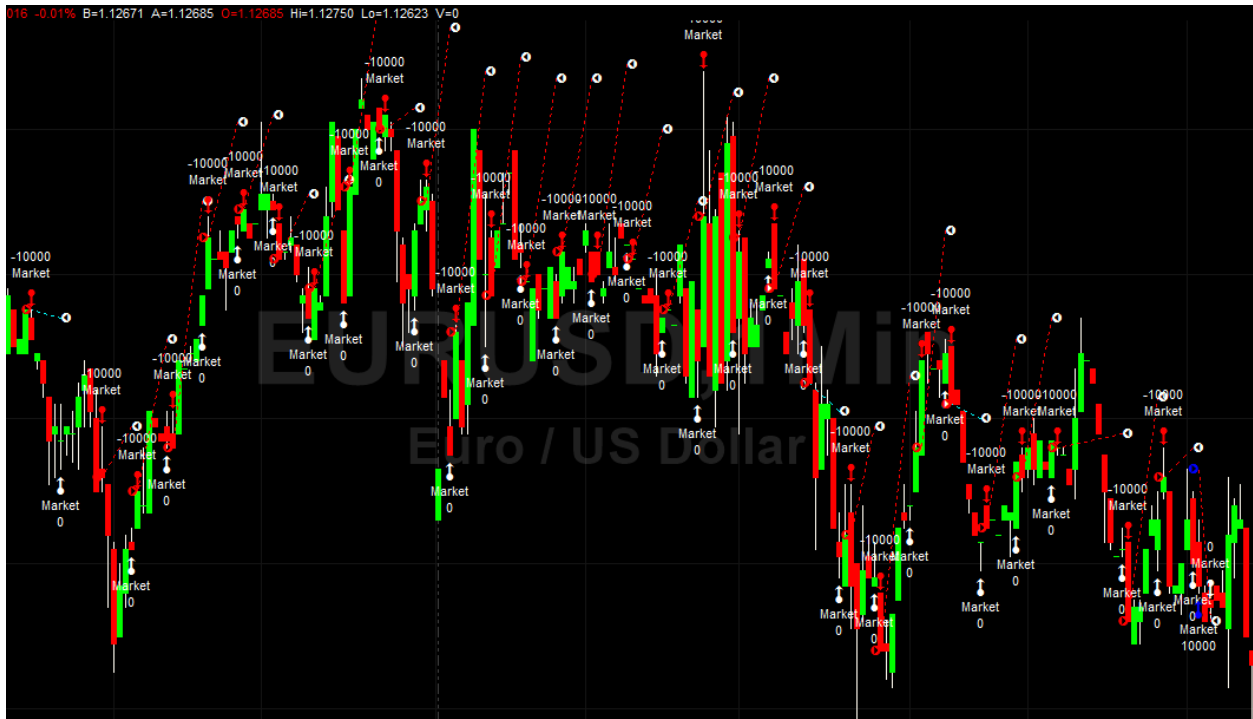
Figure 22: Neural Network 1 - Spreads on the many shorts made most trades unprofitable

This system also suffers from having a heavy preference towards predicting a downwards trend. While making minor tweaks to this system some versions of the network would instead heavily prefer to go long instead, so most likely the network just had insufficient data to make more intelligent predictions and when no pattern was identified the network chose to output the most common trend. This may have been an acceptable pattern if the data the network was trained on had a very clear trend, but there was no strong trend on the training data so it clearly was just a lack data for the network. Later versions of the network also suffer from this problem, but as the information provided to the network improved this pattern disappeared.

8.3 Version 2

Our system's second version was made to test our general approach on larger time frames. The network this time was given the time, high, low, open, and close like before, but the repeated streak value was removed and instead the network was given the differences of the open

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and close of the past 15 bars. The time frame was then expanded to have the network predict whether the price has gone up or down in 15 bars and the bars changed from minute bars to 15 minute bars. This network still sold after a fixed time like before and this time frame was appropriately changed to 15 bars. With this the system would hold a position for 3 hours and 45 minutes, a very long time compared to 5 minutes. These changes caused the network to overall perform worse, dropping the accuracy of the network's predictions to about 54%. It was easily determined that the cause was the overall time frame during testing as the kind of data provided to the network was changed after the increased time frame and the network performed even worse in that transition stage.

