

Trading System Development

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Abstract

The goal of this project was to develop a system of automated trading systems that achieves a greater return than comparable alternatives, such as the S&P 500. Over the past year, the inflation rate in the US was 2.1%, meaning that the buying power of \$10,000 would decrease by \$210. In order to counteract this, it is beneficial to identify a reliable investment vehicle to generate consistent returns. This team developed a system which achieved a 19.73% return on \$400,000 initial capital when trading from April 7th, 2017 to April 4th, 2018, beating inflation by 17.63% and the S&P 500 by 9.3%. Trading on a mix of stocks and forex, the system made 634 trades and earned \$0.27 for every dollar it risked, which compounds to \$172.63 for every year that it was in the market. Its system quality, which is a metric for determining the overall quality and versatility of a trading system, was 2.85. The sharpe ratio for this system was 0.79; this is a measure of a system's risk-adjusted returns. The overall system of systems achieved a higher system quality than the majority of its underlying systems; therefore this team recommends that a combined system of systems should be used over a single system when trading on the equity markets.

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Chapter 1: Introduction

There are many compelling reasons to invest money in the financial markets. According to numerous studies by the American Psychological Association, money and finances have been the leading cause of stress for the average American since the studies began in 2007.^[1] For individuals and families, it is important to have some level of savings to offset the cost of living and manage unexpected bills. However, excess money sitting idle in a checking account provides no long term financial benefit to an individual. In fact, the level of purchasing power drastically declines over time when money is not generating interest due to inflation. An account with a starting balance of \$10,000 in 2002 would be devalued to a purchasing power of \$7,164 after 15 years of inactivity as shown in Figure 1.1.

Figure 1.1 Purchasing power over 15 year period adjusted for inflation

¹ “American Psychological Association Survey Shows Money Stress Weighing on Americans’ Health Nationwide,” *American Psychological Association*, 04-Feb-2015. [Online]. Available: <http://www.apa.org/news/press/releases/2015/02/money-stress.aspx>. [Accessed: 25-Apr-2018].

For these reasons, it should become obvious that employing excess money in some investment vehicle is a necessity for financial longevity. It is not uncommon for individuals to avoid investing in the financial markets due to the notion that market investments bear higher risk. While this is true, investing in the financial markets with a solid understanding of market dynamics and maintaining realistic earnings expectations may dramatically improve an individual's net worth over an extended period of time. Figure 1.2 illustrates an example of how a more traditional investment vehicle compares to an investment in the financial markets.

Figure 1.2 Value of \$10,000 investment over 15 year period adjusted for inflation

Due to a lack of historical data for interest rates of savings accounts, a one month treasury bond has been used to model the returns of a savings account. Over the span of a 15 year period, a starting capital of \$10,000 invested in the S&P 500 index fund would yield \$22,956 after inflation. Conversely, a starting capital of \$10,000 invested in a savings account would yield \$8,674 after inflation.

The example above illustrates the advantages of exploring the financial markets as a potential investment vehicle. However, investing in an index fund, such as the S&P 500, is only one of many ways to invest in the financial markets. Other options include developing a portfolio comprised of various stocks in which money will be allocated to each stock based on some criteria, currency pair trading, or creating an automated strategy similar to those discussed in this report. Due to the rise of trading platforms such as TradeStation, it has become significantly easier for an individual to manage his own trading. Consumers now have access to advanced analytical tools that were once reserved for Wall Street traders, giving them the ability to make well informed decisions in a fraction of the time.

Additionally, those that feel overwhelmed with the prospect of managing their own money within the financial markets may seek professional advice from a money manager. In exchange for a fee, a money manager has a fiduciary responsibility to make well-informed investments. A professional money manager does not receive commission on transactions and is compensated based on a percentage of the assets under management.^[2] It is in the best interest for both the money manager and client to grow the portfolio over time.

1.1 Project Description

The objective of this Interactive Qualifying Project was to scientifically design and implement a system for trading or investing in the financial markets. The financial markets include: equities, fixed income, futures contracts, options contracts, currency pairs, exchange traded funds, and mutual funds. The group represents a faux hedge fund designed to work

² I. Staff, "Money Manager," *Investopedia*, 02-Jan-2018. [Online]. Available: <https://www.investopedia.com/terms/m/moneymanager.asp>. [Accessed: 26-Apr-2018].

together in order to develop a profitable set of automated trading systems. In addition to developing trading systems, the group was tasked with following the economy and global news through various financial outlets.

