Trading & Investing System Development: Adapting the 10 O'Clock Bulls and Turtle Trading Strategies for Automated Development

AN INTERACTIVE QUALIFYING PROJECT REPORT SUBMITTED TO THE FACULTY OF
WORCESTER POLYTECHNIC INSTITUE *IN PARTIAL FUFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF BACHELOR OF SCIENCE*

AUTHORED BY:
CARLOS J. BARCELOS
JUSTIN A. MYERSON

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MICHAEL J. RADZICKI, PH.D.

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1. Introduction

The purpose of this Interactive Qualifying Project is to understand the financial market and learn the techniques to build a personalized trading system. Increasingly, it is becoming necessary for individuals to take a certain amount of control of their financial futures. It is important that these individuals are knowledgeable and are able to do so with a scientific approach that will yield the desired results while minimizing risk. Attempting to invest money into the market without having a working knowledge of all of the elements of the financial world is dangerous, especially with marketing campaigns claiming "it's so easy a baby can do it." This Interactive Qualifying Project will outline the specifics of two trading systems to give the reader a working knowledge of some of the important parts of the investment world.

In the area of trading system development, there are many theories and practices of building and deploying complete trading systems. Many of these systems can be purchased through brokerages, but this method does not come with the personalization required to fit the objective of the user of the trading system. This Interactive Qualifying Project recognizes the work that has already been made in the field of personalized trading systems and uses two famous examples of trading strategies, the 10 O'Clock Bulls and the Turtle Trading strategies, as the groundwork for two new trading systems. The research completed before adapting each strategy to an automated environment includes literature such as *Trading as a Business*, rules of successfully automating trading strategies, and explanatory material on both the 10 O'Clock Bulls and Turtle Trading strategies as they were originally developed.

This Interactive Qualifying Projects takes the work done in the past and adapts it to fit the personalities of the two authors. At large, this includes the matter of converting a conventional for an automated trading environment. More specifically, Justin took the 10 O'Clock Bulls system and adapted it to an automated strategy while reworking the specifics involving entry and exit rules and support and resistance levels. Carlos adapted the Turtle Trading System, which conventionally trades commodities, to trade stocks. Finally, each author refined the trading rules to more appropriately match their personalities as a result of what they learned about the psychology of trading. The details of the changes made to both systems will be explored in Sections 6 and 7 respectively.

At the end of the project, both Justin and Carlos's systems experienced troubles. Justin's 10 O'Clock Bulls system was determined to have a negative expectancy and therefore should not be traded in the financial market in its current state. Carlos's Turtle Trading system yielded a positive expectancy but had a return on investment so low that it would not be able to "beat the market" and should not be used in the financial market in its current state. When combined as a system of systems, the 10 O'Clock Bulls and the Turtle Trading systems did cooperate to create more realistic trading scenario but were not so compatible as to make the system of systems profitable enough to trade full time.

2. Trading and Investing

As individuals become increasingly involved in managing their money, many of them choose to make their own investments in the market. An ordinary citizen taking part in the market is called “retail” trading and investing.

Trading vs. Investing

There are generally considered to be two styles of taking part in the market: trading and investing. These two different techniques used reflect the differences in mindset behind the two styles. Traders are those who tend to buy and sell assets frequently, often holding assets for no longer than a few days or weeks. On the other hand, investors are those who buy assets and then hold onto them for extended periods of time, often over 10 or 20 years. Traders generally are attempting to “beat the market” and build wealth quicker than long-term investors. Profits are generated by buying for low prices and selling at higher prices over a shorter period of time. Traders also tend to apply technical tools such as moving averages, stochastic bands, and more. Investors seek to build wealth by taking a position in a basket or “portfolio” of stocks, mutual funds, or other forms of assets. Wealth grows gradually by reinvesting, or compounding, profits or dividends earned back into the assets. (Difference Between Trading and Investing, 2017)

Beating the Market

As mentioned previously, traders attempt to “beat the market,” meaning they seek to outperform index funds that mimic the movement of the overall market, such as the Vanguard index fund. This requires traders to consistently outperform index funds by a margin wide enough to cover their costs and still return a greater yield than that of the index fund. For this reason, beating the market with trading is very difficult and comes with a lot of risk. Long-term investors will instead look to “ride the market” and assume that over long periods of time, index funds will return stable yields. They believe that one cannot systematically beat the market, meaning that the added risk of trading is not worthwhile. Traders who are indeed able to consistently beat the market will tend to achieve higher yields than long-term investors, but will assume more risk while doing so. Therefore, long-term investing is usually the go-to choice for those looking to grow their retirement funds or other important capital.

Asset Classes

There are four asset classes that are commonly traded on the market, each with their own characteristics: equities, bonds, currencies, and commodities.

Equities, or stocks, are individual shares in public companies that are traded over some type of exchange.

Bonds are a debt security whereby borrowers give money to a government for a specified period of the time with the assurance that when the bond expires, the government will return the money borrowed with added interest.

Currencies are cash equivalents that can be converted from one type to another by using an established conversion rate.

Commodities are raw materials, such as sugar or copper, that can be bought or sold by investors. These raw materials are exchanged using contracts that have a specified expiration date. When the contract expires, the owner of the contract will receive the specified quantity of the raw material for the value indicated on the contract.

The reason these are the 4 most commonly traded asset classes is because they all offer sufficient liquidity for high-volume trading, are regulated by the government, and allow for financial institutions to facilitate convenient exchanges while keeping a percentage of the traded value. For this Interactive Qualifying Project, both systems used equities traded on the New York Stock Exchange and NASDAQ Exchange.

Stock Exchanges and the Market

Equities are traded over a stock exchange, the largest and most famous of which is the New York Stock Exchange (NYSE). The NASDAQ is the second biggest exchange that is made up of mostly large technology stocks. Exchanges allow traders all over the world to buy and sell shares of thousands of stocks almost instantly. The exchange is regulated by federal law to ensure that safe trading practices are maintained and that no traders gain an unfair advantage.

There are several indices that are commonly used to get an overall read of the stock market: the Dow Jones Industrial Average (DJIA), the NASDAQ 100 (NAS) and the S&P 500 (S&P). The DJIA was created by *Wall Street Journal* editor Charles Dow in 1885 and represents 30 large companies being traded. Stocks in this index include companies like Apple, American Express, Coca-Cola, IBM, and Microsoft. The NAS is an index generally used for U.S. technology stocks and includes 100 companies like Amazon, Apple, Cisco, and NVIDIA. The S&P is an index of 500 stocks with large market caps that is seen as a reflection of the overall performance of U.S. equities. Together, these 3 indices are used to get a general idea of the direction of the market as a whole.

3. Trading Systems

A trading system is the culmination of objectives, clear rules, risk management and system management working together to have a positive expectancy when trading in the financial market. A trading system may not win every trade, but on net it should generate profits over time. A very successful trading system may also have a high winning percentage, high annual return, low drawdown, and robustness across different market conditions. While robustness is a key quality with a clear definition, “low” and “high” mean different things to different traders and are relative to the strategy by which the trader is crafting the system. The bottom line is that the system must yield a positive expectancy to be marked as a successful trading system.

Trading Platforms

It is not feasible for the average investor to gain a seat directly on the New York Stock exchange. Such a feat takes time, capital, and contacts that the everyday retail trader does not have. Calling a broker is still a possibility, but there is a better solution for an investor looking to trade on their own time and dollar: trading platforms. Trading platforms are software solutions that allow traders to open, close and manage market positions. Most platforms offer analysis techniques alongside those abilities, giving the trader the opportunity to chart the markets and perform other analysis techniques to gain a deeper insight into the market.

Trading platforms are the interface to trading the markets, but they must plug into some brokerage account. Brokerage accounts allow investors to communicate with a licensed brokerage firm (TD Ameritrade, Fidelity Investments, USAA Brokerage, etc.) where the investor may give the firm capital to invest (Brokerage Account, 2017). The firm places the orders set by the investor while transferring any gains to the investor. Brokerage firms are a business like any other and make money by charging commission fees. Commission fees will vary from firm to firm but generally a commission fee will be taken both when creating a position in the market and closing that position.

There is a choice in brokerage styles depending on the investor: full service or discount brokerage accounts. Full service brokerage accounts are the traditional brokerage account. They provide financial advice based on research that is often used for retirement planning. As compensation for these services, full service brokerage accounts charge annual fees on the total account balance, but no commissions on buying or selling within the market.

Alternatively, there are discount brokerage accounts. These brokerage accounts do not provide the premium services of the full-service brokerage, but they also do not charge a premium price. Discount brokerage accounts are a product of the information age and the do-it-yourself mentality of at-home computing. Due to the advances of the Internet, anyone can take part in the stock market, and the discount brokerage account takes advantage of this. They charge a smaller fee in the form of a commission on every buy or sell within the market.

TradeStation

The trading platform and brokerage firm used for this Interactive Qualifying Project report is TradeStation. TradeStation is an example of a discount brokerage account, but it has unique features that many discount brokerages do not have. The most important features of TradeStation for the purposes of this report are the system automation and the capability to back-test a strategy. These features of TradeStation will be described in more detail in the following sections.

Trading Logistics

The logistics behind trading can be personalized to the trader in many areas. This is beneficial in two aspects. First, traders are awarded for their creativity in creating trading systems. Finding a creative edge or twist in a trading system will give a trader a competitive edge in a market that knows the old rules. Second, because trading systems are customizable, they not only can be built, but *should* be built, to fit the trader's personality. There are research and surveys which suggest that "the most important factor in [a trader's] success [is] that they each had a trading system that [is] right for them." (Tharp, 1999, p. 1) With that in mind, the following subsections will describe the logistical items of a trading system.

Strategies

The most important part of the trading system is the strategy that it is modeling. The most basic trading strategy is to follow historical indicators such as supports and resistances in the market to determine future market order. Support refers to the price level below which the stock price rarely falls. Resistance refers to the price level above which the stock price rarely rises. Support and resistance offer a crude, historical view of the market and can be used as floors and ceilings of trades.

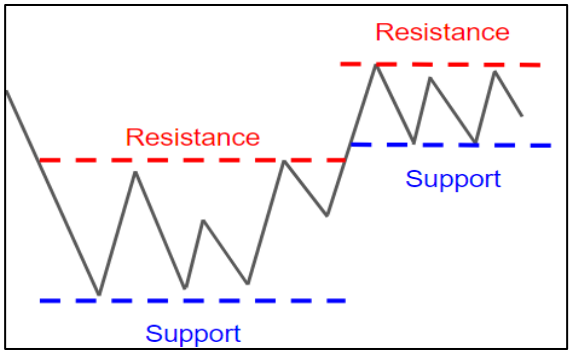

Figure 1: Support and resistance

Trend-following strategies use the idea of supports and resistances in order to take advantage of breakouts and breakdowns. Breakouts occur when the price of a stock rises above the historical resistance level of a certain stock. The price will then continue to "run" until a new resistance level is reached. Conversely, breakdowns occur because of the price falling below the support level.