Like in the previous iteration this network predicted one outcome significantly more than the other, in this case the network was optimistic and it went long most of the time. This was sometimes extremely detrimental when the present trend was against what the network was trending towards. These occurrences make clear that there needs to be some sort modification to the system to prevent the system from repeatedly making this sort of mistake or at least prevent it from taking too large of losses in the process.
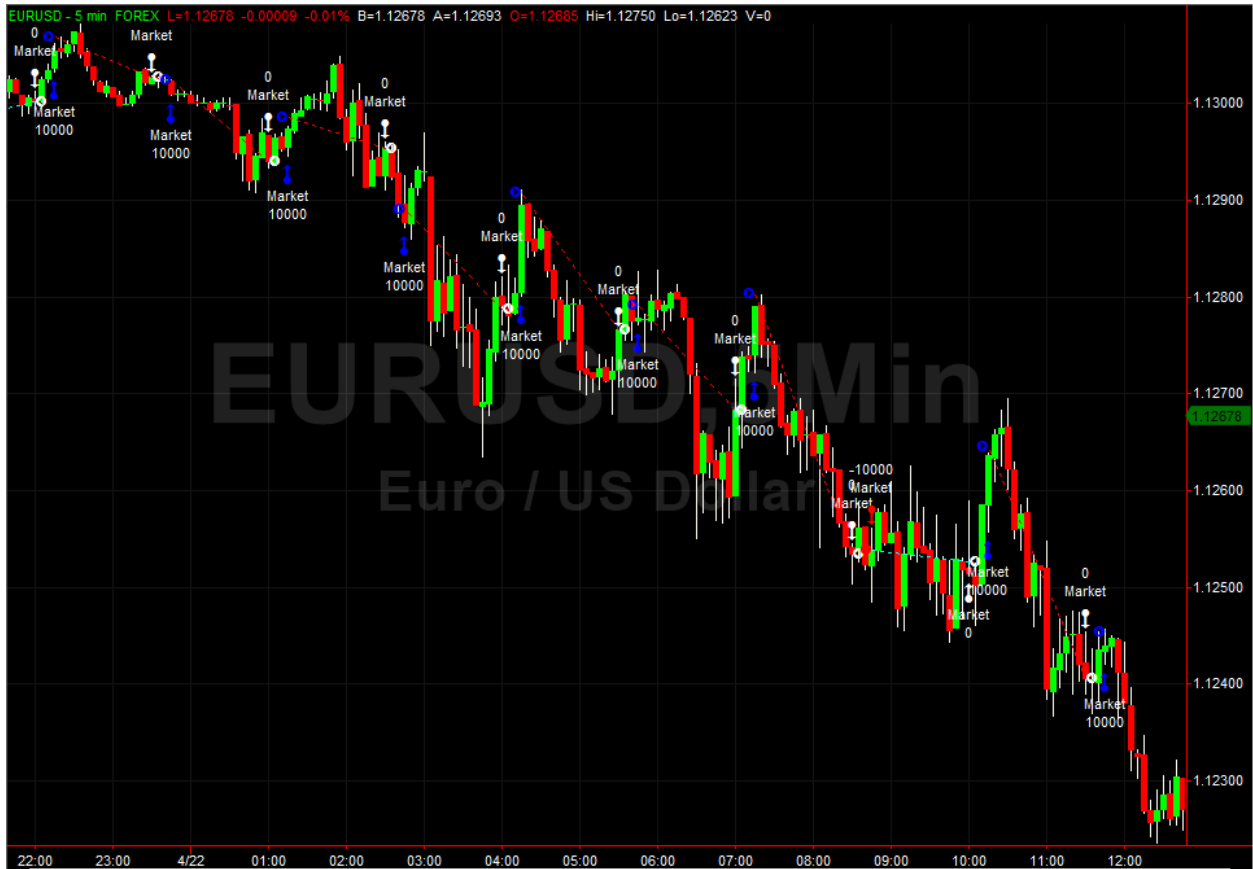
Figure 23: Neural Network 2 – Repeated long trends, but unprofitable due to a downwards trend

Despite this going long the vast majority of the time this system was still sometimes very effective at predicting changes in prices and it would short at times that were very important. This was great sign as it meant that even though the system clearly had no ability to prevent repeated losses like in Figure 23, it was very effective at recognizing other patterns. As shown in Figure 24 the system mostly went long and did not win all trades, but when the price spiked it correctly guessed a drop in price and was able to win the three largest trades in the time frame. Conversely there were cases in which the network was more conservative and would still only buy and rarely short.