Chapter 2: Background

In order to be able to intelligently participate in trading and investing, it is essential to first understand the different asset classes and market types. Furthermore, it is beneficial to understand basic principles regarding the markets such as the breadth of the market, differences between trading and investing, and the efficient market hypothesis. Pairing this information with an understanding of the available tools and trading platforms available will provide a solid foundation to begin developing a trading or investment strategy. This chapter will discuss the background information required to adequately cover the fundamental concepts required to begin participating in the financial markets.

2.1 Asset Classes

Asset classes represent various categories of investment vehicles, each with their own level of risk and return. Different asset classes can be particularly useful for diversifying an investment portfolio. The main asset classes are stocks, exchange-traded funds, mutual funds, fixed income, foreign currencies, commodities, cash, and real estate. The following sections will provide an introduction to each asset class, how it can be used as an investment vehicle, and the benefits and drawbacks of the asset class.

2.1.1 Stocks

Stocks, also known as equities, represent shares of ownership in publicly held companies. Ownership is determined by the number of shares an individual owns relative to the amount of

total shares in existence. The available stocks are listed on various exchanges such as the New York Stock Exchange and the Nasdaq. At the most basic level, an individual may buy or sell stock through a brokerage firm. Depending on the brokerage firm, a fee, called “commission”, will be associated with the transaction. Typically these fees range somewhere from \$8 - \$10. Historically, stocks have outperformed other asset classes over long periods of time.

2.1.2 Mutual Funds

A mutual fund is a method of investing established by pooling money from many investors into a variety of assets. A mutual fund is operated by a professional money manager whose job entails properly allocating the fund in an attempt to generate a profit for the investors.

^[3] A mutual fund is required by the SEC to match the investment goals stated in a formal legal document presented to the investors represented in the fund.

2.1.3 ETFs

An exchange-traded fund (ETF), is a security developed to reflect a specific index or collection of different securities. ETFs are comprised of underlying assets such as shares of stock, bonds, oil futures, gold bars, foreign currency, or other financial instruments that are divided into shares.^[4] Perhaps the most popular and widely known ETF is the Spider, which tracks the S&P 500 Index and can be traded under the ticker \$SPY. Unlike mutual funds, ETFs can be traded like a stock on an exchange.

³ I. Staff, “Mutual Fund,” Investopedia, 15-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/m/mutualfund.asp>. [Accessed: 29-Apr-2018].

⁴ C. F. A. A. Hayes, “Exchange-Traded Fund (ETF),” *Investopedia*, 03-Apr-2018. [Online]. Available: <https://www.investopedia.com/terms/e/etf.asp>. [Accessed: 29-Apr-2018].

2.1.4 Fixed Income

Fixed income, or bond investments, generally will pay a set interest rate over a given period of time, then return the principal investment. They have set interest rates and typically assume less risk than stocks, though their values can still fluctuate due to the current interest and inflation rates.

2.1.5 Currency

The foreign exchange market (forex), is the market responsible for the buying and selling of currencies. Unlike stocks, the forex market trades 24 hours a day 5 days a week. Foreign exchange markets are comprised of banks, commercial companies, central banks, investment management firms, hedge funds, and retail forex brokers and investors.^[5] On the foreign exchange market, an individual trades currency pairs. In a simple world, where there are only two currencies, the idea behind currency trading would be that either currency could increase or decrease in value due to many factors. This means that the value of one currency relative to the other increases or decreases, depending on which currency's value changed in which way. In the real world, there are many different currencies, each with its own value. This results in multiple currency pairs, which are simply the exchange rates for trading one specific currency for another. The main idea behind currency trading is to trade based on changes in a currency's value relative to another currency. For example, if a trader currently has US Dollars and predicts that the Euro is going to gain strength relative to the US Dollar, then the trader can trade for Euros, wait for

⁵ I. Staff, "Foreign Exchange Market," *Investopedia*, 14-May-2008. [Online]. Available: <https://www.investopedia.com/terms/forex/f/foreign-exchange-markets.asp>. [Accessed: 29-Apr-2018].

the value of the Euro to increase, then trade Euros for US Dollars. Because the trader is dealing in relative value, this sequence of events will result in this trader being in possession of more US Dollars than before the trades were executed. It is the same idea as buying shares of a company, except the shares are currencies, and they can be traded for any other currency.

2.1.6 Commodities

Commodities are physical goods, such as gold, crude oil, natural gas, or corn. The sale and purchase of commodities is usually done through futures contracts on exchanges. These contracts standardize quantity and minimum quality of the commodity being traded. When the contract expires, the holder actually owns the physical property. For example, if an investor bought a contract for 5000 bushels of apples and let it expire, he would own 5000 bushels of apples. The price of the contracts are predetermined, so the value of these contracts fluctuates based on what happens to the price of the goods after the contract is sold. For instance, if an investor bought a contract for a commodity at a certain price, and then the actual price of the commodity increased, then the contract would be worth more.