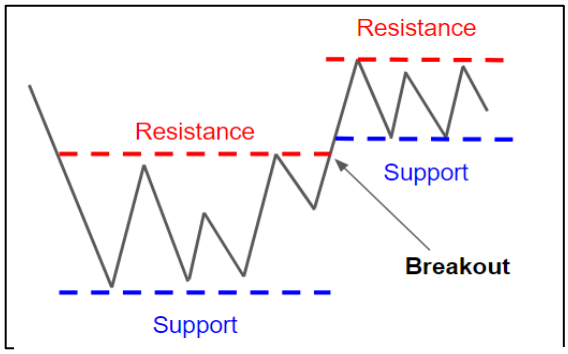

Figure 2: Support and resistance breakout

Trend-following strategies stand true to the adage, "Let your profits run, cut your losses short." They take advantage of the fact that "if there is not a trend after you buy, then you will not be able to sell at higher prices." (Tharp, 1999, p. 83) An important feature of trend-following strategies is that they must take all positive trading signals available in order to be successful. The move that a trend-following system misses is the big move. An example of a trend-following strategy is the Turtle Trading strategy.

Trend-following strategies generally search for breakouts and breakdowns. When one is found, it will be exploited until it is time to get out, at which time the trader will be out of the market and said to have a *flat position*. There are opposing schools of thought that are encompassed in the "Stop and Reverse" strategy. The main idea of the Stop and Reverse Strategy is that the trader is always in the market with some position. The trader knows when it is time to go long when it is no longer time to go short, and vice versa. The key feature of the Stop and Reverse Strategy is that the trader's market position is never flat.

There are many more examples of trading strategies, such as Volatility Expansion Strategies, Gap Strategies, and Rocket Strategies. The limitations on new strategies are the limitations on creativity. In modern times, traders have even leveraged neural networks, a computer system modeled on the human nervous system, to find new and unexplored rules. Neural networks are used to find the most optimal moves to make in the financial market while even going so far as to predict the prices of stocks (Kordos & Cwiok, 2011).

Time Frames

Along with unique strategies to trade, there are also unique time frames on which to trade the financial market. The smallest trading scale is referred to as "scalping". Scalpers trade many times every second using specialized computers and network connections directly wired to the stock exchange to profit off of the minute price fluctuations in stocks. Scalping is not feasible for retail traders due to the latency in filling orders and the high cost of commissions that come from executing so many trades made per second.

Beyond scalping, trading time frames are broken down into inter- and intra- day. Inter-day trading can be as short as holding a position for five minute increments all the way up to full-day holds. Inter-day traders ensure that all their investments are liquidated by the closing bell of the stock market. This is beneficial not only for traders who would be kept up at night with the thought of trades still being made, but also protects traders from any violent overnight swings. World events can swing the overnight market and lead to surprises at the opening bell; inter-day trading can help avoid that surprise.

Intra-day trading includes trading based on daily, weekly or even longer-period closing reports. Trading on a longer time frame reduces the risks of any one day negatively affecting the whole trade, but it also means tying up financial assets during potentially rough waters. However, because of the infrequency of trades, it also means that there are fewer commission costs associated with final earnings.

When considering the time frame on which to trade, it is important to consider how the time frame will after both the trader psychologically and the trading strategy empirically.

Fundamental vs. Technical

There are two major trading analyses to consider: fundamental and technical. Fundamental analysis consists of viewing the economic, social, and political forces affecting a market and considering how those forces affect the supply and demand of an asset. Technical analysis looks at the historical price movements of an asset in order to predict how similar changes will affect the current market conditions (Technical Analysis, 2017). Technical analysis takes the position that history will repeat itself, while fundamental analysis leans more towards the idea that the financial market has so many moving parts that it is impossible to model it accurately enough to trade with only a historical viewpoint.

When it comes to altering a trading system based on the results of either analysis technique, it is important to never make changes while the system is activated. The rules of a trading system should not be changed during trading sessions. "The only thing you should be doing during market hours is concentrating on effectively executing your strategy." (Wright, 1998) It is important to analyze the market and make changes to a broken system accordingly, but it is equally important to stick to the rules of the system in order to ensure its proper operation.

Manual vs. Automatic

Traditionally, an individual would trade the financial market by physically calling their broker on the stock exchange and placing their position over the phone. In recent times, that communication has been

automated so that the individual can now place orders on the Internet and have them filled electronically by an automated broker at the stock exchange. With this basic level of automation already in place, it is only natural that fully-automated trading came about.

As discussed previously, traders have set strategies they use to trade. These strategies are built for the trader, but still pose a psychological struggle; will the trader be able to follow their own rules? That is where automatic trading comes in. Instead of traders following their set rules and manually placing orders over the phone or over the Internet, they now have the ability to let the computer do the work for them. Trading systems are converted to lines of code that can be read by computers.

The benefits of automated trading start with the strict adherence of trading rules that are known to work. By overcoming the human fear of drawdowns, automated trading systems follow the without hesitation. Another benefit of automatic trading is consistency. "One of the biggest challenges in trading is to *plan the trade and trade the plan*." (Automated Trading Systems, 2017) Computers do not have this problem, and will always follow the code they are given. By leveraging trade data, it is also possible to conduct scientific analysis on the trading system, allowing traders to predict and make the most of the financial market.

TradeStation Automation

Many trading platforms offer only manual options, requiring a separate system to conduct automated trading. TradeStation acts as both a brokerage and an automated trading environment. By using TradeStation, it was possible to turn trading strategies into algorithms and then automate those strategies all within the same platform by using a proprietary programming language called EasyLanguage. EasyLanguage follows many of the conventions of historical programming languages while introducing unique functions for collecting and using historical stock data.

Using TradeStation to automate trading allowed the authors to perform detailed backtesting on their systems. It allowed them to use historical data in order to analyze their systems' performance and draw conclusions about their trading strategies. Using historical data is important to verify that a trading strategy is robust enough to use on live data. The goal of backtesting is to make sure that the algorithms which make up the automated trading strategy are profitable and behave successfully over a variety of market conditions.

Trading Metrics

There are many metrics on which to evaluate a trading system. Often times, these metrics will overlap with a trader's personalized objectives. Simply speaking, a trader may be more interested in a high winning percentage than a low drawdown, or vice versa. Different trading systems will cater to different trading metrics. Example trading metrics include, but are not limited to, high winning percentage, high annual return, low draw-down, robustness across market types, low time commitment, tolerance for a small account size, and a profit factor greater than some number.

TradeStation offers a built-in "Strategy Performance Report" calculated for every backtested trading strategy. This performance report offers an overview of the trades made as a financial summary. Trading with a scientific mindset it is important to collect this technical data and make adjustments to a misbehaving trading system accordingly.

TradeStation Performance Summary			Collapse
	All Trades	Long Trades	Short Trades
Total Net Profit	$88.44	$88.44	$0.00
Gross Profit	$88.44	$88.44	$0.00
Gross Loss	$0.00	$0.00	$0.00
Profit Factor	n/a	n/a	n/a
Roll Over Credit	$0.00	$0.00	$0.00
Open Position P/L	$0.00	$0.00	$0.00
Select Total Net Profit	$88.44	$88.44	$0.00
Select Gross Profit	$88.44	$88.44	$0.00
Select Gross Loss	$0.00	$0.00	$0.00
Select Profit Factor	n/a	n/a	n/a
Adjusted Total Net Profit	$25.90	$25.90	$0.00
Adjusted Gross Profit	$25.90	$25.90	$0.00
Adjusted Gross Loss	$0.00	$0.00	$0.00
Adjusted Profit Factor	n/a	n/a	n/a
Total Number of Trades	2	2	0
Percent Profitable	100.00%	100.00%	0.00%
Winning Trades	2	2	0
Losing Trades	0	0	0
Even Trades	0	0	0
Avg. Trade Net Profit	$44.22	$44.22	$0.00
Avg. Winning Trade	$44.22	$44.22	$0.00
Avg. Losing Trade	$0.00	$0.00	$0.00
Ratio Avg. Win:Avg. Loss	n/a	n/a	n/a

Figure 3: TradeStation Performance Summary

TradeStation Trade Analysis			Collapse
	All Trades	Winners	Losers
Total Number of Trades	2	2	0
Avg. Trade Net Profit	$44.22	$44.22	$0.00
1 Std. Deviation of Avg. Trade	$52.71	$52.71	$0.00
Avg. Trade + 1 Std. Deviation	$96.93	$96.93	$0.00
Avg. Trade - 1 Std. Deviation	($8.49)	($8.49)	$0.00
Coefficient of Variation	119.19%	119.19%	n/a
Time Averages			
Avg. Time in Trades	1644 days, 12 hours	1644 days, 12 hours	n/a
Avg. Time Between Trades	n/a	7 days	n/a
Avg. Time Between Trade Profit Peaks	n/a		
Outliers	**Total**	**Positive**	**Negative**
Number of Outliers	0	0	0
Outlier Profit/Loss	$0.00	$0.00	$0.00
Run-up/Drawdown		**Run-up**	**Drawdown**
Max. Value		$102.05	($13.12)
Max. Value Date		2/10/2017	11/21/2008
Avg. Value		$54.50	($6.67)
1 Std. Deviation		$67.25	$9.13
Avg. + 1 Std. Deviation		$121.75	$2.46
Avg. - 1 Std. Deviation		($12.75)	($15.79)
Coefficient of Variation		123.39%	136.97%
Efficiency Analysis	**Total**	**Entry**	**Exit**
Avg. Efficiency	83.91%	92.84%	91.07%

Figure 4: TradeStation Trade Analysis

Finally, it is necessary to evaluate the *expectancy* of the trading system. Expectancy refers to the profit or loss per dollar risked per trade. An expectancy value of 1 describes a system which breaks even over the course of its trades; a value less than 1 means the system is risking more than it is earning; a value greater than 1 means the system is earning more than it is risking.

Not only does the trading system have to be profitable, but it has to be more profitable than alternative index funds. If the investments poured into a personalized trading system are doing no better than investments into an index fund, then there is little reason to spend the time, energy, and capital running that trading system. The most important metric for a trading system is to generate what is referred to as "alpha", "the excess returns of a fund relative to the return of a benchmark index" (Alpha, 2017).

Personalized Objectives

When considering the many ways to measure a trading system, it is important for the trader to take their own bias into consideration. Trading is personal. Each trading system must be tailored to an individual and their personal objectives. A trader should not carry out a long-term trading system if it means they lie awake at night worried about the positions they have in the market. It is important to have a tailored system because trading is psychological in nature, and a trader's perception about the market can affect their decisions or cloud what is really happening in the market. Gaining an understanding of the financial market and trading systems is the first step to benefiting from the financial freedom of automated trading.

The Benefits of Automated Trading

One benefit of using automated trading is that human bias can be completely removed. By utilizing algorithms, backtesting, and all other modern tools, it is possible to create a sound trading system which was scientifically tested to produce positive returns. As long as the trader does not interrupt the trading system while it is trading, the system will operate with the rules without the human emotion that may cause a trader to sell too early or let losses drop too far.

Even experienced traders can fall prey to their emotions. As one experienced, Vic West trader states, "I began trading what I THOUGHT the market was going to do for the rest of the day, not what the market was DOING." As a result of this call to action based on perception, the Vic experienced a loss of $700

instead of a gain of $1000. Algorithmic trading prevents situations like this. Utilizing algorithms and automation, traders can avoid the temptation of their own hubris.

