WORCESTER POLYTECHNIC INSTITUTE

INTERACTIVE QUALIFYING PROJECT

Completed in partial fulfillment of the Bachelor of Science degree in Mechanical Engineering at
Worcester Polytechnic Institute

INTRODUCTION TO TRADING SYSTEM DEVELOPMENT

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Chapter 1: Introduction and Overview of Research

1.1. Problem statement

The purpose of this project is to build a trading system that uses scientific methods to ensure profitability. Creating a science-based trading system allows for an investor to design a trading system and portfolio using logic rather than emotion. This creates a trading strategy that can keep a trader from making costly mistakes that usually arise from relying on their intuition and "gut" feelings. Because asset traders are humans and not computers, they have emotions that can prevent them from making smart trades, even if they are experienced traders and know when to make a trade.

1.2. Importance of problem

The reliability of using logical criteria to create trades is one reason that professional stock market traders use quantitative trading. By using quantitative trading, traders can make better trades, which are based on scientific and statistical knowledge. Thus, an algorithmic trading system designed to trade on objective criteria prevents these emotions from ruining a trader's portfolio. Therefore, this project involved creating an automatic trading system designed to run on the trading platform TradeStation.

Methods including statistical analysis and mathematical modeling are implemented in order to fully optimize the trading system for use in the stock market. In this project, it is proven that scientific analysis is an efficient method for analyzing and writing trading programs. In addition, when the trading system is properly written and tested, the advantages of automatic trading outweigh the disadvantages of manual trading for multiple reasons. These include, but are not limited to: prevention of user error, trading consistency, and proven trading methods.

Statistically-backed information is utilized in the program to decide when to create trades, and this reduces errors caused by human interference and bias. Often times, being unsure of a trade causes people to make bad choices that result in losing money. In addition, relying on manual trading is a strategy that is prone to user forgetfulness and unreliability. By trading automatically through computer programs, emotions can no longer interfere with trades since the system relies on math and scientific

objective criteria to trade (Folger). These criteria, of course, have been determined to be statistically likely to accomplish the trader's goals. Also, trades traded by an automatic system will always be ordered to the stock broker, since the computer program cannot accidentally forget about the trade. Lastly, automatically trading is a strategy that can be built and improved upon over time, with little effort.

1.3. Literature summary and statement of creativity

For the automatic trading system, stocks were traded in swing trading time frames. Two algorithmic strategies were written and back tested with historical data, and both strategies were combined into two "system of systems" that allowed analysis of the portfolio of stocks. These two strategies were based on:

1) Trend-following resistance and support trendline charts

2) Moving Average crossover philosophies.

Additionally, analytical techniques such as Monte Carlo analysis and Walk Forward Optimization were used to determine the allocation of funds to each stock inside of a "system of systems" portfolio.

The purpose of a dual "system of systems" is to build a reliably profitable strategy for creating funds. By allocating money to each of the two systems depending on the potential expected reward gained, the entire strategy can be depended upon to create funds regardless on the individual stocks in the system or the economic performance of the market. Also, adapting the allocation of money and importance to both systems allows the "weight" of the entire "system of systems" to be calculated and optimized.

In both systems, the strategy made use of a unique stock selection method known as the "CANSLIM" method, which chooses strongly performing stocks to trade (Chen, CANSLIM). This stock selection, in tandem with the technical analysis chart trading method of using trendline support and resistance lines, is best used for trading during times of rapidly changing prices over the course of weeks and months of slow price increases. The price level reaches one of the resistance or support lines when a sharp price change happens, and this is exploited in this strategy, by finding this sharp changes.

The use of support and resistance lines is implemented in a trend-following system for the first of the two systems. A trend following system is a trading system in which trades are created that effectively

use the price level movement of a stock as a way to gauge when trades should be made. When the price is predicted by the system to increase, then the trend following strategy will purchase the stock. Likewise, when the system predicts the system will decrease, then the system will sell the stock that was previously purchased. This trendfollowing method a common method used by traders.

The second system conducts trades based on a moving average cross-over strategy, in tandem with a trend following system, that follows the trends of the moving averages in specific to conduct trades. Two moving average lines were used, and optimized for each stock, to create a system. Using historical data, the system calculates the best time range for the fast and slow moving average lines, and creates trades when the the "fast" moving average line crosses over and under the "slow" moving average line.

For the purpose of this project, the system was created on a simulated trading platform for the sake of implementing an operable code. Funds allocated by the system were not evaluated in terms of feasibility or actual implementation. Thus, commission fees and waiting periods are just two factors that must be considered before actually implementing this strategy.

This code was written with my own psychological preferences, and the purpose of doing this will be included later in the paper. To briefly explain, a trader's adversity to risk, and his/her propensity to invest and trade money, will be an important factor in how they decide to conduct trades.

1.4. Conclusions

Through these analytical techniques, it was found that creating automated trading systems is a profitable venture, as using scientific methods to build and optimize trading algorithms can vastly improve results relative to solely relying on traditional methods such as chart reading.

Chapter 2: Trading & Investing

2.1. Trading & Investing Overview

In financial management, the allocation and earning of money is done in the stock market through trading and investing strategies. These two approaches are the most commonly implemented strategies in the stock market. Traders, investors, and everyday people trade financial assets on the stock exchange for profits. Each individual person who trades must create strategies for reliable success, regardless of their mindset or preferred strategy.

Trading strategies typically involve buying and selling financial assets more frequently than an investing strategy. This is done by exploiting the changes in price of an asset class, and purchasing, selling these asset classes to make profit. This is done, usually, by holding and then selling an asset in the time frame of anywhere from a few nanoseconds to months to even multiple years. Various time frames appeal to various mindsets, and these will be discussed in further detail in Chapter 3.

The mindset of traders is short term profits with minimized risk of losing out on money-making opportunities in the short term. In addition, traders prefer to use the price level of an asset class as indication of trading potential rather than an individual asset's financial performance. Also, traders are not interested in an assets performance or purpose, instead focusing on how to take advantage of the changes in price of its shares in order to make profitable trades.

Trading assets brings the advantages and disadvantages that arise from holding onto assets for short periods of time. For instance, a trader does not necessarily have to watch the company's performance in the news, and can trade any asset that has large price movement. In addition, traders can get out of a bad trade quickly, because their money is not held up.

However, trading in short term strategies has disadvantages as well. Trading assets frequently requires commission costs paid to stock brokers, which usually cannot be ignored in real life. Unless a trader is a stock broker, or has a close relationship with their stock broker, they must pay commission costs that make it possible for their stock broker to also make money. Commission costs not only lower a

trader's profitability, but also forces traders to create strategies that are profitable in order to make money. Without a sound trading system, a trader cannot rely on their system to make money.

Investors, in comparison, are more inclined to having long term approaches in buying and selling. Investing strategies often involve researching an asset class such as a company's stock to predict the future stock price level. Researching the company's financial statements, its management, and also keeping track of the company's performance are ways that investors track a stock to decide whether to buy, hold, or sell a stock.

Investors have the, "buying and holding" mentality for long periods of time, and observing changes in the market and industry rather than focusing on the price level of a stock. Also, investors make use of dividends, money paid out to stockholders, to earn money. By holding onto stock for long amounts of time, the investor can earn money from both selling the stock at advantageous times and also from dividends.

Similarly to trading strategies, there are advantages and disadvantages that come with investing strategies. Since these strategies are run on a longer time frame, less trades are being made when compared to a trading strategy. For this reason, commission costs associated with stock brokers is lower for investors than for traders. In addition, investors do not have to keep their attention on price fluctuations, since an intelligent investor will have a strategy for selecting strong stocks that are ensured to perform well in the long run. This, however, can bring disadvantages. For instance, investors keep their money held up in an asset far longer than traders, and can miss out on potential profits if they wait too long on an unsuccessful investment. In addition, investors must pay more attention to how an asset is doing, relative to its competitors or alternatives. Keeping an eye on the fundamental analysis indicators is important for investors for this reason. Watching trends and looking out for potential catalysts of price movement is more important to an investor than just watching the price level exclusively.