2.2 Market Types

There are numerous financial instruments that are profitable to trade, however some of the most popular among investors and day-traders alike are stocks, derivatives, and foreign exchange markets, also known as “forex.” A trader should approach all three of these particular markets differently and tailor his trading systems accordingly. Some traders may find it difficult

to develop a strong understanding of multiple markets and instead decide to specialize in a single financial market and cultivate a mastery of the patterns and tendencies in their particular field.

Stocks constitute a share of ownership in a company. Generally, if a private company needs capital in order to grow, they will sell shares of ownership on the stock market. Companies have a legal responsibility to operate in accordance to the interest of the shareholders, so ownership of over 50% of the stock of a company essentially constitutes ownership of the company. There are a few ways that traders and investors can profit off of the purchase of stocks; namely by entering into temporary long or short positions, and by collecting dividends. A dividend is simply a percentage of the company's earnings, proportional to an investor's share of ownership based on his shareholdings, although not every company pays dividends to its shareholders. The value of a share in a company is simply determined by the supply and demand of that share, however this often correlates to an expected return from dividends. The prices of stocks fluctuate based on announcements from the company, like expected profits, employment numbers or even upcoming projects. Shares in the company also sometimes give the owner voting rights at shareholders' meetings.

Derivatives are securities that have a value dependent on a separate asset, like stocks, bonds or commodities. The most commonly traded derivatives are called futures contracts. Futures contracts are like a bet between two entities based on the future price of a commodity, stock or bond; they are an agreement to buy or sell the underlying asset at a future date for a specific price. Two parties often will have different predictions for the price of an asset in the future, so futures contracts can allow one to profit off of his correct prediction, without buying or selling the asset. Modern futures contracts are often cash settled. If a trader buys a futures

contract for 10,000 barrels of crude oil at \$70 a barrel in 1 year, neither party needs to own the oil, the calculated profit is paid in cash. Futures contracts are traded on exchanges just like stocks. Similar to futures contracts, there are derivatives called “options” which are different in that the buyer of an options contract does not have to ultimately follow through with the exchange at the end of the contract. It is important to note that with options that the value of the contract/exchange drops to zero if the buyers prediction was incorrect because the buyer is not obligated to perform the transaction if it is not profitable.

Foreign exchange markets are markets that exchange currencies. Forex markets are extremely liquid and include most of the world's currencies. The values of currencies are determined speculatively based on a number of economic indicators including imports, exports, employment, housing and the performance of various economic sectors. The Forex market is the largest market in the world in terms of value exchanged. Currencies are traded in pairs like EURUSD, USDGBP and USDCAD. Because of the high volume (over five trillion dollars a day) and copious fluctuation due to speculation, currency pairs are very popular to day trade and swing trade. The high volume also makes it one of the easiest markets to short, as traders can always find buyers and sellers looking to exchange. This gives a lot of flexibility for designing trading systems in forex, because traders can profit off of both bullish and bearish trends. Additionally, because of the number of currency pairs available, traders can profit off of several different pairs at once.

2.3 The Stock Market

To become a successful trader or investor it is important to not only have an understanding of the various asset classes and market types, but to also have a solid foundation of how the financial markets operate in addition to the various patterns that occur. This section will discuss what a stock exchange is and how it operates, followed by what an index is and how popular indexes can be leveraged to make well-informed decisions. Lastly, market sentiment, trend and cycle, and sector rotation will be discussed in order to identify common patterns and strategies when watching the market.

2.3.1 Exchanges

A stock exchange is a financial institution which facilitates the buying and selling of stock.^[6] Stocks can be traded on one or more of several possible exchanges such as the New York Stock Exchange (NYSE). In order for a stock to be listed on an exchange, a company must first conduct an initial public offering (IPO). An IPO signifies the first time shares of a company can be purchased by the public. Prior to an IPO, a company is considered private and generally consists of a small number of shareholders comprised of early investors (such as founders, their families and friends) and professional investors (such as venture capitalists).^[7]

The NYSE is considered the largest equities-based exchange in the world with a total market capitalization of \$20 trillion. The exchange is located on Wall St. in New York, New York and has existed since 1792. Many of the large corporations individuals are familiar with are

⁶ D. Harper, "Getting to Know the Stock Exchanges," *Investopedia*, 05-May-2017. [Online]. Available: <https://www.investopedia.com/articles/basics/04/092404.asp>. [Accessed: 25-Mar-2018].