Fundamental Law of Trading Systems

Due to the risk involved in trading, there is a fundamental law of trading systems which describes the relationship between the profits earned (P) by a trading system and the system's profit factor relative to the average win/loss ratio of the system:

This inverse relationship states that as the profit factor rises, the average trade ratio required to maintain a positive percentage falls. Alternatively, as the average trade ratio falls, the average trade ratio required to maintain a positive percentage rises. The result of the law of trading systems is that traders can design systems that fit their personal needs. Trading is a largely psychological practice, and if the trader needs to avoid big losses they may, so long as they are willing to accept the profit factor and average trade ratio associated with the desired winning percentage. It is a matter of how each individual trader tunes their own system to output a desired result from the equation.

$$P = \frac{1}{1 + (\frac{W_{AVE}}{L_{AVE}})/P_f}$$

Equation 1: The fundamental law of trading systems

Where P is the required winning percentage, $P_f = \frac{\Sigma Winning\ Trades}{\Sigma Losing\ Trades}$, *$W_{AVE}$ is the average profit of the winning trades and L_{AVE} is the average loss of the losing trades*

Trading Systems

Trading systems are built around a particular trading strategy and have key components to get the investor in and out of the market. To "be truly complete, a mechanical system must explicitly provide the following information: When and how . . . to enter the market . . . to exit the market with a loss . . and to exit the market with a profit" (Katz & McCormick, 2000, p. xvi). The key word in this definition is "mechanical". Trading systems should be mechanical in the sense that they follow a particular set of rules closely and without failure. There are times to adjust the rules, but those times are never when the trading system is running. Like a well-oiled machine, the trading system should operate uninterrupted while it is running and be tuned up, if necessary, based on clear feedback from the market *after* it is turned off. The following sections describe the most important parts of a complete trading system in detail.

Position Sizing

Position sizing refers to the dollar value of the position being taken, and can be determined dynamically according to an investor's account size and risk tolerance. Position sizing is also a way to reinvest profits in order to compound returns. By growing positions with the money earned from previous winning trades, future winning trades may return even higher profits.

It is important to consider position sizing carefully to both avoid unnecessary losses and to compound profits. Not utilizing position sizing correctly or position sizing ad hoc is an easy way to make a careless miscalculation and turn a scientific trading system into a guessing game. A Martingale position sizing technique leads traders to increase their position size after a loss and decrease it after a win. This is a common technique that gamblers use in a casino. The method assumes that there is a dependency between trades, which is simply untrue, and leads Martingale position sizing techniques to be

unsuccessful. Instead, it is advantageous to utilize Anti-Martingale position sizing techniques, such as fixed fractional or fixed ratio position sizing.

Entry

In its most basic form, an entry is "the signal by which the strategy purchases the contract in the market." (Wright, 1998, p. 2) Entries are what tell the trading system that it is the right time to place a position in the market. They may also be the confirmation of what is called a "set-up". Set-ups tell the system that there might be something worth watching, while the entry tells the system to take action on that set-up.

Different entries are appropriate depending on the style of the trading system. For example, the Turtle Trading strategy uses a breakout entry condition to confirm that the current trend is not a false positive. While there are many different entries to consider, it is important that all entries confirm the direction of the setup and guarantee that a strategy will capture every price move for which it is designed. Set-ups and entries work in unison to buy or sell into the market in the most lucrative way possible.

Order Types

There are a few different ways to actually execute getting into the market, namely Stop orders and Market orders. Stop orders are triggered when the price of a stock hits the stop price. This price is set by the trader when the order is placed. The benefit of using a stop order is that it confirms the market is moving in a favorable direction at the time of entry. Using a stop order, often referred to as "stopping into the market", is a natural filter to any entry model and can be used to confirm a position. Stop orders should not be used on exits; waiting to stop out of the market can cause significant losses if the stock does not behave as expected.

Market orders, on the other hand, are a "simple order to buy or sell at the prevailing market price" (Katz & McCormick, 2000, p. 72). While stop orders wait for the price to reach some predetermined amount, the market order places an order as soon as it can at the price the stock is currently trading at. While market orders do not offer the same price movement confirmation as stop orders, they provide a quick execution of a trade. The benefit of an instant order is guaranteed execution, especially in the case that the trader wants to get out of the market to prevent further losses. Market orders are not a strong entry, they are "the obvious and easiest way to put on a trade" (Wright, 1998, p. 3). When using market orders it is important to use other filters, set-ups and triggers to confirm the direction of the trade.

Market and stop orders are not exclusive to entries; they can also be used in a similar manner with exit orders. When considering order types, it is important to remember to use stop orders to get into the market and market orders to get out of the market. When taking a position in the market, the trader has the luxury of waiting for the perfect conditions, but when money is on the line, it is too risky to wait for an exact price.

Set-ups and Triggers

It is important to make sure the conditions are right for an entry before taking a position in the market. The set-up should "indicate the directions . . . [and] define the type of market activity" the trader is going to trade (Wright, 1998, p. 4). It is the first step indicating that there is something to watch out for in the current activity of the market. Set-ups can come in the form of data (volume, open interest, price, etc.) or fundamental factors (time, intra-market standings, etc.).

One example of a technical set-up is the cross-over filter. The cross-over filter takes into consideration the history of a stock in order to predict the future direction of the stock. There are two parts to the cross-over filter, the fast exponential moving average (fast-average) and the slow exponential moving

average (slow-average). The moving average tracks trends by smoothing a stock's price fluctuations into an average over a certain time period; the term "exponential" refers to the fact that the oldest price average weight will continuously shrink as more and more averages are calculated. The fast-average is calculated on a shorter time frame than the slow-average. Each average follows a trend when plotted onto a graph. When plotted on the same graph, the two trend lines will sometimes "cross-over" each other, creating the cross-over filter.

Using Figure 5 as an example, the fast-average is shown in blue while the slow-average is shown in red. When the fast-average crosses-over the slow-average (point 1 on the figure), it is a good sign that the price of the stock could rise, making it a good opportunity to enter the market with a long position. Alternatively, when the slow-average crosses-over the fast-average (point 2 on the figure), it is a good sign that the price of the stock could fall, making it a good opportunity to enter the market with a short position or sell off any held shares. This simple technical analysis can be used as a set-up to an entry.

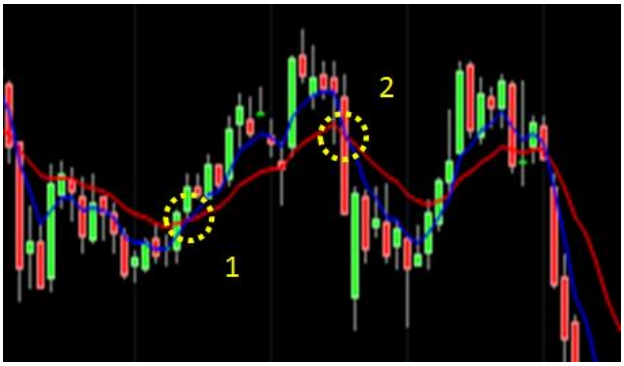

Figure 5: Cross-over filter

Triggers are then final step to purchasing a stock in the market. Triggers should confirm that prices are headed in the direction indicated by the set-up. Importantly, the trigger is only legitimate if and when the set-up conditions have been met. With reassurance between these two elements, there is a guarantee that the system will never miss an entry for which it is designed. However, it is also important not to make the trigger so strict that it is never activated. Doing so will create a trading system which is very accurate, but trades so infrequently that it is not worth its operational costs. The balance between set-ups and triggers is an important step to creating an effective entry.

Exit

Once the trader has entered into the market, it is important for there to be a plan as to how and when they will exit the market. An exit strategy is a plan to liquidate the trader's current position with the understanding that the purpose of the exit strategy is to limit losses. Exits should help the trader avoid large losses in an unprofitable scenario. In a profitable situation, exit strategies should also be used to see a trade to full maturity (Katz & McCormick, 2000, p. 282). It is important to let profits run and not exit the market too quickly. This can be accomplished by creating an exit strategy based on money management, trailing stops, or time frames.

Exits can be determined by a simple net loss equation. If a trade goes against the trader by some fixed amount the trader can exit the market immediately. This is known as a "money management stop." Money management stops get the trader out of the market at the maximum amount of money they are willing to risk on any one trade (Wright, 1998, p. 5). It is important to find a stop that "effectively controls losses without sacrificing too many of trades that provide profits." (Katz & McCormick, 2000, p. 284) As a result, money management stops should be a last-resort exit strategy.

While money management stops may work to prevent losses, it is also possible to lock in profits by using "trailing stops". A trailing stop "protects profits once the trade has moved into profitable territory." (Wright, 1998, p. 5) Trailing stops operate by trailing the highest market price achieved during the trade and placing a stop order at that price. This adaptive measure keeps moving with profits in order to lock

in some level of profits made on a stock. It is important to neither make the trailing stop too far away from the current price as to not lock in enough profit, nor too close to the current price as to take a position out of the market with slight price movements.

Finally, it is a legitimate strategy to exit to market based on how long a position has been held. A time frame exit is important when considering that "the reason for having entered the trade in the first place may no longer be relevant" (Katz & McCormick, 2000, p. 287). For example, when utilizing a day trading strategy, it is important to put a time based exit near the end of the day so that any positions held during the day are liquefied before the market close.

Stock Screening

Trading systems are only effective if they operate on well-chosen stocks. Because a system is built with unique entries, exits, and other rules, it is important that those rules are applied to a complimentary stock or group of stocks. A stock screener is a tool that traders can use to filter all the available stocks in a given market and choose only those that match the criteria desired. Stock screening can be done manually, by observing stock charts and data, or automatically using stock screening software, such as the stock screener built into TradeStation.

When using a trend-following system it is important to trade stocks that are trending. The trending strategy "assumes that the present direction of the stock will continue into the future." (Trend Trading, 2017) As such, before trading a trend-following system, it is important to screen for stocks which have, and are expected to hold, a strong trend. Alternatively, there are more technical ways to screen for stocks. In the 10 O'Clock Bulls strategy, for example, stocks are screened to select those stocks which have volatile market movement.

4. Optimizing and Analysizing Trading Systems

Avoiding Overfitting

A common problem experienced when working with optimization functions is overfitting. This occurs when the rules of a system are optimized on training data so finely that the system is being fitted to every little nook and cranny of the graph. This should be avoided, because fitting a system too closely to one data sample will result in a system that is only effective on that exact data set. Instead, one should attempt to fit the system to the "trend" and not the "noise" of the data. This means optimizing a system such that it will find patterns in training data without being so closely fit that it's rendered ineffective on non-training data.

Optimizing with a Portfolio

One of the best ways to avoid overfitting trading systems is to not only optimize on a large data set, but to optimize on many different stocks as well. This ensures that within the data set there is a large range of patterns that will prevent a system from being overfit to any one stock. Both systems in this IQP were optimized using all of the stocks in the portfolio.

Training Data and Testing Data

When optimizing a system, it is important to test the resulting system on a significant amount of data as well. Testing data should never overlap with training data, because testing a system on the same data it was just optimized on will not yield meaningful results. One way to do this, which was utilized with the Bulls system, is to test the system on data both before and after the date range of the training data. This gives a sense of how the system will perform in multiple points of time and will hopefully represent different states of the market. This is especially true since the market has been rising since 2009, so optimizations in this time period for long-term systems will be biased towards successful long trades. For day-trading systems like the Bulls, this is not as important since even in a strong bull market, there will be plenty of days where stocks fall in price as well.

Avoiding Algorithmic Bias with Walk-Forward Analysis

When testing algorithmic trading systems, a good method is to couple any backtesting with walk-forward analysis. The reason for doing a walk-forward of the system is to avoid any potential algorithmic bias. Because the optimal parameters for any input variables are determined by the backtesting of a trading system, it is important to ensure that the values chosen for backtesting work in the future. One method for confirming that the values are correct is through walk-forward analysis.