Investors and traders have different mentalities with respect to earning money on the stock market, and these differences bring their own advantages and disadvantages. Differences in one's risk

averse and one's willingness to watch individual assets for long periods of time are the biggest differences between the two mindsets.

2.2 Stock Market and "Beating the Market"

Independently of trading and investing mindsets, is the idea of whether or not is it beneficial to attempt individually "beating" the market or if focusing on "traveling" with the market is more advantageous. "Beating" the market in this case refers to individuals who attempt earning higher average returns than the "market," or the large stock market indexes such as the Dow Jones or S&P 500. The agreed upon annual return rate for these indexes is around 5-10%. Strategies that attempt earning larger rates than these are more aggressive, and often more risky than the alternative.

Many individuals, historically, have found it possible to "beat" the market. By creating unique strategies and taking full advantage of volatility and irrational behavior, these strategies are commonly used. Robert Shiller, a 2009 Nobel laureate in Economics, was an early proponent of this idea of systematically beating the market (Shiller 421-436).

Shiller noticed inefficiencies in the market, which he discovered were largely due to emotional rather than rational mindsets. Because asset holders overreact to changes in the market, those with good strategies can predict and make use of these overreactions. However, this idea was not commonly accepted until Shiller wrote about behavioral finance, and discussed inefficiencies in the market. Up until then, the efficient market hypothesis was commonly accepted as the model for economic and trading behavior. This hypothesis, in contrast to Shiller's ideas of behavioral finance, assumed that all market participants make rational choices in the market (Fama). This idea believes that stock prices are indicative of the average expectation for the stock's price, and that this price accurately gauges the price, at which an individual cannot exploit the market for their own gain. Thus, this theory, developed by Eugene Fama, implies that investing in individual stocks is a poor idea, and that investments in index funds is more likely to earn consistent profits

These various theories about market efficiency are congruent with the practices that abide by the principles that constitute them. Not only are the practices opposite in principle, but they are

interconnected in their analysis of price level action of assets. The aggressive behavioral finance proponents make trades that the efficient market proponents believe set the appropriate price level. Both theories and practices are not the only ideologies about market behavior, since any individual trader can create their own hypotheses about the market and its inefficiencies. Individual traders can be educated on trading methods through independent research as well as through formal education such as college. As a trader self-educates himself/herself through actual trades, they begin to notice patterns in the market cycle and in price level action. One of the repeating patterns in an asset's price level, if the asset is a stock of a company, is the well hidden buying and selling of shares in the company by large financial institutions. Banks, hedge funds, investment firms, and other companies with large budgets and experienced, intelligent employees guide the price level of a stock through buying and trading (Accumulation). These institutions do this through allocating large amounts of money into shares of an asset, and building up their reserves of stock while the price is still low.

These patterns and underlying trading motives are the core of an assets price, and consequently are also the building blocks of stock market price movement. Since the stock market is comprised of all of the publicly sold stocks, the large financial institutions that manipulated the price level have significant influence on the stock market. Stock prices are set by investors who calculated the supply and demand of an asset, and thus the price at which the shares can be sold. Shares of a company are sold as very small percentages of ownership. Publicly traded companies sell shares of their company in order to gain revenue for the operation of their company, or simply for profit. Privately traded companies can go public, and sell their shares publicly through the stock exchange in their Initial Public Offering (IPO). When this occurs, the shares are then sold on stock exchanges, such as, but not limited to, the New York Stock Exchange and NASDAQ.

These two stock exchanges are two of the most famous and influential in the world, and are both headquartered in New York City. Not only do companies trade shares of assets on the stock exchange, but individual traders as well as trading firms also conduct trades. The prices of the stocks in the stock exchange are determined by market supply and demand. In order for traders and financial institutions to

analyze stock prices, they use stock market indices in order to infer whether the market is optimistic or pessimistic.

2.3 Bull and Bear markets

During a bull market, trading and investing is done more frequently because the market is optimistic about the future. When the demand for an asset rises, relative to its supply, the price also rises. An example of a bull market is the post-Great Recession U.S economy, in which stock prices in the S&P 500 have risen. In addition, because more shares are being sold, the total amount, or the shares supplied decreases. When the supply of an asset decreases, the price also increases. This continues as a positive feedback loop, creating higher price stocks.

When a company's stock price is high, they may decide to issue, or sell, more shares of their company in order to gain revenue. The company then has more money to spend on production, research, or other ways to improve their business. This is beneficial to the company, and individuals who have ownership of shares.

During a bull market, a company's stock share may not increase in value. If a company operates poorly, such as with a bad management team, or sells an obsolete product or service, then investors will be less likely to purchase shares of the company. In addition, negative media attention for a company can also drive its stock price to decrease. For instance, when a Tesla combusted due to a faulty battery, media attention to the event drove its share price down (Hanley) . Because investors believe the company will become less popular, and will receive less customers, then they will also believe other investors will also believe the same thing, and thus many investors will sell their shares to get rid of an asset they believe will depreciate in value.

Traders can take advantage of these large drops in price, and "short sell" the stock's shares. Short selling a stock share is when the share is borrowed, and then sold without money being exchanged. The strategy of short selling is to sell the borrowed share when the price is relatively high, and then once the price has dropped, purchase the share in order to repay the debt.

When the market, and the economy, are doing well, and people are optimistic about their future, these people tend to be less conservative with money and more willing to invest and make trades. This is known, in trading, as a "Bull market". The reason for this is a bull attacks with his horns in an upward motion, and his horns are compared to the price level graph which indicates rising price. On the other hand, the opposite of a bull market is a bear market. This is when the market and the economy is doing poorly, and individuals are more conservative with their money and thus are more skeptical about trading and investing. This is typical of recessions, and downtrending markets. Bear markets get their name from a bear who attacks downwards with his claws, similarly to how price levels go down in a bull market.

2.4 Asset classes

The four main asset classes that can be traded in the stock market by traders are: equities, bonds, currencies, and futures contracts. Each asset class has its own advantages and disadvantages that can be useful to exploit depending on a trader's mentality.

Equities are the asset class that is the focus of this project, and these are stocks of a publicly traded company. The value of these assets is typically determined by the performance of the company. Stock allocation is how ownership of a company is divided. The owner and directors and a company issue stocks in order to raise money for the company. These assets are traded on the stock market by traders. The advantage of trading equities such as stocks is the high amount of liquidity that allows traders to purchase and sell stock shares quickly. However, stocks that have been owned for a year or less are taxed more heavily than those owned for more than a year. Additionally, stock trading does not require large amounts of margin to trade. With online brokerages such as Robinhood or TDAmeritrade, it is easy for beginner traders to trade with relatively small amounts of money. However, some brokerage accounts require larger amounts of margin, to pay for the benefits of using the superior brokerage firm. Margin is a loan that a brokerage account can give out.

Another asset class is the bond market. Bonds are debts from the U.S Treasury that are paid to an investor, with interest added. The advantage of purchasing bonds is the promise of being repaid the set amount agreed upon during purchase. The U.S Treasury always pays its bond payments back, which

makes it a reliable investment. However, the rate of return on trading bonds is lower than that of trading stock shares. This gives the trader a longer term, more stable investment. Bonds can be purchased with relatively small amounts of money, and typically, United States government bonds are purchased by investors. A disadvantage of investing in bonds is the tax rate is similar to that of stock trading.

Next, currency trading or FOREX trading is an asset class that is used by many traders and investors. This is done by purchasing or shorting foreign currencies to exploit the currency-pair market. FOREX trading is similar to stock trading, in that the shares have high liquidity and thus trades are fairly frequent. In addition, both FOREX and stock trading come with additional fees. Purchasing foreign currencies typically requires a small fee to be paid to the currency exchanger, as does converting it back to U.S. dollars. This is similar to stock trading, where small fees must be paid to the stock broker for their services. The advantages of FOREX trading include high potential for short term profits, but this comes at the expense of the disadvantage of volatility and fees.