Figure 24: Neural Network 3

Figure 25: Neural Network 4 - network properly responds to a downward trend, but too late

8.4 Version 3

Because the second version of the neural network trading system had a notable drop in accuracy compared to the first due to the increased time frame, the third iteration of the system operates on 15 bar trades on 2 minute bars. This change was reasonably effective and the accuracy of the network increased to about 56% and the spread on trades was not large enough to majorly affect profits. As this system was mostly like the previous two it still predict one outcome the vast majority of the time. The only other modification to the system from the previous version was the addition of a SetStopLoss function into the TradeStation strategy. This feature was unfortunately only sometimes helpful and other times much more hurtful. In a few cases after the stop loss function was used to end a losing trade, causing the system to make a new trade the next bar that was in line with the present trend, but much more often it would cause the system to make a new trade which was still against the trend. In the worst cases the system would make a new trade every two minutes that would lose for as long as a downwards trend continued.

8.5 Version 4

The final version of the our neural network system differs mainly from the third by removing the SetStopLoss function and instead allowing the system to enter and exit the market whenever the network predicts the price will switch directions in five bars. This replaces the need for the SetStopLoss function and it does not have the problem of ending a trade that the system just reinitiates. The data given to the network also changed considerably in this iteration. First the first three differences of the opens and closes of prior bars were removed. Those values were then replaced with values generated from the exponential moving averages of 5, 9, 15, and 30 bars. With each of those averages data entries for the average, the average minus the present close, and the average minus the previous average were given as attributes to help the neural network make predictions.

Giving the fourth version of the system the ability to exit the market when it the prediction changed the behavior of the system in large ways, but as a whole it was an improvement. In some cases this modification helped the system perform very well as shown in Figure 26 where after 5:00 the system made a series of very well timed trades because the network properly predicted the switching in the direction the prices moved. Unfortunately the times between 3:00 and 4:30 the system had a much harder time. This appears to have been caused by the network recognizing a change in price movements and it being too sensitive to the minor changes. As a result the system would end trades to make a trade in the other direction that only lasted a few bars or just re-enter the market in the same direction, incurring no benefit.

Figure 26: Neural Network 5

Figure 27: Neural Network 6

The problem where the system would change repeatedly continued in a few other cases like in Figure 27. It can be seen from the prices listed on the left that in Figure 27 the market moved in four hours about as much as it did in ten in Figure 26. This most likely means that the system is bad at making consistent decisions when the market is volatile. More specifically in this case, the system has difficulty when it comes to predicting when there isn't a strong trend because it is not actually predicting a trend, but instead it is simply predicting whether prices will be up in five bars. This could be either solved by having the network predict something that better approximates the present trend or by having the system choose to not be in the market when the network is indecisive and is rapidly changing its predictions.

One interesting pattern that the network portrayed is that in some cases it would make the same prediction for hours. While this is not necessarily a problem itself, this is most likely something that the system would be better off without. When this happens there are probably some particular values that cause unusual values that the network's data do not account for. This could either be because there is just insufficient training data and the network is getting overfit to something like particular times that by chance had the same pattern in all cases in the training set or the training data did not encompass some possibilities that are now important such as the network's decisions depending on raw price values and the network attempting to predict values that are outside of any in the training set. The latter of these two came up in some later testing of the system. When the network was making predictions after not being retrained with new data for about a week it was extremely confident that prices would drop, but this was generally not the case. This most likely happened because the EUR/USD had risen over the course of the week and the network saw high prices as a sign of prices dropping soon.

Figure 28: Neural Network 7

Though this large trade was good it could have exited after the first major drop and potentially have made more good trades in this time.

Chapter 9: System of Systems

9.1 System Analysis

The objective of this project is to replicate a professional portfolio in terms of performance. The concept of a system of system allows multiple systems to intertwine in terms of performance, so that each system can cover another system's flaws. No one system can be perfect at all times in the market, thus having multiple ensures you can attempt to still profit at all times. A diversified portfolio will limit the risks involved with each trading system.