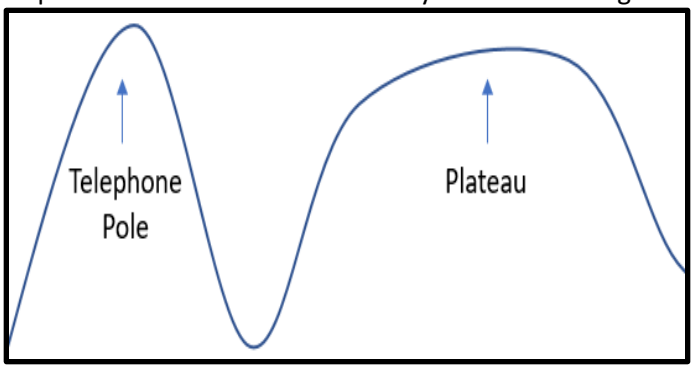

Figure 6: Explanation of algorithmic bias

As an example, Figure 3 visually explains the difference in strong and weak algorithmic bias. The first curve in the figure, the "telephone pole," represents the work of strong algorithmic bias. In this curve, the heuristic value has found an optimal setting and maximized itself. The problem is that there is only a narrow band to achieve that

optimal value.

The second curve in the figure, the "plateau," represents the work of a well-rounded algorithm. The maximum value achieved by the heuristic is not a high as that of the telephone pole, but there are more chances to achieve that value. The plateau represents a more versatile algorithm with which it is more likely to achieve positive performance.

System Quality

Overall system quality can be measured in a variety of ways. This IQP makes use of "expectancy," "opportunity," and "expectunity." Expectancy, the average profit or loss of the system, is defined as the total profit/loss divided by the total number of trades. Opportunity is how often a system will open a position in the market, generally denoted in trades per year. Expectunity, the expectancy-opportunity, is defined as expectancy multiplied by opportunity, and a system with an expectunity above 1.5 is generally considered to be profitable enough for real-world application.

$$Expectency = \frac{Total\ Profit/Loss}{Number\ of\ Trades}$$

Equation 2: Calculating expectancy

$$Expectunity = Expectancy * Opportunity$$

Equation 3: Calculating "expectunity"

$$System\ Quality = \frac{Expectency_{Avg.}}{\sigma(R_1\ Mults)} * \sqrt{Number\ of\ Trades}$$

Equation 4: Calculating system quality

Monte Carlo Analysis

Monte Carlos Analysis is a simulation that performs many trials in which the order of the trades in the data set is scrambled in random order. At the conclusion of these trials, probabilities are calculated (usually at 5%, 50%, and 95% confidence) about the profitability of a system. If done correctly, combined with other optimization and analysis techniques, this can give the designer of the system confidence that the system will more than likely perform somewhere within the 90% range of confidence determined by the simulations. It can also give the designer confidence that the system will, at worst, perform at the level determined by the 95% confidence threshold.

5. Literature Review

To understand each trading system, it is first necessary to understand the background that shaped the methodology in creating the systems. The best way to do this is to gain an understanding of what others have done with these strategies in the past.

Trading as a Business

Scientifically trading the financial market is not a new concept. There are numerous news articles, books, and forums discussing how to trade the markets in a predictable manner. The book the authors used to understand strategic trading is Charlie Wright's *Trading as a Business*. Wright's work explains the methodology to creating a successful trading system. His literature starts with the basics, describing where traders have gone wrong in the past and how to avoid the common pitfalls of an overenthusiastic trader looking for the "holy grail". The key takeaway of his discussion of trading is to treat it like a business; there will be slow days and there will be busy days. It is important to understand the risk involved with trading and to be patient and scientific with the process.

Wright's work led the authors to understand the common movements in the market (trending, directionless, and volatile) and the associated strategies to be successful in each market (trend-following strategies, support and resistance strategies, and volatility expansion strategies). Wright's *Trading as a Business* then clearly explains the "profile of a winning strategy" which are the parts of a trading system that make it successful, shown in Table 1.

System Part	**Description**
Set-up	The set of conditions that are necessary before *considering* taking a position in the market
Entry	The signal by which the strategy decides to get into the market, after confirmation from the set-up
Exits	The signal by which the strategy decides to get out of the market
Stop Loss	The signal by which the strategy decides to get out of the market in order to protect capital

Table 1: Parts and descriptions of a trading system

Reading Charlie Wright was particularly useful to the authors' because of his experience using TradeStation and automated trading. The authors set out to create automated trading systems by following Wright's model. While Wright may not have been the first or best author to consider a successful and scientific trading system, reading what he wrote was beneficial because of the experience he was able to share. The authors believed that they could avoid the common mistakes of beginning traders and focus on what was required to craft a successful trading system.

10 O'Clock Bulls

The Basics of the Bulls

The 10 O'Clock Bulls (often shortened to simply "the Bulls") is a day trading system, meaning that at the end of the trading session the trader has all cash and no stocks remaining. The Bulls strategy is one that focuses on "breakdowns" and "breakouts," and makes use of "support" and "resistance" calculations. In essence, the trader attempts to find the highest and lowest prices over a period of time, and make trades when the stock either exceeds the highest price or drops below the lowest price. The Bulls system can be traded using any multiple of minute bars. For this system, 5-minute bars were used.

Support and Resistance

A support price is an approximate price at which a stock is said to meet some market counteraction, preventing it from dropping below the support. Likewise, a resistance price is an approximate price at which a stock is said to meet some natural counteraction, preventing it from rising above the resistance. (Bysshe, 2009)

In Figure 7, the upper black horizontal line represents a resistance price, while the lower black horizontal price represents a support price. One can see that the price of the TSLA stock over this time frame seems to "bounce" off the support and resistance prices, staying within the range for the overwhelming majority of the time.

Figure 7: Bulls Support and Resistance

Opening Range

The basis of the Bulls is the idea of the opening range. The opening range is traditionally identified as the first 30 minutes after the opening bell of the stock market, 9:30-10am. This tends to be one of the most active times during the day, as overnight orders come piling in and positions are being taken for the day. This activity often causes volatile prices, and large swings are often seen. A trader using the Bulls system will take advantage of this by recording the highest and lowest closing prices during this time. Once those prices are recorded at the end of the 30 minutes, the lowest and highest prices become the support and resistance for the day. This forms what is known as the "opening range." During this first 30 minutes, no trades are made. The chart below shows one example of an opening range.

Figure 8: Bulls Opening Range

The horizontal black lines show the support and resistance of the first 30 minutes of the trading day, forming the opening range. Note the dramatic movement of the first bar, which is often seen during the volatile beginning of the day.

Breakdowns and Breakouts

When a stock exceeds the resistance level without immediately bouncing back, the stock is said to have "broken out" of the resistance. Similarly, when a stock falls below the support level without immediately bouncing back, the stock is said to have "broken down" out of the support. These breakouts and breakdowns are where trades are made when using the Bulls strategy. Traders will look for opportunity to take long or short positions on the basis that there is profit to be made when a stock breaks out of its normal behavior. The chart below shows one example of a breakout.

Figure 9: Bulls Breakout and Breakdown

The horizontal black lines represent the support and resistance that held until November during this time frame. In early November, the stock broke down and stayed below what used to be the support price. One good indicator that a stock has truly broken down is when the previous support price then becomes a resistance price, as can be seen in this example. The same holds true for breakouts, with resistance prices becoming supports.

Turtle Trading

The History of the Turtles

Turtle Trading has become a famous trading strategy because of the 1983 experiment that asked the question, "Are traders born or made?" Richard Dennis, a renowned commodity trader, believed that he could teach a group of individuals, who he referred to as "turtles", how to trade commodities without them having prior experience. "Mr. Dennis provided classroom training for two weeks," and then the turtles were set loose with $1 million to trade the commodities market. (Angrist, 1989) They took their training and specified ruleset provided by Dennis in order to make profit from their initial capital in the commodity market. The experiment was a success when, over the course of four years, the turtles "earned an average annual compound rate of return of 80%." (Faith, 2003, p. 7)

The students of this experiment were hand selected by Dennis. He preferred people with mathematical and game-playing aptitudes, but otherwise, the individuals chosen were not trading professionals. The fact that the students were successful after trading Dennis's strategy proved that trading could be taught. The complete Turtle Trading strategy was then recorded by one of the original Turtles, Curtis Faith, in a paper titled "The Original Turtle Trading Rules".

The Turtle Tactics

Carlos used Faith's literature to learn the Turtle trading rules and apply them to an automated equities trading system. The original Turtle Trading rules were as follows:

Position Sizing: The Turtles used a position sizing algorithm that normalized the dollar volatility of a position by adjusting the position size based on the dollar volatility of the market. Normalizing the volatility of diverse markets meant that trades in different markets had the same chance for dollar loss or dollar gain. By normalizing markets the Turtles were able to trade based on "trade units". Each unit they traded was based on 1% of the account equity. As the Turtles lost money they became more conservative. As the Turtles gained money they began compounding their returns.

The Turtles used trade units as a measure of risk, and limited the number of active trade units they could hold depending on the type of market they entered. Using trade units, the Turtles were able to create maximum position limits in order to protect their investments.

Type	**Maximum Units**
Single Market	4 Units
Closely Correlated Markets	6 Units
Loosely Correlated Markets	10 Units
Single Direction - Long or Short	12 Units

Table 2: Turtle Trade Units

Set-up: The Turtles set up their trades by considering whether the previous breakout would have resulted in a winning trade. If the previous breakout - whether traded or not - would have resulted in a winning trade, then the Turtles would ignore the signal to enter the market on the current breakout.

Entries: The Turtle entry was based on a channel breakout system originally created by Richard Donchian. A breakout is defined as the price exceeding the high or low of a particular number of days. In the case of the Turtles, this was 20 days. The Turtle rules stated that the Turtles trade on every breakout in order to capture the next "big move", a common ideology of Trend-following systems.

Stops: The Turtles always used stops in order to get out of a losing market position. Stop orders were always placed at 2% of the account equity so that no trade could exceed a 2% risk to the overall account. Like position sizing, stops were also normalized to the market volatility, taking into consideration the unique risk in each market.

Exits: Most breakouts do not result in trends. For that reason, it was important that the Turtles got out before a trade went too far against them, but not too early that they did not let their profits run. After a ten-day low, the turtles exited the position and sold all of their trade units.

The original Turtle Trading rules were not complicated, but they needed to be followed closely in order to work. Turtle Trading produces large returns over a long period of time, but that comes with long periods of drawdowns. Faith explains that many lost faith during periods of drawdown due to the infrequency of successful trades being made. Those Turtles who changed the rules of the system in an effort to reduce risk often found the change negatively affected the system. The historical example of the Turtles offers a reinforcement of the psychological strength that it takes to trade the financial market and the importance of sticking to trading rules that are designed to be successful.

Trend-following Stocks

Because the Turtles traditionally traded commodities, Carlos thought it important to research whether Turtle Trading had been attempted on equities and whether or not that endeavor had been successful. Thankfully, there was a research paper called "Does Trend-following Work on Stocks?" written in 2005 that answers that very question. While the paper did not focus directly on the Turtle Trading System, it did analyze the performance of the authors' own trend-following system using entries and exits that are in line with the methodology behind the Turtle Trading System.

The authors' research came to the conclusion that "trend-following can work well on stocks." The authors' system worked so well that it yielded a 15.2% expectancy over an average trading year. This positive groundwork lead Carlos to believe that adapting the original Turtle Trading rules to trade on stocks would be a fruitful experiment.

6. 10 O'Clock Bulls

Justin created a 10 O'Clock Bulls system for day-trading equities. The system creates both long and short trades and ends the day with all cash and no positions in the market.