Lastly, futures trading is a trading strategy that can be used by traders to create profits. Futures trading involves trading ownership of actual goods, such as gold, oil, corn, etc, at an agreed upon price. This means that buying futures contracts can be a financial risk if the trader does not wish to actually own the goods. Instead of having the goods delivered to their house, the trader usually opts to sell the ownership of the goods before the delivery occurs. That is one main disadvantage of trading commodities.

Chapter 3: Trading Systems

3.1. Trading System Overview

Although this report is written for an automatic trading system in relatively medium length intervals, it is necessary to mention both shorter and longer length interval strategies, and the respective mindsets that align with these strategies. As previously mentioned, a trader's psychological preferences will determine his mindset for trading and investing money. For example, an individual's psychological preferences will determine the specific methods he/she will use to trade through a stock broker. These include, but are not limited to: stock brokerage preferences, time intervals of trades, personalized objectives, choosing manual or automatic trading, and utilizing fundamental or technical analysis. Lastly, an individual's mindset will be a deciding factor in the rules he/she places in her trading/investing system. The entry rules, exit rules, position sizing, and order types are all decisions an individual must make when creating a trading strategy.

3.2 Trading platforms and brokerages

The most common way trades are executed by investors in today's day and age is through online trading platforms. For years, trades were ordered between buyers and sellers in trading floors through loud yelling and bargaining. This was before the widespread use of computers, and this method of trading was often hectic and noisy in comparison to today's methods. In addition, trading floors were less efficient at creating many trades for large amounts of people. Because traders could only order trades physically, they were unable to order trades from anywhere other than the trading floor. In contrast to today's methods of making trades online, trading in the pits was less organized. Trading online is popular among all kinds of traders for its organized, cleaner methods and structure. Online platforms such as TD Ameritrade, Tradestation, and MetaTrader are utilized by individuals looking to make money on the side in addition to their career, as well as being implemented in offices of professional trading companies. The advantages of these platforms outweigh the disadvantages due to today's sophisticated technology in computing and trading.

Trading platforms allow traders and investors to order trades, either buying or selling, with a stock broker. The stock broker conducts the trade for the client, by trading on the stock market. Stock brokers offer their services at a fee, usually commission costs that allow them to make money. In addition, stock brokers can give advice to an individual on the best trades to make. Trades between the involved parties is done through exchanges. The two most popular brokerage account types are cash accounts and margin accounts.

The borrowing of money is often a topic that must come up between clients and professionals. Individuals, or clients for a company, can purchase assets on, "margin," meaning they borrow money in order to make the purchase. This is done instead of buying the asset upfront in cash. Buying assets on margin has loan interest rates that must be paid to the broker. These interest rate payments must be paid back to the broker regardless if the trade is successful or not. Buying on margin can also be done through using owned assets such as stock as collateral to buy new assets. Lastly, margin brokerage accounts allow individuals to short sell assets.

Cash brokerage accounts are beneficial for those with money saved up to purchase assets, and do not have to borrow money to purchase assets. In addition, purchasing assets in cash gets rid of interest rate payments that must be paid to the broker. However, an individual must have money initially in order to purchase assets with cash.

3.3 Growth and Value Investing

The two most prevalent stock investing styles used in today's technological age are, "value investing investing" and "growth investing." Value investing is the strategy used by investors to gain profit through misvalued stocks. Investors such as Warren Buffet will capitalize on an underprice or overpriced stock, that they predict will reach its intrinsic value. This misalignment of intrinsic value to trading price is caused by volatility in the stock market, or miscalculated financial fundamentals. In general, this strategy is less useful in bull markets, like the current economy, since the stock is likely to be rising in price anyway, so purchasing it at a high price is less beneficial. Additionally, miscalculating the intrinsic value of a stock can decrease the profitability of this strategy.

Another popular investing strategy is growth investing. This strategy involves profiting from stocks that are expected to increase in price, by purchasing the stock when before a significant uptrend. An advantage of this strategy is its usefulness in bull markets, or when a companies performance improves its stock price. However, this strategy has a disadvantage during bear markets, and when the companies are performing poorly.

The least risky, and the most profitable investing systems are those that incorporate both investing and growth investing strategies. Diversification in strategies, and stocks, is helpful for investors who wish to hold on to money for long periods of time. These systems, called hybrid systems, incorporate both strategies in a, "system of systems."

3.4 Trading Styles

In addition to investing strategies, another way to profit from the stock market is through trading strategies. As opposed to investing strategies, trading strategies are shorter term, and include more frequent buying and selling of assets. Four trading styles are scalp trading, day trading, swing trading, and long term trading. Scalp trading is buying and selling stocks extremely frequently. This is done through specialized hardware that is not available to the general public. Scalp trading, if done through a stock broker, would require high commision fees due to the high number of trades. However, these commission fees are not paid by Wall Street traders, and thus they can create large amounts of profit with an effective trading system. The reason Wall Street traders do not pay commissions is because they make agreements between companies and exchanges in order to create profits for both parties.

Day trading is trading assets within a single trading day. Scalp trading is one type of day trading. Generally, day trading strategies conduct trades within a single day, rather than keeping the stock until the next day. This strategy is advantageous for the same reasons as scalp trading, such as high potential for profits from a well-built strategy. However, commission fees are a disadvantage for non professional day traders.

Thirdly, swing trading is a trading strategy that is used by traders to create profit in a longer time frame than that of day trading. Swing trading is typically done through purchasing and selling assets in a

time frame of anywhere from two days to several weeks. This strategy takes advantage of uptrends in a stocks price. Therefore, less trades are needed than in a scalp or day trading strategy. Thus, less commision fees are necessary. However, swing trading has its disadvantages in the risk of the trade. Swing trading is more risky, due to the longer time frames, as holding onto a stock for long periods of time inherently is more risky.

Lastly, long term trading is a trading strategy with longer time frames than swing trading. Long term trading requires less commission fees than the previously mentioned trading strategies, at the cost of higher risk. This strategy is very similar to investing, since both require trades of long time frames. These time frames can range anywhere from months to years before selling the trade. Long term trading, however, utilizes short selling in order to make profits, while investing does not.

Traders can use different methods of trading, as well. Two types of trading methods used today in the age of computers are manual trading and automatic algorithmic trading. Manual trading requires the trader to manually trade stocks through purchasing and selling the stocks through a stock broker. This can be done either on the phone or on the computer. Automatic algorithmic trading is used as a way to purchase and sell stocks automatically, through the use of computer algorithms that have been developed for the traders personalize objectives.

In this report for the Interactive Qualifying Project, the personalized objectives were chosen by the writer, David Cardoza. He chose to create two automatic algorithmic strategies to fit his personal objectives, and then created a, "system of systems" that optimized the two strategies through diversification and allocation of funds. His personalized objectives included creating the most amount of profit, with the least amount of drawdown. In addition, his strategy required little market research, and was primarily focused on technical analysis for the purpose of this project. Technical analysis contrasts with fundamental analysis, in that it focuses on the use of mathematical methods to create profits. Fundamental analysis uses qualitative data such as market performance, or company management to evaluate a stocks value. The use of technical analysis is useful when conducted with fundamental analysis

in order to create a diversified, robust strategy. Using just one does not allow a trader to see the big picture of a company and its stock price.

Technical analysis can be done through measurements or indicators of a stocks price movement. One major indicator used by swing traders is, "support and resistance lines," which help a trader recognize price movement patterns. A support is a price level at which a stock drops down to, but does not go below. A resistance is a price level at which a stock moves up to, but does not surpass. These lines can be utilized to predict the range of a stocks price level.

Using support and resistance lines, a trader can implement a strategy that involves "smoothies", a method in which trades are conducted as the price reaches the resistance and when the price drops to the support. When the price level reaches the support, the trader can assume the price will rise, and can purchase the stock in order to sell it. Likewise, when a stock price reaches the resistance line, the stock can be shorted and then bought when the price drops to a desired range. This is also known as a stop and reverse system.

The strategy requires the stocks be chosen manually, as there is no way to automatically select growth stocks on a computer. Through stock selection screeners, such as on finviz.com, criteria were determined through online research on growth stocks. For each letter of the acronym "CANSLIM", technical analysis was done to select stocks that qualify as growth stocks.