The following system of systems currently consists of the Gap system and the Daily Trend system. Currently the Neural network has not reached a point where it can output trade data on TradeStation, however it has shown potential when giving outputted data from TradeStation.
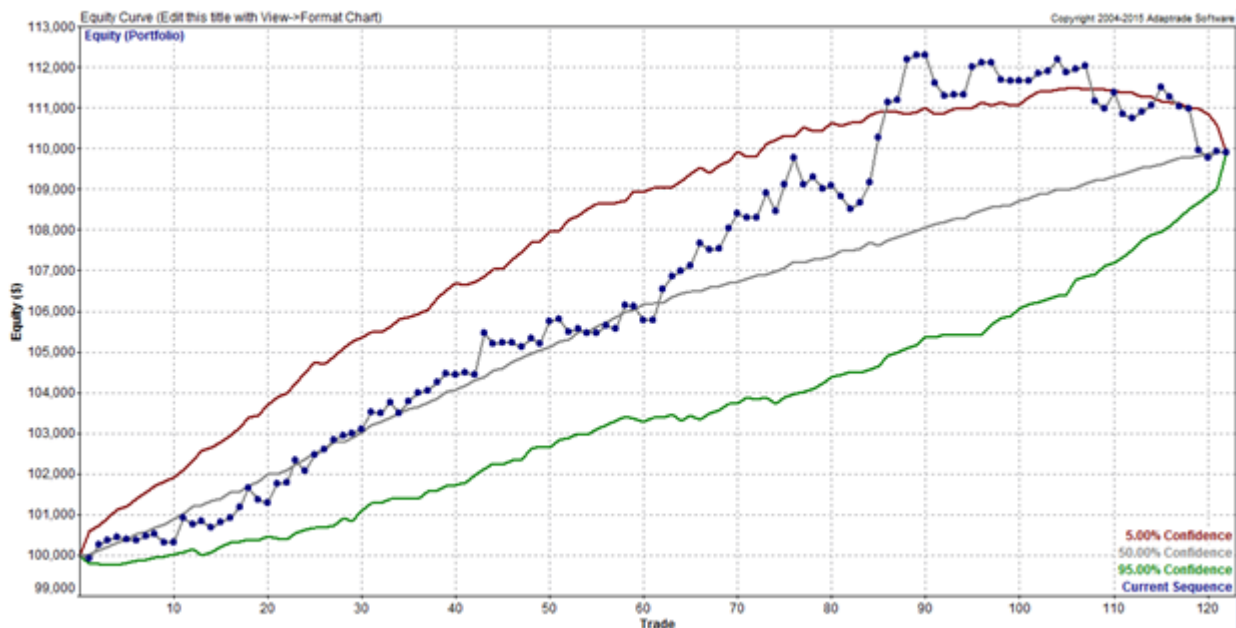

Figure 29: System of Systems Aggregate Equity Curve

Monte Carlo Results at 95.00% Confidence

Total Net Profit: $9,900.00

Final Account Equity: $109,900.00

Return on Starting Equity: 9.900%

Profit Factor: 1.948

Largest Winning Trade: $1,083.00

Largest Winning Trade (%): 0.9889%

Average Winning Trade: $278.68

Average Winning Trade (%): 0.2615%

Average Trade: $81.15

Average Trade (%): 0.07792%

Trade Standard Deviation: $348.11

Trade Standard Deviation (%): 0.3333%

Worst Case Drawdown: ($3,211.00)

Worst Case Drawdown (%): 2.998%

Average Drawdown: ($643.75)

Average Drawdown (%): 0.6044%

Maximum Position Size: 500

Minimum Position Size: 100

Average Position Size: 201

Largest Losing Trade: ($1,028.00)

Largest Losing Trade (%): -1.006%

Average Losing Trade: ($213.14)

Average Losing Trade (%): -0.2042%

Win/Loss Ratio: 1.308

Win/Loss Ratio (%/%): 1.309

Max Consecutive Wins: 6

Max Consecutive Losses: 7

Return/Drawdown Ratio: 3.302

Modified Sharpe Ratio: 0.2339

Figure 30: System of Systems Monte Carlo Analysis

The above equity curve is displayed along with the 95% confidence interval for the drawdown of the system. From this analysis it can be determined that there is 95% confidence that the system will have an average drawdown of 0.6044%, with the worst case being 2.998%. Additionally there is 95% confidence that the system will have a rate of return of at least 9.9%.