Choosing Stocks

For the Bulls system, the best stocks to use are those that make significant moves during the day and have enough volume so that the trader can buy and sell shares with ample liquidity. In creating this strategy, a stock screener was used to look for stocks matching these criteria and a sub-selection of these stocks was used as the final choices. The stock screener criteria were an Average True Range of at least 2.5 and a 10-day average volume of at least 1,000,000 shares. This provided a weekly list of about 40 stocks, from which the final stocks were chosen. The chosen stocks were those that regularly appeared in the weekly screening and were familiar to the authors. These stocks were Boeing Airlines (BA), Amazon (AMZN), Nvidia (NVDA), Tesla (TSLA), Goldman Sachs (GS), and Apple (AAPL).

Bar Lengths

As the 10 O'Clock Bulls is a day-trading system, it is necessary to choose bar lengths that make it possible to do analysis and calculations with enough data during each trading session. For the purposes of this system, 5-minute bars were used.

Defining Breakouts and Breakdowns

The Bulls system depends on the capitalization of breakdowns and breakouts, however the exact definition of these terms is up to the user of the system. The implementation of the breakdowns and breakouts used for this specific system will be discussed in the Entry Rules below.

Support and Resistance

The support and resistance levels comprising the opening range for this system remain unchanged from the traditional approach described in Chapter 5. Literature Review.

Price Bands

The use of "price bands" is a new adaptation to the original system created for this system. The price bands have a dual purpose: helping to provide a definition of breakdown and breakout, and allowing the system to be tuned and optimized more easily. In addition to the standard support and resistance levels, a price band is added to each such that there is a small range of prices around the support and resistance levels. This range can be tuned to a specific amount and allows for a more generalized approach to breakouts and breakdowns.

The Rules

Position Sizing: For the purposes of this system, all trades were done with one-hundred shares of the stock. The reason for this is that the Bulls system is more concerned with frequent winning trades than it is large "home run" style winning trades. This also reflects the personality of the user of the system, who prefers small, consistent wins rather than larger risks.

Setup: The setup rules for the system make use of the price bands as a way to define breakdowns and breakouts. Both setup rules have the requirement that the system does not currently have a position in the stock. A setup for a breakdown trade is as follows:

If the price of the stock is within the price band of the support level and the stock has two consecutive downward closes, then the stock is considered to have broken down.

Similarly, a setup for a breakout trade is as follows:

If the price of the stock is within the price band for the resistance level and the stock has two consecutive upward closes, then the stock is considered to have broken out.

Entry: Once the setup conditions have been met, the system then places a market order for that stock for one-hundred shares. The order will be a long order if the breakout setup is met, and a short order if the breakdown setup is met.

Exit: There are two different exit conditions for this system: a money management exit, and a trailing stop exit. The money management exit states that if the current position has lost more than $75, close the position immediately and get out of the market. This exit most frequently occurs when a position is taken in the market and the position immediately starts losing money without ever being profitable. The purpose of this exit rule is to minimize the damage caused by a bad trade and get out of the market. The trailing stop exit, which is explained in Section 2, activates when a position becomes profitable.

Optimization and Analysis

A significant amount of pre-testing was done on the system to allow tuning of the money management stops, the various rules, and the use of the variables to minimize the amount of drawdowns and the "maximum adverse excursion" of the system. Maximum adverse excursion refers to the maximum amount of loss experienced by a position before the position was closed. This is important because the Bulls system makes a high volume of trades and only wins approximately 40% of the total trades. If the system is allowing large negative swings, this unnecessarily adds to the amount of risk of the system and could significantly alter the overall performance. By cutting money management stops as close to 0 as possible without affecting the winning trades, maximum adverse excursion can be minimized and potentially large losses will be smaller.

After pre-testing analysis was done, the system was run through TradeStation's optimization engine using two years of stock market data for each of the six stocks in the portfolio. This resulted in thousands of trades, and an average value of the variables was taken. The values of these variables were then used for 2 months of stock market data before and after the two years used for optimizing. This resulted in a total of 417 trades and a loss of $36. It is important to note the breakdown of the different stocks when thinking about this number as described in Figure 10.

Stock	P/L	Trades
AAPL	$599	61
AMZN	-$806	112
BA	$1035	51
GS	-$350	75
NVDA	$485	52
TSLA	-$999	66
Total	**-$36**	**417**

Figure 10: Bulls breakdown of trades

This information seems to imply that the Bulls system developed either works very well, or very poorly, on particular stocks. It is also interesting to note that the stocks with the most trades (112, 75, and 66) were the 3 stocks that performed the worst with this system. This could suggest that the system is finding a lot of false breakdowns and breakouts and losing money on those trades. This may simply be a result of bad luck, but more likely comes down to the "personalities" of the stocks. Some stocks are known to behave certain ways (for example, US Steel is said to be a "smoothy" and often displays patterns

of long, slow, ups and downs). Because these “personalities” were not taken into account when making this system and stocks were chosen on purely numerical data, it is possible that the authors simply chose bad stocks for the Bulls system.

With further refinement and better stock picking, this could very well be a viable system. However, in its current state and an expectunity of -2.1 with the chosen portfolio, this would not be a practical system for real-world trading.

7. Turtle Trading

Carlos created two Turtle Trading strategies; one which was long-only and one which was short-only. The idea behind separating the systems is the theory that shorts are not just the opposite of longs. There are certain market conditions that favor a short over a long. This makes it important to separate the two systems and turn on one or the other depending on the long-standing trend of the market. The mechanics behind each of the strategies was developed from the theory executed by the Original Turtle traders.

The Original Turtles

As discussed previously in Section 5, the original Turtles were individuals who were not seasoned traders. They were part of an experiment to answer the questions "Are traders born or made?" The answer to this question was that traders are made, using the success of the Turtle Traders as an example. "The Turtles with the best trading records consistently applied their entry rules." (Faith, 2003, p. 22) The success of the Turtles rested in the fact that they followed the rules they were given carefully and consistently. Given this rationale, it was assumed that the Turtle Trading strategy would perform well under the mechanical reliability of an automated trading system.

Algorithmically Turtle Trading Equities

Choosing the Market and the Stocks

Converting manual trading rules on commodities came with two main challenges. How would the Turtle Trading rules work on equities, and how could the original trading rules be programmed into an automated trading system? The solution to the first challenge was found in a 2005 paper by Wilcox and Crittenden titled "Does Trend-following Work On Stocks?" The short answer to their research was "evidence suggests that trend-following can work well on stocks." (Wilcox & Crittenden, 2005, p. 11)

With confidence in applying the Turtle Trading rules to the equities market, Carlos then set out to find the most trending stocks. There are a few ways to determine whether a stock is trending or not: One technical analysis is to look at the history of the stock and observe which part of the cycle it is in. If the stock is characterized by a series of lower highs and lower lows then it is said to be down-trending. However, if the stock is characterized by a series of higher highs and higher lows, it is said to be up-trending. The third option is if a stock is doing neither of these, and is said to be trendless. If a stock is trendless, it can wreak havoc on a trend-following system due to the "choppiness" of the stock while it finds bearings; this can cause systems to start following false positive breakouts.

Figure 11: Downtrending Chart

Figure 12: Choppy Chart

Figure 13: Uptrending Chart

Another, more fundamental, method is to follow the news and what other traders are talking about. One resource Carlos used to find trending stocks is scruitfy.com's Trending Top 100 seen in Figure 14. This website aggregates "socially active" stocks and builds a word map based on their trend. Larger symbols are higher trending while the color of the symbol determines the direction of the trend; from dark green to dark red the stocks are in a strong uptrend or in a strong downtrend.

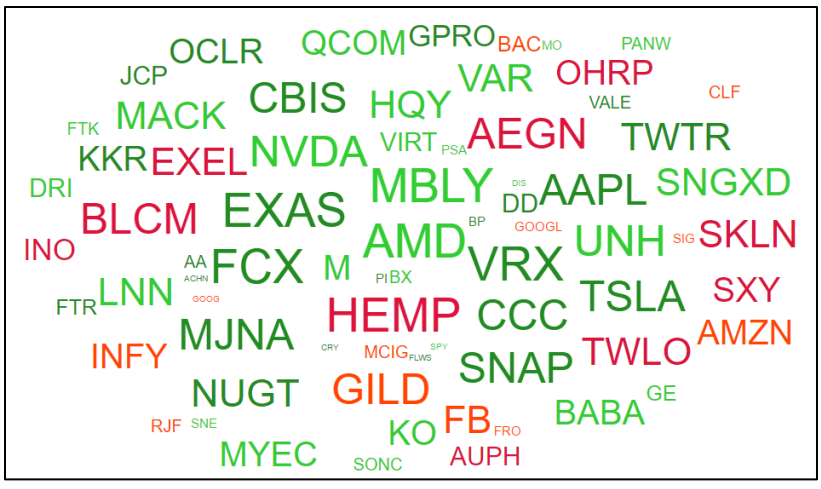

Figure 14: Trending stocks cloud

Carlos used the fundamental analysis to get an initial list of trending stocks and confirmed the trends through technical analysis. As a result, he produced a list of seven symbols to trade for the purposes of testing and backtesting his trading system: Apple Inc. (AAPL), Alibaba Group Holding Ltd. (BAC), Citigroup Inc. (C), Caterpillar Inc. (CAT), Netflix Inc. (NFLX), Nvidia Corp. (NVDA) and Tesla Inc. (TSLA).

During analysis, Carlos was able to obtain the following figure which describes the correlation of each stock with the others. The chart lists positive correlations in green and negative correlations in red. A stock which is perfectly correlated with another has its intersection value listed as "1"; a stock which is perfectly inversely correlated with another has its intersection value listed as "-1"; a stock which has no correlation with another has its intersection value listed as "0". The closer to 0 two stocks' correlation is the better, as this improves the diversity of the portfolio. Using the correlation analysis table (Table 3) it is possible to observe that the strongest correlation between two stocks is Citigroup Inc and Caterpillar Inc. with a correlation of 0.384. Theoretically, the portfolio of seven stocks is diverse enough that when combined, the winnings of one and losings of another will be smoothed out to create a net positive gain.

	AAPL	BABA	C	CAT	NFLX	NVDA	TSLA
AAPL	1.000	0.305	0.027	0.196	0.123	0.225	0.123
BABA	0.305	1.000	0.020	0.175	0.193	0.271	0.173
C	0.027	0.020	1.000	0.384	0.104	-0.114	0.046
CAT	0.196	0.175	0.384	1.000	0.323	0.099	0.109
NFLX	0.123	0.193	0.104	0.323	1.000	0.133	0.159
NVDA	0.225	0.271	-0.114	0.099	0.133	1.000	0.234
TSLA	0.123	0.173	0.046	0.109	0.159	0.234	1.000

Table 3: Turtles correlation analysis table

Programming the Rules

Carlos followed the original Turtles rules closely in order to benefit from the Turtles original success. The main deviations from original Turtles were the **decision to trade equities** and the **decision to replace the original Turtles' set-up with a simple cross-over indicator**. In detail, these are the rules that dictate the behavior of both the long and short only trading strategies. The complete source code can be viewed in the Appendix.

Set-up: The first set-up condition was the maximum position limit taken directly from the original Turtles. Carlos's system was composed of one long-only strategy and one short-only strategy. Therefore, before entering into the market, the first condition to check for was that the maximum positions limit, or 12 trade units, was not exceeded.