In this project, which uses historical data to analyze the profitability of trades and algorithms, it is assumed that stocks that have qualified as being growth stocks in the present will have also been qualified as a growth stock in 2010, which is how far back the historical data is used .While this may not be a strong assumption, it does however provide a systematic way of selecting stocks that can be used for scientific methods.

Chapter 4: Optimizing and Analyzing Trading Systems

4.1. Overview

The use of optimization further ensures a system is profitable, as well as increasing the extent to which it is profitable. Doing so can help a trading system develop an "edge" over the market, and thus create profits. Having an edge over the market means a system has positive expectancy. Otherwise, a system that cannot beat the market is not likely to generate the optimal amount of funds, as a trader can find other methods that will generate larger revenue. This optimization is done through mathematical methods such as Walk Forward Optimization and Monte Carlo Analysis. These methods are used to determine if a system is likely to be profitable or not.

Another analytical technique used to optimize a trading system is Monte Carlo analysis, a statistical method that also predicts a system's future performance. The probability of a systems performance metrics, such as maximum drawdown can be predicted through Monte Carlo analysis. While Monte Carlo analysis can assist a trading system, ultimately the trader must use his intuition to determine if a trade is a logical idea.

4.2 Value of Managing a System of Systems

A system of system can be improved through methods such as position sizing and diversification of stocks. Selecting the best stocks to trade allows a system to create the largest possible amount of profit per dollar, while minimizing risk. This is valuable because it lowers the risk of losing money, since each strategy is allocated funds based on its performance. Therefore, stocks with higher risk are allocated less money than those with lower risk.

Additionally, diversifying the stocks used can be helpful in activating or suspending the strategies used in the system of systems. When a strategy that can perform better in a certain situation, it is valuable to replace a strategy that does not perform as well.

4.3 Expectancy, Expectunity, andSystem Quality

Expectancy, expectunity, and system quality are statistical metrics used in the evaluation of a trading strategy that help an automatic trading system by providing information on the profitability, risk, and variability of a strategy. For a trading strategy, the list of trades can analyzed to determine these three metrics.

Expectancy is the sum of the R multiple of all of the trades, divided by the total number of trades. To find the R multiple of a trade, the net profit of the trade is divided by the average loss of all the trades in the system. Expectancy is an evaluation of the profit or loss per dollar risk per trade.

Expectunity is closely related to expectancy, as it is the profit or loss per dollar risked per year. Another term for this is the annualized expectancy. This is found by mulitplying the expectancy by the trades per year. This is typically used as a metric to compare two systems, that may have differing amounts of trades per year. For the calculations done for this project, these results are normalized to find the system quality.

The third metric, system quality, is the net profit per dollar risked, relative to the total variability of the net profit per dollar risked. This metric is useful in determining the allocation of funds to the numerous strategies in a system of systems. Each strategy with a positive system quality will be allocated funds, with each one being allocated a fraction determined by its performance relative to the others. For allocation of funds, the fraction allocated to each strategy is the system quality of that strategy divide by the sum of the system qualities of all of the strategies that were allocated funds. System quality is calculated by multiplying the expectancy of a trading strategy by square root of the total number of trades, divided by the standard deviation of the R multiples of all of the trades.

4.4 Walk Forward Analysis

Walk forward optimization evaluates a trading system strategy through its code, and determines the optimal parameters to use. it does this through a method known as out of sample testing. For instance, parameters such as the number of days forward or backward in a trend following strategy, or the length of a moving average are some examples of parameters that can be optimized through the use of walk

forward optimization. This is valuable for traders who wish to test their strategy without money, before using real money. Additionally, walk forward analysis determines the time intervals in which parameter optimization is useful. This is useful since the optimal parameter values may change over time, as the market adapts over time as well.

A method to ensure the profitability in the future is done through cluster analysis. Cluster analysis is done to create data on the walk forward efficiency of a strategy, which is an indication of how well the strategy will perform in the future in comparison to its past performance. A walk forward efficiency of 100% is an indication of the strategy performing just as well as the in-sample tests. A number higher or lower than 50% will indicate the strategy is likely to perform, respectively, better or worse than its has previously. (Walk Forward Summary)

The optimal parameters for Walk Forward Analysis are useful for the specific strategy, and its designed purpose. For the strategy created in this project, the parameters indicated by the Walk Forward analysis are useful for bull markets, or whenever a stock's price level is increasing. It is not designed for shorting stocks, nor is it designed for decreasing price levels.

Chapter 5: Literature review

In this project, analytical techniques were used to create the best possible system. Fundamental techniques such as CANSLIM stock selection were used to pick the stocks to be traded. Technical techniques such as trend-following "smoothies" trading and moving averages were utilized to optimally time trades. The two strategies utilized CANSLIM stock selection, with one strategy using trend following methods to take advantage of a rising price level, while the other strategy uses moving average crossover strategies to exploit price level movement.

5.1. CANSLIM Stock Selection

CANSLIM stock selection is a stock selection method for choosing stocks with rising price levels. To take advantage of a rising stock price, this stock selection method uses seven criteria to determine if a stock should be chosen for a system, with each letter of the acronym CANSLIM representing criteria. While some of these methods cannot be easily quantified, it is up to the trader to use mathematical criteria to determine if a stock fits one of the criteria. For instance, in this system, market leaders were seen as those with high market caps, as there is no quantitative metric to determine if a stock is a market leader.

CANSLIM

C- "Current quarterly earnings" must be high in comparison to the previous years. This indicates that a company is growing, and thus the price movement is uptrending as well.

A- "Annual earnings changes over five years" must be positive, which indicate the company is doing well and the price movement is improving.

N- "New product or new events" indicate a company will have positive price trends in the future as investors invest in the company due to the new product. For this project, the stock selection process gives preference to stocks which have a new product, or companies that consistently produce new products.

S- "Supply" and demand for the stock's shares must be high, which indicate investors and traders are interested in the company and thus cause positive price movement. Through technical analysis, this can be determined through the volume of a stock.

L- "Leaders" in the market perform better than "laggards" do, and thus the stock has more demand and the price will be uptrending.

I- "Institutional Ownership" indicates a stock in which most of the shares are owned by large financial institution such as banks, hedge funds, equity firms, etc. A large percentage of institutional ownership is typically an indication a stock will perform well in the future.

M - "Market direction" indicates a company will be more likely to be uptrending if the market is in a bullish direction.

5.2. Trend Following "Smoothies" Strategy

Trend-following strategies are strategies that follow the price level of an asset such as a stock share. These trend-following strategies typically keep the price level between the support and resistance trendlines. However, when the price level makes sharp changes, it will go outside of the space between the trendlines, indicating a change in a trend.

Figure 1: Visual explanation of support and resistance lines (How to Trade)

A simple trend-following strategy will use moving averages to determine if the price is increasing, and if the trend will continue. By making a trade when the price level reaches the resistance or drops to the support, the trend-following strategy is optimized to make small improvements on the profits. This method is known as the "smoothies"method because it smooths out the trend by optimally timing trades.

5.3. Moving Average Crossover Strategy

Moving averages are a widely used technical indicator used in order to estimate the direction a price level is moving. To calculate a moving average for a specified time interval, the price level at that time interval is averaged, resulting in a moving average calculation. For instance, the 5 day moving average is the sum of the previous 4 price levels plus the current price, divided by 5 days. This is a simple moving average, in contrast to an exponential moving average. An exponential moving average gives larger weighting to the most recent prices, thus reflecting the price of the recent price changes more than a simple moving average does.

Shorter time frame moving averages are more reactive to changes in price levels, in comparison to longer time frames which react very slowly. These are respectively known as "fast" and "slow" moving averages. A common method of using moving averages is to compare a fast moving average to a slow one. If the fast is larger than the slow, it indicates the price level has increased rapidly. Also, if the slow is larger than the fast, then the price level has likely dropped sharply recently. Comparing a fast and slow moving average is just one method of analyzing the price level of a stock.