Rules

Activation rules for the system occur on a daily basis. Since the current systems are mainly daily set-up conditions, each system would identify when it enters the market. Thus the system of systems would execute regularly over the course of the week. Suspension rules would be put in place for the case of a company releasing news or other market news that would impact how a stock would be traded or sentiment on the stock. Thus, it would be safe to halt any trades and explore whether the stock should still be traded or not. Retirement rules would focus more on the profit goals of the system. Once the system has reached its financial goals it can halt. In the case of a portfolio typically it's best to look at annual performance. Thus, looking for over 10% on annual return over 10 years would be ideal for a true system of systems.

9.2 Allocation Rules

Money in the account of the portfolio needs to be allocated. In order to divide the money, the money would be allocated passed on system performance. In the case of the Neural Network, 35% of the accounts will automatically be designated for it. This is due to the fact that the system is still unproven and has yet to be statistically analyzed. However initial testing through inputted data has shown positive results. The following formula will be used to determine the rest of the allocation of the account money:

Fraction of Money = Quality of System X / (Sum of all System Qualities)

For each system, the equation would be applied based on its respective system quality value. This formula will partition out systems that performing better than others, resulting in a higher percentage.

	Gap	Daily Trend
Expectancy	0.77	0.12
System Quality	2.413657974	0.39653821
Fraction Money Allocated to Each System	0.5624	0.0881

Figure 31: System Money Allocation

As a result of the formula, the Gap system would receive about 56% of the money, with the remaining 9% going to the Daily Trend system. Further tests and trades would alter the results. Currently both systems were tested in about a 3 month timeframe; it is difficult to gather enough trades to represent a true year of trading. Thus this allocation may not be representative of true system of system with a yearly timeframe. However, for this project this would be how the account money is allocated.

Thus, it begs the question whether a system of systems is truly better than just a single system applied three times. In this sense, yes a system of system should perform better. When performing the Monte Carlo analysis, a system is exposed to its worst drawdown percentage. If this system was used multiple times in a portfolio, it would have the same percentage. Thus if the portfolio of the same system experiences that worst case scenario, then the whole portfolio would be compromised experiencing significant loss. The purpose of the system of systems is to prevent unnecessary and similar risks in one portfolio. Thus if one system is performing poorly, it does not necessarily mean the others are also performing poorly. The systems complement each other and by diversifying the portfolio, traders can prevent exposure to the weakness of a single system.

Chapter 10: Summary & Conclusions

Currently the system of systems would not be ideal for real trading application. The system can make money, however it is unreliable and would only make very little profits over time. In order to refine it, each individual system would require revisions. As mentioned earlier there would be changes to each of the individual systems. Once those systems can individually be robust on their own, then the system of systems can be further evaluated for profitability.

Challenges include adjusting the system for incorrect logic. Though stop losses prevent major losses in trades, identifying why and observing whether there were indications of the loss were difficult. The logic using EasyLanguage on systems sometimes does not function as expected. Only through repeated back testing was the issue to be solved, however sometimes the system will still lose. It shows that not every system can be perfect nor work perfectly as expected. Also finding the right set of systems proved also challenging. In theory different timeframes and styles would complement each other. If time permitted it would have been more beneficial to create one system and specifically make another system that focused on some of the flaws on the first. Future implementations should focus more on the portfolio as a whole rather than individuals systems that combine, it would seem more robust if designed as so.

Appendix A: Morning Gap

Gap System EasyLanguage Code:

```
Inputs:
            psize(500),
            ProfitTargetPct(0), { pass in 0 if you don't want a profit target }
            StopLossPct(0) ; { pass in 0 if you don't want a stop loss }
Variables: JNRSI(0),
                  TrRisk(1),
StopCalc1 (0),
StopCalc2 (0),
      Minutes        (0),
      ThisHourHigh    (High),
      ThisHourLow     (Low),
      ThisHourTimeH   (0),
      ThisHourTimeL   (0),
      PrevHourHigh    (High),
      PrevHourLow     (Low),
      PrevHourTimeH   (0),
      PrevHourTimeL   (0);

Minutes = MinutesFromDateTime ( ELTimeToDateTime ( Time ) ) ;

If Minutes = 30 or Minutes = 35 or Minutes = 40 or Minutes = 45 or Minutes = 50 then begin
      PrevHourHigh = ThisHourHigh ;
      PrevHourTimeH = ThisHourTimeH ;
      PrevHourLow = ThisHourLow ;
      PrevHourTimeL = ThisHourTimeL ;
      ThisHourHigh = High ;
      ThisHourTimeH = Time ;
      ThisHourLow = Low ;
      ThisHourTimeL = Time ;
end ;


If High > ThisHourHigh and time < 950 then begin
      ThisHourHigh = High ;
      ThisHourTimeH = Time ;
end ;

If Low < ThisHourLow and time < 950 then begin
      ThisHourLow = Low ;
      ThisHourTimeL = Time ;
end ;
```