Both the long-only and the short-only strategy rely on a simple cross-over filter using exponential moving averages. As a condition to enter the market, the strategy uses the cross-over filter in order to make sure that the current market conditions are "smooth" and the strategy is not detecting a false positive. The details of the cross-over set-ups are in Section 5.

Position Sizing: Carlos chose a position sizing algorithm similar to the original Turtles. On every new trading bar, the algorithm follows the equation below in order to determine the position size of the next trade.

Entry: The first condition Carlos's Turtle Trading system needed to pass was to not exceed the maximum number of trade units, twelve, on the market at any point in time. As a result, it was necessary to keep a running tally of the number of Trade Units currently in the market. For Carlos's Turtle Trading system, one Trade Unit can be defined as

$$Trade\ Unit\ = [\frac{Notational\ Account\ *\ 0.01k}{N\ *\ Dollar\ Per\ Point}]$$

Equation 5: Definition of a Trade Unit

Here, the *Notational Account* refers to a breathing account balance. The Notational Account keeps track of wins and losses; winning trades make the Notational Account grow while losing trades make it shrink in order to ensure the system remains conservative. By following the original Turtle rules, Carlos's system decreases "the size of the notional account by 20% each time [he] went down 10% of the original account." (Faith, 2003, p. 19)

The value *N* is describes the underlying volatility of the stock being traded. It is calculated using an *NDay* statistical volatility calculator using the standard deviation of closes for *NDays.* The number of days over which to determine the volatility of the stock was made with a variable to optimize during the final stages of testing Carlos's trading system.

Dollar Per Point refers to the number of dollars a $1 change in the stock makes. For stocks, this is a 1:1 relationship. As a result, the Dollar Per Point value in the above equation can be calculated as the last close of the stock.

Carlos's Turtle system then used a simple cross-over filter to set-up the entry position. The set-up determined whether or not the market was "choppy". If there was too much of a price fluctuation in the market, then Carlos's strategy would not enter the market on that bar; if the market was smooth, it moved on to the final entry condition. The final entry condition had two parts, one each for the long- and the short-only strategies.

The long-only strategy finally entered the market, buying *N* shares of a stock, if the current high was higher than the preceding *NDay* bars (the same *NDay* used for calculating trade units). If this condition was met, the strategy would either buy into the market or buy more shares in the same position with N/2 shares.

The short-only strategy entry operated similarly. However, instead of making a decision based on highs, it would enter the market selling short if the current low was lower than the preceding *NDay* bars.

In either case, on each entry, the number of Trade Units held was incremented in order to maintain an accurate count of how many positions Carlos's system held in the market. Storing this information made sure that the strategy did not over-extend into the market.

Stop: Carlos followed the Original Turtle's model of never allowing a trade to incur more than a 2% risk. According to this rule, Carlos's Turtle system placed a stop loss at 2N of the price movement of the stock. In the long-only system, the stop loss indicator is turned on when the current price minus the price the stock was bought at exceeds the 2N stop loss. In the long-only system, the stop loss is turned on when the current price minus the price the stock was bought at is less than the 2N stop loss.

Exit: The first step to exiting Carlos's Turtle Trading system is for the stop loss indicator to be turned on. The next step is to consider the current price relative to either the lowest low or the highest high of the previous N Days/2. In the long-only strategy, all current shares were sold when the current close was less than the low of N Days/2. In the short-only strategy, all current shares were bought-to-cover when the current close was higher than the high of N-Days/2.

When exiting the strategy, it is an important feature of the trading system to reset how many trading units are held on the market. This allows the trader to then re-enter the market normally.

Optimization

Several optimizations were made between Carlos first translating the Turtle Trading strategy to EasyLanguage and the final build of the strategy. The first optimization made was separating the trading strategy into two: one to long stocks and one to short stocks. Then Carlos used the objective functions derived from the TradeStation performance summary to find optimal system settings for his Turtle Trading system.

Separating Longs and Shorts

The decision to separate the final Turtle Trading system into two parts was made based on a conversation held between Carlos and Professor Radzicki. Professor Radzicki explained that many traders consider longs and shorts as two unique forces, and not mirror images of each other: "Longs are not simply the opposite of shorts." With this in mind, Carlos considered the implications of separating a trading system into a long-only strategy and a short-only strategy, since each could be turned on or off based on the general trend of the market.

An Example

While it is important to let a trading system operate as it was designed and not interfere with the system while in operation, it is just as important to analyze its performance over time and observe its behavior. Carlos made use of this information when considering the general time frame of the period in which he was trading and backtesting his system; namely, the ten years from 2007 to 2017. Because of the longer time frame of Carlos's Turtle Trading system, it was important to note the financial crisis lasting from Q1 2008 to Q3 2009 (shaded in Figure 15) and the recovery thereafter.

Figure 15: Gross domestic product from 2002-2016

When the trading system was separated, it performed better, and there were no short positions held in the market preventing long positions from being made. The conditions for a long trade are unique from those for a short trade. Recognizing the general trend of the market, whether bulllish or bearish, can make a significant difference in the performance of a trading system. Take for example the chart below. The prices signify the total earnings over the respective four year period. While the long strategy outperformed the short strategy on every instance, it is important to note that the short strategy performed its best, 183.47x, during the years of the financial crisis.

	2004 - 2008	2008 - 2012	2012 - 2016
Long Strategy	*$1,309.20*	*$1,136.49*	*$1,622.64*
Short Strategy	*$0.61*	*$112.29*	*$1.42*

Table 4: Turtle earnings relative to trading period

Parameters

The two parameters that Carlos optimized were the initial starting balance and the *NDay* value used by the system. The initial starting balance represents how much money the trading system starts with, and therefore initializes the Notional Account with the initial starting balance. This affects how large of a trade the system can make and how the system compounds its earnings. A higher initial starting balance leads to a higher Notional Account, meaning that the system can enter the market with a larger position size. On a successful trade, a larger position size leads to a larger Notional Account and the possibility for even larger position sizes. On an unsuccessful trade, a larger position size leads the system to become more conservative, reducing the Notional Account by 2 * N.

While reading the Turtle Trading literature, Carlos noticed that some strategies suggested trading based on 20 day intervals, and some suggested trading on a 55 day interval. These intervals, *NDay* intervals, determined the time frame on which the underlying volatility of the stock and the lows and highs of the stock were calculated. For example, using the 20 day interval meant that the condition to enter the market with a long position depended on whether or not the close of the stock was higher than the highest high of the last 20 days. Carlos questioned which of these two date ranges was best and if there was a third, even better data range.

Carlos ran each of the trading strategies over the stocks contained in his portfolio, searching for optimal values, using the following ranges:

Initial Balance: $10,000 to $1,000,000
incrementing by 1,000

NDay: 18 to 60 incrementing by 2

The results of the optimization trials can be viewed in Table 5:

Stock Symbol	***InitialBalance* Value**	***NDay* Value**
AAPL	*528,000*	*18*
BAC	*531,000*	*18*
C	*490,000*	*20*
CAT	*45,000*	*36*
NFLX	*50,000*	*46*
NVDA	*275,000*	*50*
TSLA	*447,000*	*38*

Table 5: Result of Turtles optimization trials

Taking the average of the test results, Carlos decided to use an *InitialBalance* value of 338,000 and an *NDay* value of 24 for the final analysis of his Turtle Trading System.

Analysis

Maximum Adverse Excursion

The Turtles Trading system can be a very profitable system when it successfully trades on trending stocks. However, trends are both difficult to detect and take advantage of early on in the cycle. For that reason, the Turtle Trading strategy is traditionally characterized by incurring heavy drawdowns in capital between successful trades. Carlos used the maximum drawdown as one method to optimize his Turtle Trading system. He set out to find the line between minimizing drawdown as much as possible while still remaining profitable. However, this was not a successful endeavor. Focusing too much on finding this line led Carlos to develop a system that was too conservative and did not take enough risks to maximize his profits.

The Maximum Adverse Excursion, shown in Figure 16, represents the final profits/losses of each trade relative to the drawdown incurred, where green triangles(▲) represent profitable trades and red triangles (▼) represent losing trades. Looking at the Maximum Adverse Excursion chart below, taken from TradeStation after the application of Carlos's Turtles Long strategy over a ten year period, it is possible to see some strengths and weaknesses of the system.

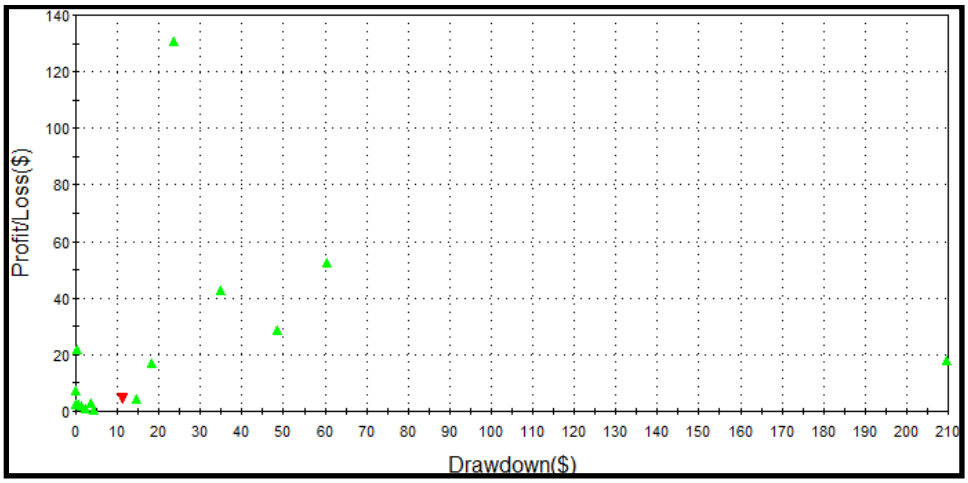

Figure 16: Turtles maximum adverse excursion

The first data to notice are the profitable trades clustered close to the origin of each profit and drawdown axis. These trades represent trades that neither go against the trader nor earn the trader much money. Too many of Carlos's trades lie at this point on the chart, meaning that his system did not take enough risks; it was low risk and low reward. Furthermore, the trades that do incur more drawdown do not yield the high rewards that the Turtle Trading strategy promises. The system searches for breakouts, but often comes up short. While this chart only represents one part of the trading system, trading one symbol reveals the largest downfall of Carlos's system - it is too conservative in its trades.

Final Results

Carlos's final results are a product of two testing metrics - backtesting over a period of 5 years, and walking the system forward for 1 year. The backtesting was used to observe the performance of Carlos's Turtle Trading system over a long enough time period to produce enough trades for significant data.