Chapter 6: Trend-following System

6.1. Overview.

The first trading system created utilized CANSLIM stock selection process in order to choose growth stocks that will rise in price in the immediate future. To optimize the process of buying and selling the stocks, a Trend-following system bought and sold shares of stock through the guidelines of a resistance and support line trading strategy. These two analytical strategies complemented each other, and allowed for high profit margins with success in growth stocks specifically. Using both a stock selection process and an algorithmic trading strategy ensured the creation of a profitable system that will exploit price movements to earn money.

The advantage of this strategy is the high profit margins that come from growth stocks. Additionally, using a trend-following support and resistance method provides the trader with a way to maximize the profit by taking advantage of sharp increases in the stock price as it increases slowly over time. Thus, this strategy works best as a swing trading strategy, where stock shares are held over the time span of between several days and several weeks. Stock purchases and sells were optimized through the use of Walk Forward Optimization software, in order to find the optimal time span between the purchase and selling of a stock share. Trading stock shares too frequently will not create large profits, due to "overfitting" of a price level. Overfitting can lead to incorrect predictions and loss of money. However, too infrequent of trades will cause the strategy to take profits too late, and lose possible profits.

```
inputs:
Startbar(0),
TgtBar(0),
Endbar(0),
Length1(10),
Length2(25);

Value1=TLValueEasy(High, 1, 1, 1);
Value2=TLValueEasy(Low, 1, 1, 1);
Value3=Average(High, Length1);
Value4=Average(High,Length2);
Condition1= Value4 > Value3;
Condition2= Value4 < Value3;
Condition3= Value3< Open;

If Condition2 and Value4< Open and High crosses over Value1
Then sell next bar at market;

If Condition1 and Low crosses under Value2 and Open > Value3
Then buy next bar at market;
```

Figure 2: Code for the Trend-following strategy

In the above picture, the code shows the programming language Tradestation Development Environment which conducts trades based on user inputs. Here, the trendlines are programmed by the function TLValueEasy. The inputs of Start bar, Tgt (target) bar and endbar represent the starting point, the point to which to extend the trendline, and the final point of the trendline.

Stocks are purchased when the slow moving average exceeds the fast moving average, the open value for the day is larger than the fast moving average, and when the low reaches the trendline support. This ensure that trades are conducted at the lowest possible point. They are sold when the opposite occurs for each scenario, to allow the trades to be made at the highest possible point.

Consequently, the main disadvantage of using this strategy is the lack of adaptability that the strategy can provide to a trader. Using a one-size-fits-all algorithmic automatic strategy is not ideal for timing stock share purchases and sells. The erratic nature of stock prices makes it difficult to create a strategy capable of determining a timeframe or algorithm that will work every single time. Additionally, this algorithm will theoretically not work on stocks that are not growth stocks, and have not been selected through a CANSLIM selection process. Because such stocks will not have an uptrending price movement in the future, the algorithm will not be as useful as it would be for a stock selected through the CANSLIM selection. Also, during bear markets where price levels drop rapidly, this stock is likely to underperform and should be replaced by a different system.

6.2. Stock Selection

The stock selection process for this strategy was the use of CANSLIM stocks, that passed numerous criteria in order to be chosen. Stocks were chosen from the stock screener on finviz.com, which has a wide variety of numerous technical and fundamental indicators to choose from, for analysis of each stock. For the stock selection, only stocks with market caps above $80 billion were chosen, as these are leaders of their industries, and are likely to be producing new products regularly as well. Next, institutional ownership, monthly performance, and annual performance percentages were found, and formatted onto an excel document. The criteria for each percentage was 10%, 5%, and 10% respectively. Any stock that fit at least 2 out of 3 of the percentage criteria were chosen. Finally, out of the 29 stocks that fit these criteria,

10 stocks from different sectors and industries were chosen in order to allow for a robust system. See the attached excel document for the chart.

6.3. Trend Following Automatic Algorithm

Because growth stocks have been selected through the CANSLIM method, they are likely to have uptrending price movements in the future. Thus, an algorithm that creates trades must keep in mind that the price will be increasing over time. In order to trade stocks that will be upwardly trending, a Trend following automatic algorithm trading strategy was created. Through the use of forward-projecting trendlines that determine support and resistance lines, this algorithm purchases stocks as it reaches its support line, and sells the stock when it reaches its resistance line. This ensures a more profitable system.

Figure 3: BA Daily chart with the trend-following system trade times

The above chart shows when trades are conducted for Boeing, with day bars implemented. BA is the stock ticker used on the stock exchange for Boeing. This system was designed for rising price levels, and performed well for most of the stocks selected through CANSLIM selection. It is apparent from the picture that the strategy works best when the price level is increasing, and performs sub-optimally when
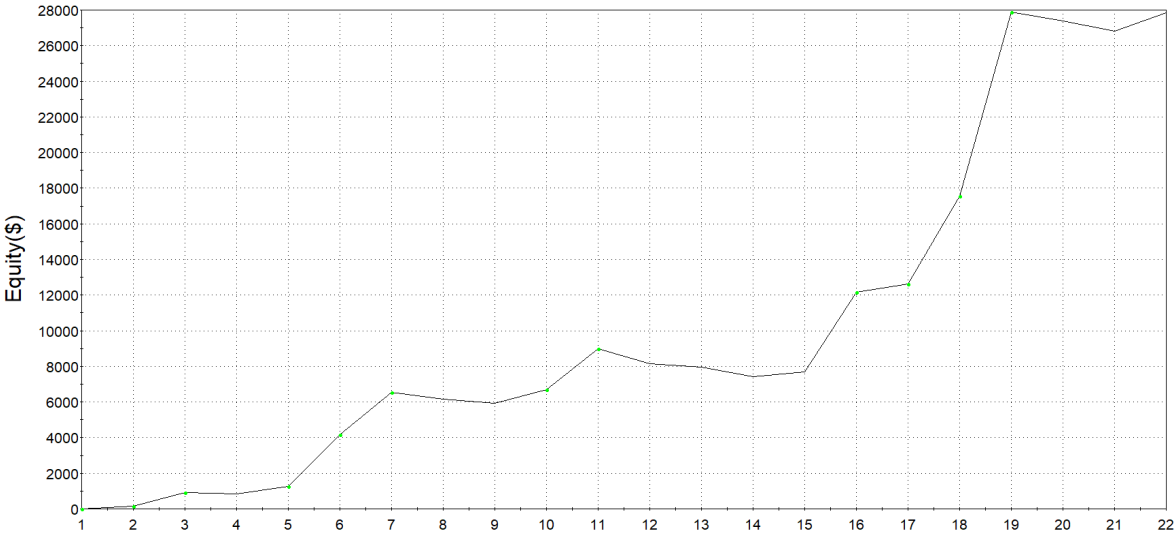
the price level is volatile.

Figure 4: Equity Curve for BA Daily, using the trend-following Strategy

Chapter 7: Moving Average Crossover System

7.1. Overview

For the second trading strategy, CANSLIM stocks were chosen to create strategies that exploit rising

price levels in order to generate a profit. This strategy utilized swing trading strategies that create profits

in a swing trading time frame. In order to accomplish this, a strategy was created that utilizes price

changes in swing trading time frames in a single trading day, with minimal trades such that the system is

not overfitted. The goal of this strategy is to purchase the stock at a price when it has decreased in price

relative to its previous price level, and selling it when the price has increased. By optimizing the moving

average lengths, the strategy creates profits.

This strategy is advantageous due to the lack of time commitment necessary for selecting stocks to use.

However, similarly to the algorithm for the first strategy, a one-size-fits-all algorithm is difficult to create

as every stock has different volatility. Thus, a disadvantage of this stock is that the strategy cannot predict

unpredictable price movement in a day. Therefore, a strategy that works for one stock may not work for a

different one. Additionally, a strategy that worked one day for one stock may not work the next day.

However, this algorithm was optimized such that trades are reliably profitable.

7.2. Moving Average Crossover Algorithm

For this strategy, a fast and a slow moving average were compared, and when the fast crossed over or

under the slow, then a trade is initiated. The code is as follows:

```
inputs:
 Length1(34),
 Length2(22);

Value1=Average(Open,Length1);
Value2=Average(Open,Length2);

If Value1 crosses over Value2
Then buy next bar at market;

If Value1 crosses under Value2
Then sell next bar at market;
```

Figure 5: Code for Moving Average Crossover Strategy

This system exploited the random price changes in a stocks price level without much concern about why the price level has changed. Overall, the system performed well. From Tradestation, the Lengths of the moving averages were optimized in terms of profit for each stock.