If entriestoday(date)=0
      and time <1010
      And time > 950
      and High>ThisHourHigh

Then buy("GapDown Long") psize contracts next bar at market;

If entriestoday(date)=0
      And time<1010
      And time > 950
      {and High<OpenD(0)} And Low<ThisHourLow

Then sellshort("GapDown Short") psize contracts next bar at market;

StopCalc1 = EntryPrice - (EntryPrice*StopLossPct);
StopCalc2 = EntryPrice + (EntryPrice*StopLossPct);

//exit stoploss
if MarketPosition > 0 and Close < StopCalc1 and time > 1015 then
      Sell("sell stoploss")next bar at EntryPrice - (EntryPrice*StopLossPct) Limit;

If MarketPosition < 0 and Close < StopCalc2 and time > 1015 then
      Buytocover ("buy stoploss")next bar at EntryPrice + (EntryPrice*StopLossPct) Limit;

//exit at 1030 all positions
if MarketPosition <> 0   and time = 1030 then
      Begin
            If MarketPosition = 1 then Sell All Contracts Next Bar at Market;
            If MarketPosition = -1 then Buytocover All Contracts Next Bar at Market;
      end;

Appendix B: Trend Following

Trend Following 2.0 EasyLanguage Code:
Inputs:
Len(32),Barlimit(23),Brkpoint(0.050),MMstop(400),PO(2100),OverSold(30),OverBought(70);
Vars: MA(0), myRsi(0),TrRisk (1);

```
{****** Moving Average Calculation}
MA = Average(Close,Len);
{****** RSI Calculation}
myRsi = RSI( Close, Len);


{******* Entry Signals *********************}
If MarketPosition = 0 then
Begin
        if (Close > MA and LowestBar(Low,3)= 0) or (Currentbar > 1 and MyRSI crosses over
OverSold) then
                Buy("Trend LE") next bar at high + BrkPoint Point Stop;
        If (Close < MA and HighestBar(High,3) = 0) or (Currentbar > 1 and MyRSI crosses
under OverBought) then
                Sellshort("Trend SE") next bar at Low -BrkPoint Point Stop;
End;

{******* Exit Routines *********************}

{profit objectives}
If MarketPosition = 1 then
        sell("Trend LPO")next bar at Entryprice +(PO/BigPointValue) Limit;
If MarketPosition = -1 then
        Buytocover("Trend SPO") next bar at Entryprice - (PO/BigPointValue) Limit;
{stop loss}
If MarketPosition = 1 then
        sell("Trend LX")next bar at Entryprice -(MMSTOP/BigPointValue) stop;
If MarketPosition = -1 then
        Buytocover("Trend SX") next bar at Entryprice + (MMSTOP/BigPointValue) stop;

{Bar Limit Exit}
If BarsSinceEntry >= BarLimit Then
        Begin
                Sell("Bar Limit LX") this bar on close;
                BuyTocover("Bar Limit Sx")this bar on close;
        End;


{Value99 = WriteTrades_ ( TrRisk , 0 , 0 , 10 , 0 , "c:\google_new.csv" ) ; }
```