Backtesting

The results of backtesting Carlos's Turtle Trading system are summarized in the following figures, representing the performance reports for the short-only and long-only strategies:

Summary	Value
Total Return	($195.53)
Total Realized Return	$21.47
Gross Profit	$22.17
Gross Loss	($0.70)
Open Trade P/L	($217.00)
Number of Trades	10
Number of Winning Trades	7
Number of Losing Trades	3
% Profitable	70.00 %
Average Trade	$2.15
Average Trade (%)	9.88 %
Standard Deviation	$4.15
Standard Deviation Trade %	15.16 %
Largest Winning Trade	$13.31
Largest Losing Trade	($0.30)
Profit Factor	31.67
Average Win/Average Loss	13.57
Sharpe Ratio	-81.8809
K-Ratio	-0.2766
Return Retracement Ratio	-0.1937

Figure 18: Performance Summary - Turtles Short Back-tested

Summary	Value
Total Return	$1,551.50
Total Realized Return	$1,903.96
Gross Profit	$1,909.94
Gross Loss	($5.98)
Open Trade P/L	($352.46)
Number of Trades	70
Number of Winning Trades	67
Number of Losing Trades	3
% Profitable	95.71 %
Average Trade	$27.20
Average Trade (%)	9.85 %
Standard Deviation	$66.76
Standard Deviation Trade %	21.08 %
Largest Winning Trade	$485.60
Largest Losing Trade	($2.95)
Profit Factor	319.39
Average Win/Average Loss	14.30
Sharpe Ratio	-16.4513
K-Ratio	0.3840
Return Retracement Ratio	2.4696

Figure 19: Performance Summary - Turtles Long Back-tested

Summary	Value
Total Return	$1,090.31
Total Realized Return	$995.87
Gross Profit	$995.87
Gross Loss	$0.00
Open Trade P/L	$94.44
Number of Trades	34
Number of Winning Trades	34
Number of Losing Trades	0
% Profitable	100.00 %
Average Trade	$29.29
Average Trade (%)	7.66 %
Standard Deviation	$42.91
Standard Deviation Trade %	9.09 %
Largest Winning Trade	$174.59
Largest Losing Trade	$0.00
Profit Factor	0.00
Average Win/Average Loss	0.00
Sharpe Ratio	-29.0113
K-Ratio	2.2152
Return Retracement Ratio	0.0000

Figure 17: Performance Summary - Turtles Long Walk-Forward

The first alarming thing in these summaries is the percent profitable value in each trading system. Having such a high percent profitable rate is worrisome at first glance, but the other piece to the puzzle is the total number of trades that were made. In the long-only strategy, there are 70 trades made, and 67 are profitable. This finding is what led Carlos to the conclusion that his system is either too conservative in the trades it makes, or it is feeling the effects of algorithmic bias. When considering the results of the trading system being run on new data, it is clear that Carlos's Turtle Trading system is too conservative and not taking risks or reaping the rewards of those missed opportunities.

Walk-forward

Finally, Carlos walked his system forward, simulating a trading time period of one year ending at the last date of the academic calendar, May 2, 2017. Using these parameters, he was able to produce a performance report for the long-only Turtle Trading strategy. Unfortunately, the short-only strategy did not make any trades over the year-long period, the most probable reason being that that year was marked by a strong bull market.

The strong bull market is again shown by the strong performance of the long-only Turtle Trading strategy. However, analyzing the report (see Figure 20) further shows the same problem discovered during backtesting - the trading system is too conservative. Based on an initial starting balance of $338,000, a $1,090.31 total return represents a mere 0.32% increase in capital. This is not a good investment considering the amount and length of time the initial capital investment was held for such a slight reward.

Summary	Value
Total Return	$1,090.31
Total Realized Return	$995.87
Gross Profit	$995.87
Gross Loss	$0.00
Open Trade P/L	$94.44
Number of Trades	34
Number of Winning Trades	34
Number of Losing Trades	0
% Profitable	100.00 %
Average Trade	$29.29
Average Trade (%)	7.66 %
Standard Deviation	$42.91
Standard Deviation Trade %	9.09 %
Largest Winning Trade	$174.59
Largest Losing Trade	$0.00
Profit Factor	0.00
Average Win/Average Loss	0.00
Sharpe Ratio	-29.0113
K-Ratio	2.2152
Return Retracement Ratio	0.0000

Figure 20: Performance Summary - Turtles Long Walk-Forward

Carlos tried to use the results of the trade data produced over this year-long period in order to calculate the expectancy, expectunity, and overall system quality of his Turtle Trading system, but quickly found that the data produced led to insignificant results. Due to the fact that there were no losing trades, there were instances where calculations resulted in infinite expectancy. Instead, Carlos used the back-tested trade list in order to get empirical evidence of the overall system quality. Doing so yielded more significant and more numerous trade data.

Using the five year historical data yielded 89 trades on which to calculate expectancy, expectunity, and overall system quality[1]. The **expectancy** was calculated using the two definitions of the R multiple value: $Expectency_{R1.}$= 0.37 and $Expectency_{R2}$= 0.07. Even with the most liberal calculation of Carlos's Turtle Trading expectancy, it is not a positive figure. On average, the system is not expected to gain positive returns over time. Annualizing the expectancy of the system shows 18.67 annual opportunities yielding an **expectunity** of 6.93. While greater than 1.0, this figure is still not positive considering the fact that even if the gains from the system can be guaranteed, they cannot be guaranteed at a rate that will be more profitable than an index fund. The system may win on a yearly basis, but it does not take enough risks to win enough to be called successful. Finally, the overall **system quality** was calculated to be 2.09. This system quality value is important when considering the system of systems that Carlos and Justin explained in Chapter 8. System of Systems.

Monte Carlo

The result of running the Monte Carlo analysis on the one year of trade data produced by Carlos's Turtle Trading system can be seen in Figure 21.

[1] See Appendix A for the details of the following calculations

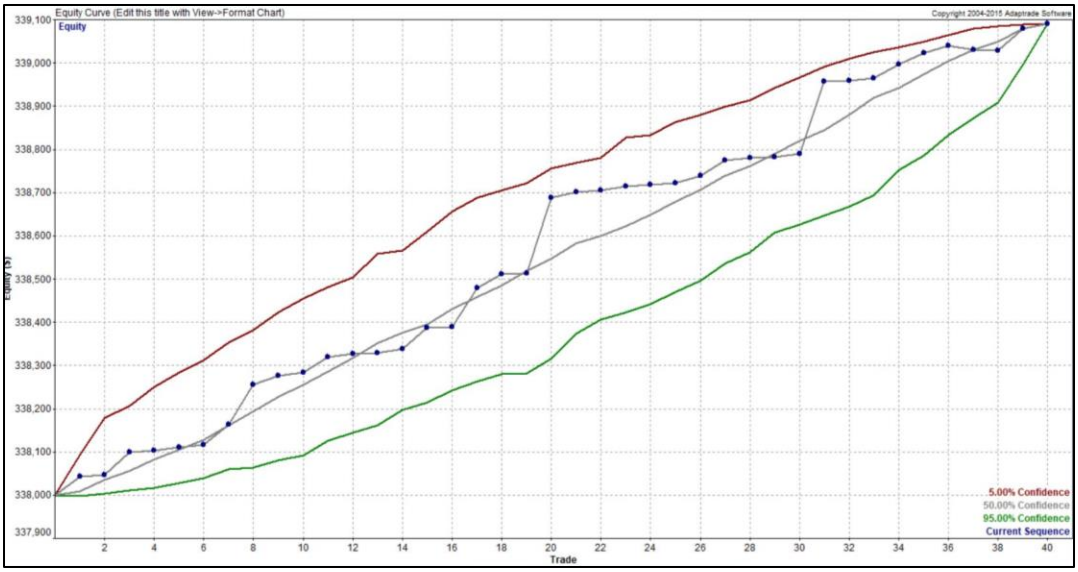

Figure 21: Turtles Monte Carlo Analysis

Out of the 34 trades Carlos's Turtle strategy made in the year, all of them were successful trades. This behavior is what led to such a predictable Monte Carlo simulation. No matter how the trades are randomized, their final state will always be similarly successful. But a successful trade does not mean a profitable trade, and exiting the market before the final date can lead to less of a growth than other scenarios. In any case, the growth discovered by analyzing the data in this way was less than inspiring.

Results

Using the Monte Carlo analysis, along with the other technical analysis techniques, Carlos was able to empirically state that his system took no risks and got no rewards. Over the course of a year, Carlos's Turtle Trading system returned only 0.323% on the initial $338,000 investment. The low return on investment and low expectancy value led Carlos to conclude that his system was, in its current form, not worth the cost of operation - especially when considering the high initial startup that the system requires in order to produce such modest returns. Carlos's system proved that the Turtle Trading strategy could be adapted to operate in the equities market. However, it did not prove that this process would always be *successful*. There may be adaptations to this trading system to make it more willing to trade and take risks, which would ultimately make it more successful in the market.

8. System of Systems

Creating automated trading systems was only one part of this Interactive Qualifying Project. Like the diversity in Carlos and Justin's trading systems, the goal was to create a system of systems which operated more effectively than either system did on its own. The goal was that while either system may fall short on some trades the other would be performing well.

Aggregated Reports

The aggregated equity curve when combining both the Bulls and the Turtle trading systems is shown in Figure 24. For reference, both the equity curve for the Bulls, Figure 22, and the Turtles, Figure 23, trading systems have been included. The first thing to note about the trading trends is that the 10 O'Clock Bulls trading system made 417 trades, while the Turtle trading system made only 40. This discrepancy between how many trades made, coupled with the Turtle trading system's weak ability to produce high gains, led the final data to be skewed towards the 10 O'Clock Bulls system.

Before comparing the results of the aggregated reports, it is interesting to note that the system of systems created a report similar to that of the Bulls trading system, only smoother. During the time period in which both systems are simultaneously trading, the combination of the systems created less severe drawdowns and smoother trends towards positive earnings.

The final report being smoother told the authors two things. First, the Turtle Trading system's conservative reliability helped the Bulls trading system in its periods of frequent losses. Second, while neither system performed strongly, it is still possible to show that the diversification of trading systems produces a more well-rounded system of systems.

Performing a Monte Carlo analysis on the system of systems produced a result that was skewed towards the Bulls, but was rounded out by the Turtle trading system. At the 95% confidence interval, the system of systems suggests a profit factor of 1.075. Compared to a profit factor of 0.932 and 106.4 for the Bulls and Turtles trading systems respectively, it seems that the system of systems produces a more realistic scenario for trading.

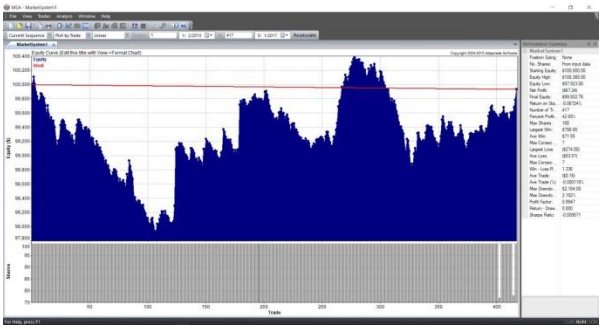

Figure 22: Bulls Equity Curve

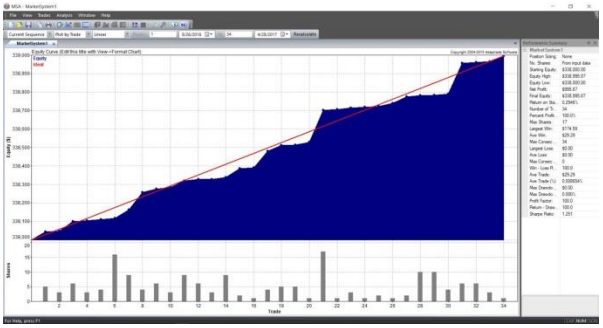

Figure 23: Turtles Equity Curve

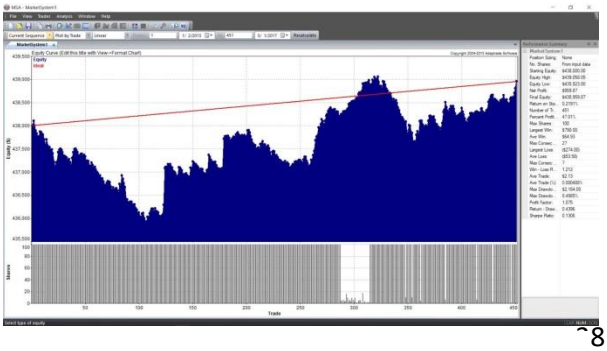

Figure 24: Aggregated Equity Curve

System Allocations

Because the system of systems draws from the same account, there needs to be a scientific way to allocate portions of the money to each of the systems. The best way to do this is by creating a ratio of their respective system qualities. However, with the current state of the Bulls system, this would mean 100% of the money would be allocated to the Turtles system, because the Bulls system has a negative system quality. For the purpose of demonstrating how this process would traditionally work, the allocation in this section will use a revised sample of the trades from the Bulls, removing the trades of AMZN, GS, and TSLA due to their large negative yields as discussed previously. When only the 3 positive-yielding stocks were used (AAPL, BA, and NVDA), the Bulls system was calculated to have a system quality of 2.29. The Turtles system remains the same as before with a system quality of 2.09. This means that the allocation of money for this theoretical system of systems would see 47.7% of the money going to the Turtles system, and 52.3% of the total money going to the Bulls system. It is important that the money be allocated optimally so that the combined systems can operate as efficiently as possible.