Figure 6: Boeing stock chart with daily bars, and optimized moving average lines.

In the above chart, the optimized time for each moving average was 34 days and 22 days, found through optimization on TradeStation. This was advantageous to find the time frames that have historically worked the best with this stock.

The chart on the top shows BA stock prices, with the overlaid time when trades occured. The chart on the bottom shows the slow moving average in red, and the fast moving average in blue. These values were found to be 34 days and 22 days. However, the parameters set on the optimization code were between 1 and 35 days. Therefore, 34 days and 22 days were the optimal conditions for fast and slow moving averages of 35 days or less. Larger time frames will produce lower risk, but require longer

computation times for optimization on Tradestation. From the graphs, it is shown that this strategy worked well during both price level runs and during volatility. This is indicated by relatively small drops in the cumulative equity graph, and the consistently increasing price level.
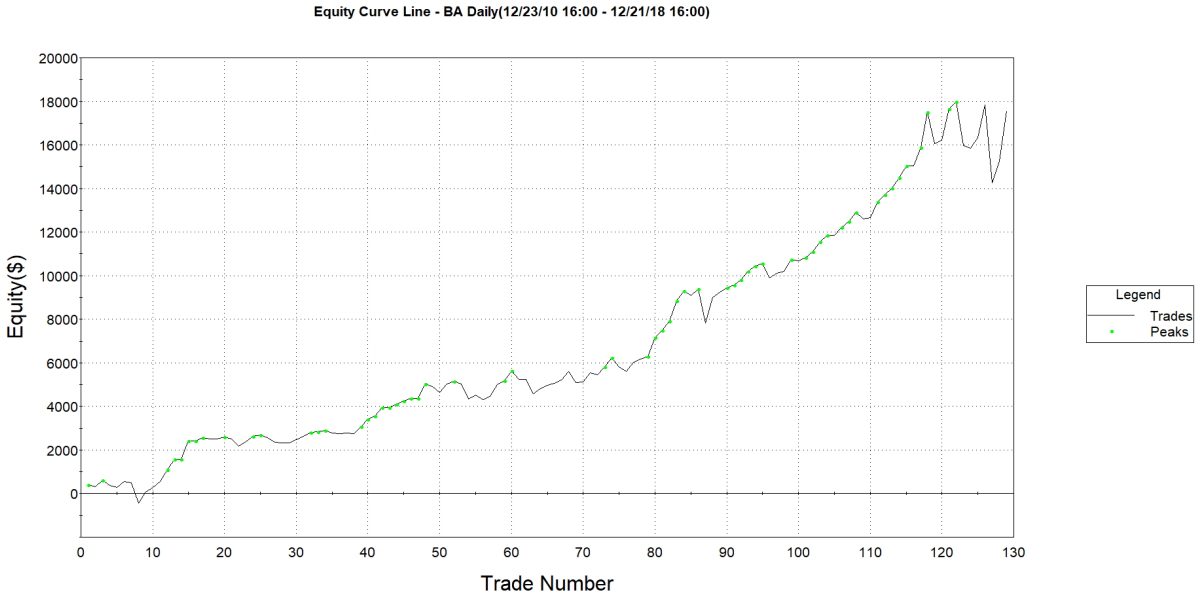
Equity Curve Line - BA Daily(12/23/10 16:00 - 12/21/18 16:00)

Figure 7: Equity Curve of BA Daily using Moving Crossover strategy

Chapter 8: System of systems

8.1 Overview

A system of systems was created on Portfolio Maestro on the TradeStation software. Using Portfolio Maestro allowed for fast calculations to be run on Monte Carlo analysis and for Walk Forward optimization. In addition, Portfolio Maestro created a total equity curve of the ten stocks in the portfolio, for both strategies. These ten stocks were: Boeing, United Healthcar Group, Microsoft, Verizon, Mastercard, Pepsico, Nike, Starbucks, and Paypal.

The second way that the system of systems was analyzed was through a unique analytical technique created for this project, in which the stocks that had positive system qualities were allocated money that was weighted based on its system quality performance relative to the other positive system qualities. The chart below demonstrates how each stock performed in each strategy. Those with negative system qualities were not included in this analysis.

	Strategy 1				Strategy 2	
Stock	System qlty.	Fraction allocated		Stock	System qlty.	Fraction allocated
BA	0.96	0.05		BA	0.79	0.04
UNH	-0.86	0.00		UNH	-0.49	0.00
MSFT	1.98	0.11		MSFT	-0.37	0.00
V	0.77	0.04		V	-0.92	0.00
VZ	-0.92	0.00		VZ	0.75	0.04
MA	1.16	0.07		MA	2.21	0.13
PEP	0.96	0.05		PEP	1.67	0.09
NKE	0.87	0.05		NKE	3.62	0.20
SBUX	1.90	0.11		SBUX	-0.14	0.00
PYPL	-0.36	0.00		PYPL	1.67	0.00

Figure 8: System quality and weighted allocation of funds chart

Those that have positive system qualities were implemented onto Portfolio Maestro. These are the same stocks used for the first system of systems as well.

Overall, both system of systems performed well, and improved results. The advantage of using a system of systems was that it lowered risk by decreasing the value and frequency of price drops in the

total equity curve. While both system of systems were rudimentary and didn't take advantage of strategy

activation or suspension rules, it did allow for a diversification of stocks that made the system less risky.

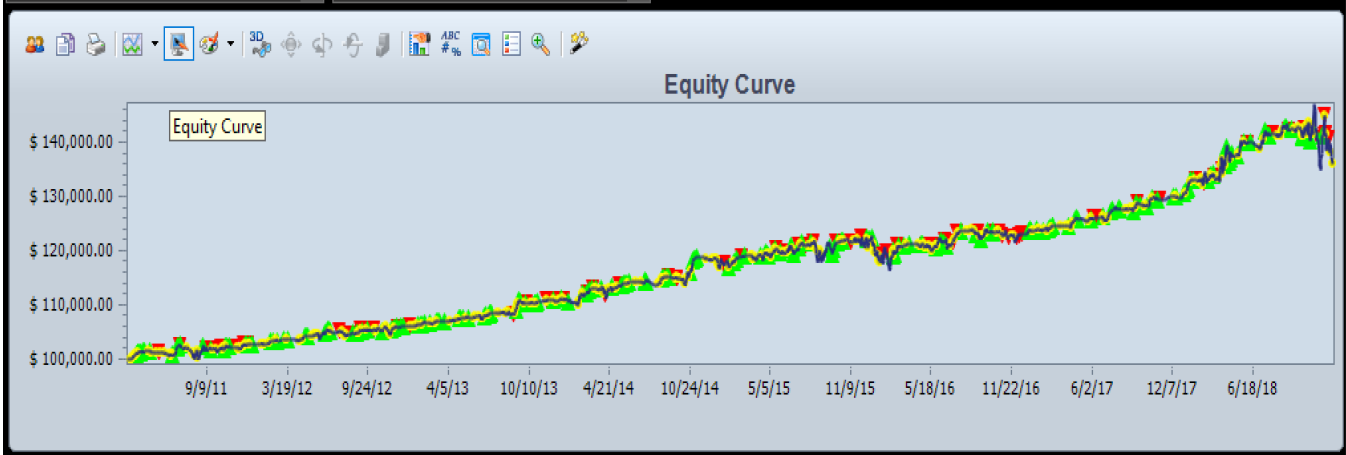**8.2 Portfolio Maestro System of Systems**

Figure 9: Aggregate equity curve obtained from Portfolio Maestro, the first system of systems. Here,

money allocation and optimization of individual strategies were not conducted. The initial value allotted

to this sysem was $100,000. For this equity curve, all ten CANSLIM stocks were included regardless of

its performance. Therefore, this had the two strategies both using the same ten stocks. Additionally, each

strategy was given parameters that were constant. For the trendline support and resistance strategy, the

parameters were kept constant. Similarly, for the moving average crossover strategy, the parameters were

kept constant. This was not an ideal way to analyze the stocks, as the parameters in both strategies did not