Appendix C: Neural Network

Neural network python code:

```python
import time
import numpy as np
from numpy import genfromtxt
np.set_printoptions(suppress=True)

go = True
databars = 5 #number of bars to predict forward

while go:
    #[open, high, low, close, time]
    backwards_bars = genfromtxt('D:/output.txt', delimiter=',')

    same_sign = True
    i = 0
    bars = [[0 for x in range(len(backwards_bars[0]))] for x in
range(len(backwards_bars))]



    for j in reversed(backwards_bars):
        for k in range(len(backwards_bars[0])):
            bars[i][k] = j[k]
        i += 1

    hlmax = 0

    for bar in range(len(bars)-databars):
        hlmax = 0
        for j in range(databars):
            if abs(bars[bar][0]-bars[bar+j][0]) > hlmax:
                hlmax = bars[bar][0]-bars[bar+j][0]
        bars[bar+databars] =
np.append(bars[bar+databars],np.sign(hlmax))


    np.savetxt("D:/output.csv", bars, delimiter=",", fmt="%s")

    #
    ##
    #turn CSV into ARFF

    f1 = open("D:\\output.csv","r")
    f2 = open("D:\\output.arff","w+")
    #print( f1.read(200))
    content = f1.read()
    f1.seek(0, 0)
```

```
    f2.write("@relation output\n\n@attribute open numeric\n@attribute
high numeric\n@attribute low numeric\n@attribute close
numeric\n@attribute time numeric\n@attribute exav5 numeric\n@attribute
dexav5 numeric\n@attribute dfexav5 numeric\n@attribute exav9
numeric\n@attribute dexav9 numeric\n@attribute dfexav9
numeric\n@attribute exav15 numeric\n@attribute dexav15
numeric\n@attribute dfexav15 numeric\n@attribute exav30
numeric\n@attribute dexav30 numeric\n@attribute dfexav30
numeric\n@attribute d1 numeric\n@attribute d2 numeric\n@attribute d3
numeric\n@attribute cupafter5? {-1.0,0.0,1.0}\n\n@data\n" + content)
    f1.close()
    f2.close()

    time.sleep(40)


    #
    ##
    #parse weka output
    f1 = open("D:\\check.txt","w+")

    f2 = open("D:\\wekaout.txt","r")

    mystr = f2.read(150)
    numloc = mystr.find(":",100)
    numend = mystr.find(" ", numloc)
    print(mystr,numloc,numend,mystr[numloc+1:numend])

    f1.write(mystr[numloc+1:numend])

    f1.close()
    f2.close()


print("terminated")
```

Neural network execution command:
```
java -cp "D:\weka.jar" weka.classifiers.functions.MultilayerPerceptron
-l D:\2min_eurusd2.model -T D:\output.arff -p 0 > D:\wekaout.txt
```

Data output for neural network TradeStation strategy:
```
[IntrabarOrderGeneration = false]
variables:  beginTime (1000), endTime(1545), AvgExp1(0), AvgExp2(0),
AvgExp3(0), AvgExp4(0);


AvgExp1 = XAverage( close, 5 ) ;
AvgExp2 = XAverage( close, 9 ) ;
AvgExp3 = XAverage( close, 15 ) ;
AvgExp4 = XAverage( close, 30 ) ;

Print (File("D:\output.txt"),
     1000*open,", ",
```

```
      1000*high,", ",
      1000*low,", ",
      1000*close,", ",
      Time,", ",
      1000*AvgExp1,", ",
      10000000*(AvgExp1-close),", ",
      100000000*(AvgExp1-AvgExp1[1]),", ",
      1000*AvgExp2,", ",
      10000000*(AvgExp2-close),", ",
      100000000*(AvgExp2-AvgExp2[1]),", ",
      1000*AvgExp3,", ",
      10000000*(AvgExp3-close),", ",
      100000000*(AvgExp3-AvgExp3[1]),", ",
      1000*AvgExp4,", ",
      10000000*(AvgExp4-close),", ",
      100000000*(AvgExp4[0]-AvgExp4[1]),", ",
      10000000*(close[0]-open[0]),", ",
      10000000*(close[1]-open[1]),", ",
      10000000*(close[2]-open[2]) );
```

Trade execution TradeStation strategy:
```
using elsystem;
using elsystem.io;
using elsystem.collections;


[IntrabarOrderGeneration = false]
variables: beginTime (1000), endTime(1545), doTrade(0), StreamReader
reader(null);

reader = StreamReader.Create("D:\check.txt");


doTrade = strtonum(reader.ReadLine());

Print (File("D:\tout.txt"), doTrade, " , ",MarketPosition,", ", time);


reader.Close();

If MarketPosition = 0 then begin
     if dotrade = 1 then
          buy 10000 shares this bar at close;
     if dotrade = -1 then
          sellShort 10000 shares this bar at close;
end;



If MarketPosition = 1 then begin
     if dotrade = -1 or BarsSinceEntry >=120 then
```

```
            sell this bar at close;
end;
if MarketPosition = -1 then begin
      if dotrade = 1 or BarsSinceEntry >=120 then
            buytocover this bar at close;

end;
```

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