9. Summary and Conclusions

Summary

The trading systems in this IQP show how an ordinary citizen can fully take hold of their financial future and get involved with the stock market. However, the Bulls system especially shows that it requires an extremely sophisticated approach to creating a system with extensive testing and research. Investing in the market is very complicated, and without a solid foundation of knowledge, ordinary traders are bound to end up losing the money they invested. Despite this challenge, it is important for the average person to be able to survive in the market, and simply trusting a hedge fund with your retirement money isn't always a wise decision. This IQP outlines many of the areas of investing that should be studied before risking real money, but only scratches the surface of the full complexity of the market.

Conclusion

With the results of the systems created here, the authors have no choice but to conclude that these systems are not viable for real-world application. Even though the Turtles system does make some money, the amount of time it takes to gain profits makes it unrealistic to use as a system that produces significant yield. The Bulls system does not make any money, and therefore would have no reason to be traded on the real market. However, the authors can also conclude that while the systems as they stand are not successful, they both show potential, and with some refinement, could very well be viable systems. Both of these systems are indeed widely used among actual traders, so it's clear that they can be made to work.

Next Steps

After analyzing the two systems demonstrated in this IQP, there are a number of possible next steps for improving both systems. For the Bulls system, there is a lot of potential if there are better stocks chosen and the rules of the system can be more refined. Significant research should be done into the behavior of the stocks rather than filtering them solely by numerical methods. Once that is done, it will be easier to optimize the system when the portfolio chosen is more suitable to the system as a whole.

For the Turtle trading system, the next step is loosening the constraints on the system. The system should have more room to take risks and hold onto trades. This would include allowing the system to take on more Trade Units and utilizing a more sophisticated set-up filter. Furthermore, a unique next step to take would be to develop a more sophisticated method to get out of the market. This could include analyzing previous trades in order to algorithmically determine the market condition and make changes accordingly.

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Appendix A: Calculations

Turtle Trading System

$$Expectency = \frac{\sum \frac{Profit\ or\ Loss}{Average\ Loss}}{Number\ of\ Trades}$$

$Expectency_{Avg.} = \frac{\sum R_1}{89}$ $Expectency_{Avg.} = 0.37$	$Expectency_{Largest} = \frac{\sum R_2}{89}$ $Expectency_{Largest} = 0.7$

$$Expectunity = Expectency_{Avg.} * Annualized\ Trade\ Opportunities$$
$$Expectunity = 0.37 * 18.67$$
$$Expectunity = 6.93$$

$$System\ Quality = \frac{Expectency_{Avg.}}{\sigma(R_1\ Mults)} * \sqrt{Number\ of\ Trades}$$
$$System\ Quality = \frac{0.37}{1.67} * \sqrt{89}$$
$$System\ Quality = 0.22 * \sqrt{89}$$
$$System\ Quality = 2.09$$

Appendix B: Easy Language Code for 10 O'Clock Bulls Trading System

```
Inputs:
      TradeUnit(100),
      Band1(0), // Should be between 0 and 1
      Band2(0), // Should be between 0 and 1
      ExitBand(0); // Should be between 0 and .5

Variables:
      Support(0),
      Resistance(0);

If CurrentBar = 1 then
Begin
      Support = C;
      Resistance = C;
End;

If time >= 930 and time <= 1000 then begin
      If Close > Resistance then begin
            Resistance = Close;
      End;
      If Close < Support then begin
            Support = Close;
      End;
End;

If time > 1000 and time < 1500 then begin

      { Long Entry }
      If Close <= (Resistance + Band1) and Close >= (Resistance - Band2) and
Close > Close[1] and marketposition = 0 then begin
            Buy TradeUnit shares next bar market;
      End;

      { Long Exit }
      If marketposition = 1 and marketposition = marketposition(1) then begin
            Sell TradeUnit shares next bar at (Close - ExitBand) stop;
      End;

      { Long Money Management }
      If marketposition = 1 and (Close - EntryPrice)*TradeUnit <= -75 then
begin
            Sell TradeUnit shares next bar market;
      End;

      { Short Entry }
      If Close <= (Support + Band2) and Close >= (Support - Band1) and Close
< Close[1] and marketposition = 0 then begin
            Sell short TradeUnit shares next bar market;
      End;

      { Short Exit }
      If marketposition = -1 and marketposition = marketposition(1) then
begin
            Buy to cover TradeUnit shares next bar at (Close + ExitBand)
stop;
```

```
      End;

      { Short Money Management }
      If marketposition = -1 and (EntryPrice - Close)*TradeUnit <= -75 then
begin
            Buy to Cover TradeUnit shares next bar market;
      End;
End;

If time >= 1530 then begin
      If marketposition = 1 then begin
            Sell TradeUnit shares next bar market;
      End;

      If marketposition = -1 then begin
            Buy to Cover TradeUnit shares next bar market;
      End;
End;
```

Appendix C: Easy Language Code For Turtles Trading System

Long-Only Strategy

```
Input:
      InitialBalance(100000),   // The account size at start of trading
      NDay(20)                    // How many days long is this systems basis
(20 or 55 day)
;
Variables:
      N(0),                       // Underlying volatility of the stock
      DPP(Close),                 // Dollar per price of the stock
      StopLoss(0),                // Stop loss value
      DollarRisk(0),             // Dollar risk value
      TradeUnit(100),             // How much to trade based on idea that 1N
represents 1% of account equity
      UnitsHeld(0),              // How many units are currently held
      NotationalAccount(10000), // Notational Account, hard coded for testing
purposes
      LastAccount(0),               //   Last   account   size   to   reevaluate
drawdown
      Stop_On(False),               // Stop loss boolean
      Fast_Ave    ( 0 ) ,        // Fast moving average value
      Slow_Ave    ( 0 ) ,        // Slow moving average value
      Cross_Over (False);           // Simple cross-over filter
;

{ Set-up }
Cross_Over = False;
Fast_Ave = Xaverage ( Close , 50 ) ;
Slow_Ave = Xaverage ( Close , 200 ) ;
If Fast_Ave > Slow_Ave and Slow_Ave > Slow_Ave [ 1 ] Then
      Cross_Over = True;

{ Position Sizing }
N = VolatilityStdDev(NDay);
DPP = Close; // Price of the stock is equal to its close
DollarRisk = NotationalAccount * 0.01;
TradeUnit = IntPortion(DollarRisk/(N*DPP));
StopLoss = 2 * N;

// Decrease the size of the notational account if 10% drawdown
If NotationalAccount < (LastAccount * 0.9) Then Begin
      NotationalAccount = NotationalAccount * 0.8;
      Print(File("c:\turtle_notational.txt"), NotationalAccount);
End
Else Begin
      LastAccount = NotationalAccount;
End;


{ Entry }
// Do not even consider a trade if too many units are on the line
If UnitsHeld < 12 then Begin
      // Enter if price exceeds by a single tick high of the preceding NDays)
      If Close > HighD(NDay) and Cross_Over then Begin
            If marketposition = 0 then begin
```

```
                  Buy ("Long") TradeUnit shares next bar market;
                  UnitsHeld = UnitsHeld + TradeUnit;
            End;
            If marketposition = 1 then begin
                  Buy ("Long more") (TradeUnit / 2) shares next bar market;
                  UnitsHeld = UnitsHeld + (TradeUnit / 2);
            End;
      End;
End;

{ Stop }
if ( Close - EntryPrice ) > StopLoss then begin
      Stop_On = True;
End
Else begin
      Stop_On = False;
End;

{ Exit}
If Close < LowD(NDay/2) and Stop_On then begin
      Sell ("Long Exit") currentshares shares next bar market;
      UnitsHeld = 0;
End;
```

Short-Only Strategy

```
Input:
      InitialBalance(100000),   // The account size at start of trading
      NDay(20)                    // How many days long is this systems basis
(20 or 55 day)
;
Variables:
      N(0),                       // Underlying volatility of the stock
      DPP(Close),                 // Dollar per price of the stock
      StopLoss(0),                // Stop loss value
      DollarRisk(0),            // Dollar risk value
      TradeUnit(100),             // How much to trade based on idea that 1N
represents 1% of account equity
      UnitsHeld(0),             // How many units are currently held
      NotationalAccount(10000), // Notational Account, hard coded for testing
purposes
      LastAccount(0),               //   Last   account   size   to   reevaluate
drawdown
      Stop_On(False),               // Stop loss boolean
      Fast_Ave    ( 0 ) ,       // Fast moving average value
      Slow_Ave    ( 0 ) ,       // Slow moving average value
      Cross_Over (False);           // Simple cross-over filter
;

{ Set-up }
Cross_Over = False;
Fast_Ave = Xaverage ( Close , 50 ) ;
Slow_Ave = Xaverage ( Close , 200 ) ;
If Fast_Ave < Slow_Ave and Slow_Ave < Slow_Ave [ 1 ] Then
      Cross_Over = True;

{ Position Sizing }
```

```
N = VolatilityStdDev(NDay);
DPP = Close; // Price of the stock is equal to its close
DollarRisk = NotationalAccount * 0.01;
TradeUnit = IntPortion(DollarRisk/(N*DPP));
StopLoss = 2 * N;

// Decrease the size of the notational account if 10% drawdown
If NotationalAccount < (LastAccount * 0.9) Then Begin
      NotationalAccount = NotationalAccount * 0.8;
      Print(File("c:\turtle_short_notational.txt"), NotationalAccount);
End
Else Begin
      LastAccount = NotationalAccount;
End;

{ Entry }
// Do not even consider a trade if too many units are on the line
If UnitsHeld < 12 then Begin
      // Enter if price exceeds by a single tick high of the preceding NDays)
      If Close < LowD(NDay) and Cross_Over then Begin
                  SellShort ("Short") N shares next bar market;
                  UnitsHeld = UnitsHeld + TradeUnit;
            End;
            If marketposition = -1 then begin
                  SellShort ("Short more") (N / 2) shares next bar market;
                  UnitsHeld = UnitsHeld + (TradeUnit / 2);
            End;
      End;
End;

{ Stop }
if ( Close - EntryPrice ) < StopLoss then begin
      Stop_On = True;
End
Else begin
      Stop_On = False;
End;

{ Exit}
If Close > HighD(NDay/2) and Stop_On then begin
      BuyToCover ("Short Exit") currentshares shares next bar market;
      UnitsHeld = 0;
End;
```