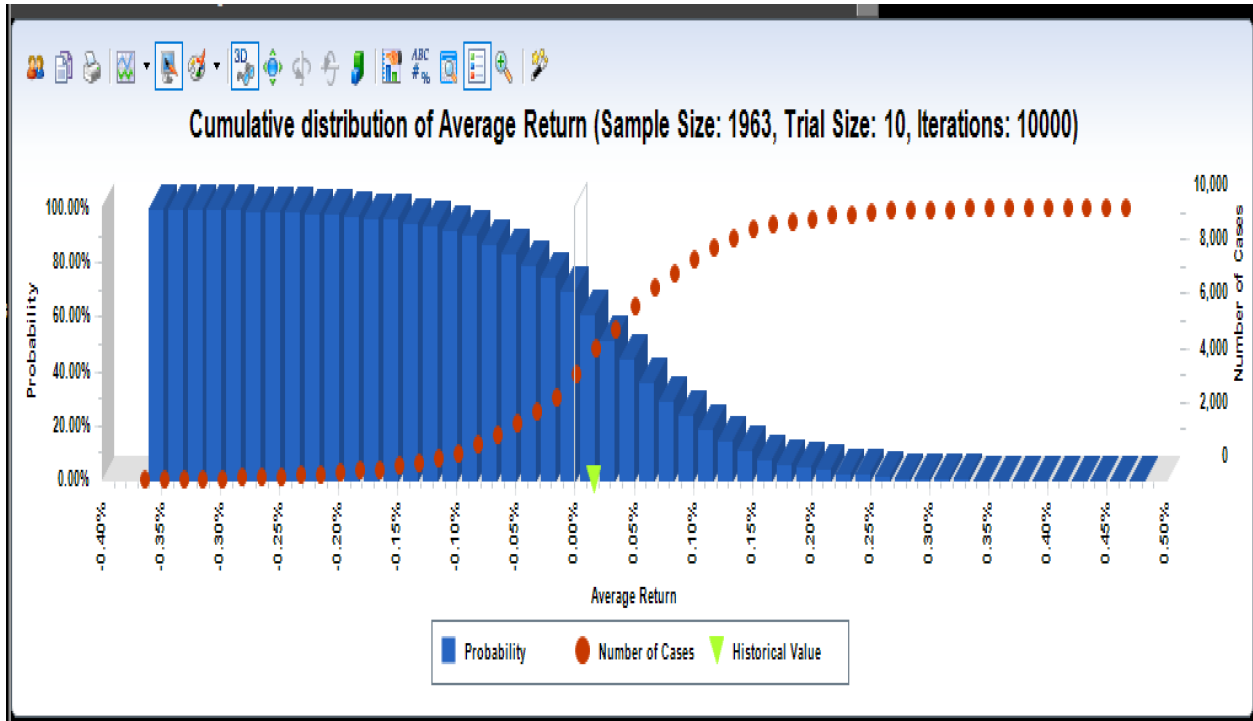allow for strong performance for every single stock.

Figure 10: Aggregate Monte Carlo chart showing the probability of average return per trade. In this analysis, money allocation and optimization of individual strategies were not conducted. For the first system of systems, this analysis was conducted for both strategies, similarly to the total equity curve. Not only were the strategies not optimized for each stock, but also the Monte Carlo analysis included every stock in its evaluation regardless of its performance. The Monte Carlo analysis indicated that the system was unlikely to have a positive average return per trade, as indicated in the above figure. However, the historical value was slighlt positive, at an average of 0.015% return per trade. This number can be optimized through disregarding the underperforming stocks, which had negative system qualities. The average return per trade would likely improve if both strategies were optimized for each stock, rather than using the same parameters for each stock.

Total Return	$35,994.00
Total Realized Return	$44,232.00
Gross Profit	$62,252.00
Gross Loss	($18,020.00)
Open Trade P/L	($8,238.00)
Number of Trades	342
Number of Winning Trades	253
Number of Losing Trades	88
% Profitable	73.977%
Average Trade	$129.33
Average Trade (%)	1.714%
Standard Deviation	$357.87
Standard Deviation Trade %	4.110%
Largest Winning Trade	$2,125.00
Largest Losing Trade	($2,361.00)
Profit Factor	3.45
Average Win/Average Loss	1.20

Sharpe Ratio	0.1742
K-Ratio	0.4675
Return Retracement Ratio	5.4786
Compounded Annual Return	4.022%
Compounded Monthly Return	0.325%
Average Annual Return	$4,499.25
Average Annual Return (%)	3.930%
Average Monthly Return	$382.91
Average Monthly Return (%)	0.332%
Percent Days Profitable	50.866%
Percent Months Profitable	70.213%
Percent Years Profitable	100.000%

Figure 11 and 12: Total equity chart data summary

In the above figure, the total statistical analysis of the system of systems is shown. The average winning trade of $129.33 is very favorable, as it shows that the system of systems successfully creates profitable trades. In addition, 73.99% of trades were profitable, indicating that the system was constantly creating winning trades. This shows that the stock selection process, in tandem with the system of systems, was profitable in the trading platform.

However, the largest losing trade was rather significant, as it was larger in dollar value than the largest winning trade. This shows me that the system requires more risk management. This can be done through stop orders, which automatically sell the shares when it drops below a certain dollar amount. This would

would in contrast to the current signal for selling a stock, which is written in the Easylanguage code on Tradestation. The system can also lower its risk by not trading the stocks with negative system qualities, and optimizing the strategy parameters for each individual stock.

Statistics	Total Return	Average Return	Maximum Drawdown	Longest Period Between Peaks
Historical Value	39.23%	0.08%	7.64%	32
Sample Size	406	406	406	406
Trial Size	10	10	10	10
# Iterations	5000	5000	5000	5000
Mean	0.75%	0.07%	1.14%	5.61
Median	0.83%	0.08%	0.73%	5
Standard Deviation	2.17%	0.22%	1.33%	2.49
Maximum	7.77%	0.76%	11.01%	10
Minimum	-11.01%	-1.15%	0.00%	1
1st Percentile	-5.44%	-0.55%	0.03%	2
5th Percentile	-2.88%	-0.29%	0.10%	2
10th Percentile	-1.62%	-0.16%	0.16%	3
15th Percentile	-0.89%	-0.08%	0.22%	3
20th Percentile	-0.57%	-0.06%	0.31%	3
25th Percentile	-0.26%	-0.02%	0.38%	4
30th Percentile	0.03%	0.00%	0.45%	4
40th Percentile	0.37%	0.04%	0.59%	4

50th Percentile	0.83%	0.08%	0.73%	5
60th Percentile	1.16%	0.12%	0.93%	6
70th Percentile	1.66%	0.17%	1.15%	7
75th Percentile	1.90%	0.19%	1.40%	7
80th Percentile	2.22%	0.22%	1.55%	8
85th Percentile	2.66%	0.27%	1.93%	9
90th Percentile	3.12%	0.31%	2.66%	10
95th Percentile	3.91%	0.39%	3.84%	10
99th Percentile	6.23%	0.62%	5.65%	10

Figure 13 and 14: Total Monte Carlo analysis statistics

The above figure demonstrates the Monte Carlo statistics of the system of systems. I do not believe the system of systems was properly analyzed by the Monte Carlo analysis on Portfolio Maestro. Because the Monte Carlo analysis for the total percentage returned was so high compared to the predicted percentiles,

it shows that the selection of stocks I used was very effective when used in tandem with the algorithms. However, the statistics on average return and maximum drawdown were within the normal distribution. These numbers were the historical values, and I believe these would be higher if the system ignored underperforming stocks, and optimized the strategy for each stock.

8.3 Microsoft Excel System of Systems

In the second system of systems, all ten stocks were optimized for each strategy, and the list of trades were exported to a Microsoft excel spreadsheet. Here, the system qualities, expectancy, and expectunity were calculated. Then, the stocks that had a positive system quality in a strategy were chosen. Those with negative system qualities, as shown in Figure 8, were not selected and these are highlighted in red in the figure. Next, the selected stocks, that had positive system qualities in a strategy, were used to create a total equity curve. This was done in two ways, as shown in Figures 15 and 16.

The first curve demonstrates the aggregate equity curve of the second system of systems, with the weighted fraction allocation. The fraction allocated was calculated by dividing the stock's system quality by the sum of all of the positive system qualities. This was done by listing all of the trades in an excel spreadsheet, multiplying the profit or loss for each trade by its stocks fraction allocation, then organizing all of the trades by date. This resulted in an aggregate equity curve over time.

The second chart, shown in Figure 16, was done very similarly. However, each stock was not given its fraction allocation. This was done to compared the equity curve to the one done on Portfolio Maestro, shown in Figure 9, since the Portfolio Maestro software did not account for optimzing each stock for each strategy, while my analysis on Excel did.
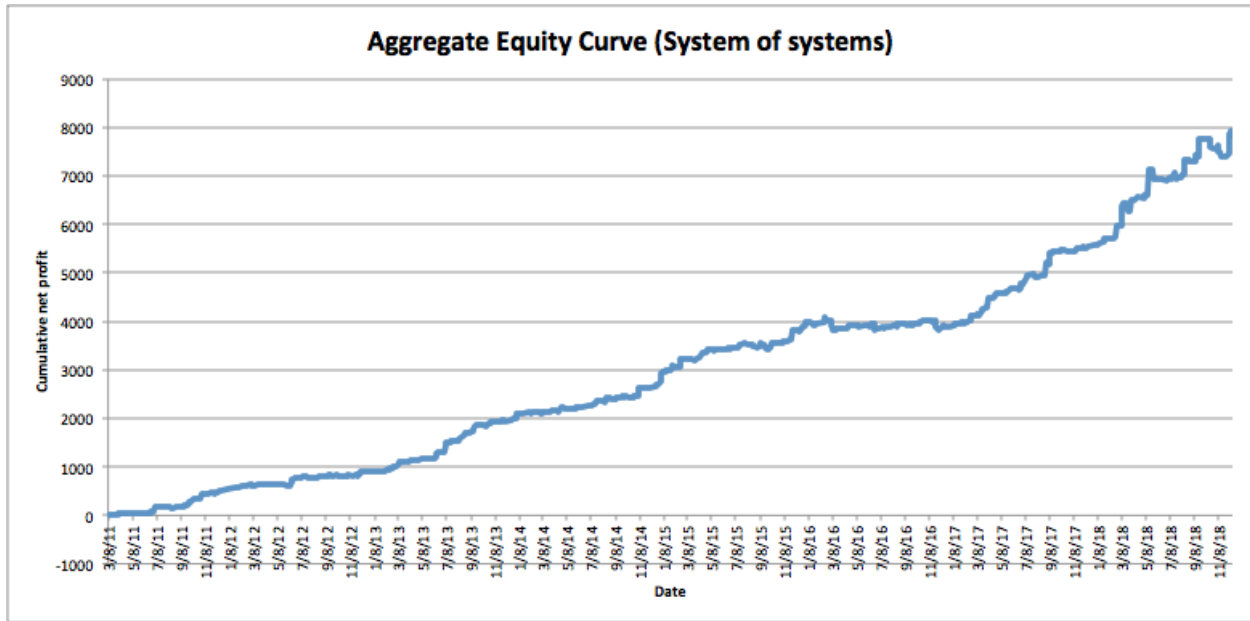
Figure 15: Aggregate equity chart of the system of systems, with weighted allocations.

For the optimized strategies with the use of weighted money allocation, the return was $7986 over the same timespan. From the system qualities of all the stocks, which indicates the overall return and risk of a system, the money was allocated to each stock. Stronger performing stocks, with higher system qualities, were given larger fractions. Ultimately, profits were less on this analysis, since the fraction allocations decreased the total trades conducted. As seen by comparing the Portfolio Maestro equity curve to the above graph, it is shown that this curve has less extreme drops in cumulative return, with larger rises in equity.
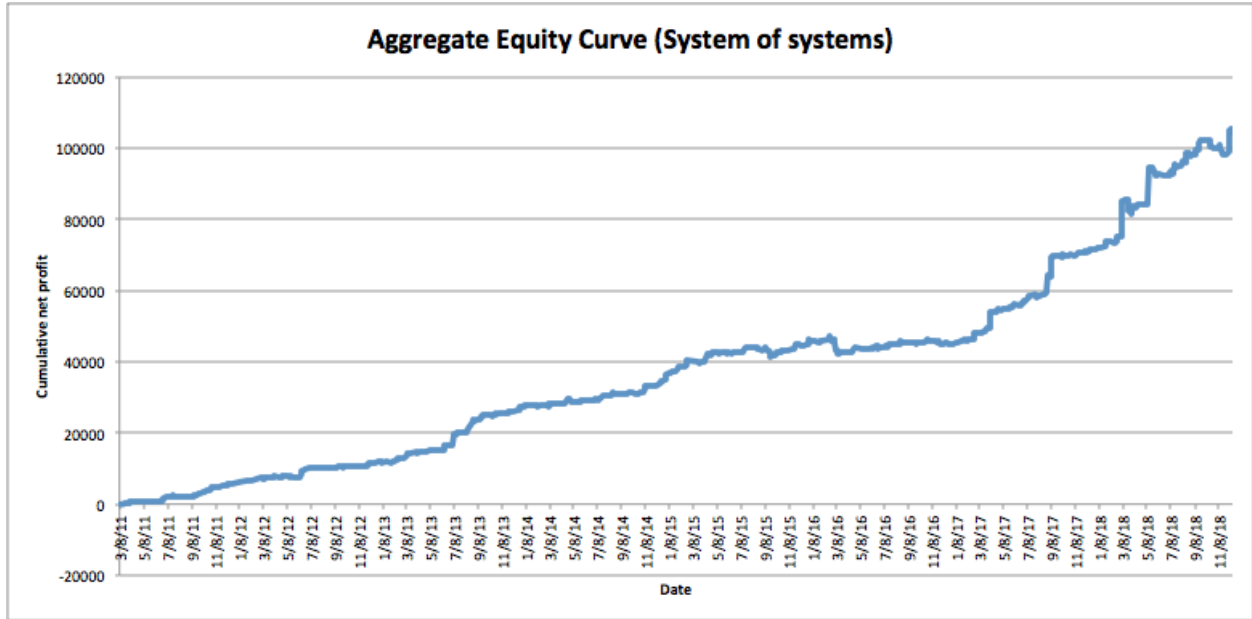
Figure 16: Aggregate equity chart of the system of systems, without weighted allocations.

Through my own analysis, and without weighted money allocation, the individually optimized strategies

created a profit of $105,219. Similarly to the equity curve of, this equity curve was created on excel with

optimized parameters for each individiual system. This can be compared to the Portfolio Maestro graph,

which also did not weight the allocation of money, but did not optimize each individual strategy. This

strategy had a higher net profit than the equity curve in the Portfolio Maestro, while also seeing less

extreme drops in cumulative return.

Chapter 9: Summary and conclusions

The overall system of systems was profitable, and I believe it can make money in its current state. For this system to make money, it would require money that can be used for trading. Such money can be used to trade on platforms such as Robinhood, where there are no commission costs. Additionally, commission costs can be diverted through trading with a stock broker that is willing to conduct trades for free.

The system of systems was useful in reducing risk, and optimizing the profits through position sizing and diversification. By diversifying the stocks used, the entire system was less volatile, as underperforming stock were accompanied by other stocks which performed well. Further risk management such as stop orders may help reduce the amount of negative return trades. In addition, more stocks can be researched, and backtests can be conducted on non-CANSLIM stocks in addition to stocks with diminisihing prices to determine if the strategy can work under those scenarios as well. Also, a wider range of parameters can be tested, to allow for large time frames in the moving average crossover strategy. The advantage of this will be lower risk, as larger time frames are usually less risky.

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