⁷ C. F. A. A. Hayes, "IPO Basics: What Is An IPO?," *Investopedia*, 24-Mar-2017. [Online]. Available: <https://www.investopedia.com/university/ipo/ipo.asp>. [Accessed: 25-Mar-2018].

listed on the NYSE such as General Electric, Walmart, Coca Cola, and many more.^[8] The physical location of the exchange was initially meant to be used as the place of business for trading to occur, however, due to the success of the internet, many trades are now placed electronically. The NYSE generates revenue through transaction fees, listing fees, data fees, and trading software.^[9]

2.3.2 Indexes

To gain a better understanding of how the market is performing as a whole, investors typically turn toward stock indexes. An index is a small sample of the market, similar to a portfolio, that is representative of the market as a whole. Ideally, an index is setup in such a way where a change in the price of an index represents an exactly proportional change in the stocks included in the index. In other words, if an index rises by 1%, then the value of the stocks that comprise that index have also risen by a net of 1%.

While today there are many different stock indexes that exist, the first of its kind and still one of the most popular was created in 1896 by Charles H. Dow known as the Dow Jones Industrial Average (DJIA). Initially the DJIA was simply an average of the top 12 stocks in the market. Since its inception, revisions have been made to the DJIA to more accurately reflect current market conditions. Today, the Dow uses a form of price-based weighting in a portfolio of 30 stocks in order to calculate its index.^[10]

⁸ “The New York Stock Exchange,” *NYSE: Listings Directory - Stocks*. [Online]. Available: https://www.nyse.com/listings_directory/stock. [Accessed: 26-Mar-2018].

⁹ S. Seth, “How The NYSE Makes Money,” *Investopedia*, 05-May-2015. [Online]. Available: <https://www.investopedia.com/articles/investing/050515/how-nyse-makes-money.asp>. [Accessed: 25-Mar-2018].

¹⁰ J. Folger, “Index Investing: What Is An Index?,” *Investopedia*, 05-Dec-2017. [Online]. Available: <https://www.investopedia.com/university/indexes/index1.asp>. [Accessed: 25-Mar-2018].

Another popular index is the S&P 500. The S&P 500 is widely regarded as the best single measure of large-cap U.S. stocks. The index incorporates the top 500 U.S. companies in leading industries, and captures about 80% coverage of available market capitalization.^[11] Many traders and financial institutions use the S&P 500 as a benchmarking utility to assess their individual performance compared to the broader market.

2.3.3 Market Sentiment

Market sentiment is the overall attitude of investors toward a particular security or financial market.^[12] Typically, market sentiment refers to a relatively short period of time and is particularly important to day traders and technical analysts that rely on technical indicators. However, market sentiment may also apply to the feeling or tone of the market over an extended period of time.

Market sentiment is commonly associated with bearish or bullish terminology. When investors claim a market is bearish, stock prices are going down. Conversely, when the market is bullish, stock prices are going up. It is important to note that market sentiment does not always accurately reflect the fundamental analysis of a stock and is generally influenced by emotion.

2.3.4 Trend and Cycle

Trend and cycle are principles defined in Macroeconomics attributed to the expansion or recession of an economy at any given point in time. In the United States the long term trend is

¹¹ J. Folger, "Index Investing: The Standard & Poor's 500 Index," *Investopedia*, 05-Dec-2017. [Online]. Available: <https://www.investopedia.com/university/indexes/index3.asp>. [Accessed: 25-Mar-2018].

¹² I. Staff, "Market Sentiment," *Investopedia*, 18-Jan-2017. [Online]. Available: <https://www.investopedia.com/terms/m/marketsentiment.asp>. [Accessed: 26-Apr-2018].

generally positive, despite the occasional recession. The cycle can be defined as a sinusoidal pattern in economic data resulting from periods of economic boom and busts. During a boom, economic growth is above the trend line, generally resulting in unemployment falling. During a recession, economic growth falls below the trend line. Depending on the individual, one might wish to short during downtrends and go long during uptrends.

2.3.5 Sector Rotation

Sector rotation is an investment strategy that involves moving money from one industry sector to another with the goal of beating the market. Traders may try to employ this strategy by paying close attention to economic news and trying to predict which companies could be successful in the next stages of an economic cycle.

2.4 Difference Between Trading and Investing

Trading and investing are two very different methods wherein the end goal is to attain a profit in the financial markets. Investing can be defined as an attempt to gradually build wealth over an extended period of time by developing a portfolio consisting of stocks, mutual funds, bonds, and other investment instruments and subsequently buying and holding these assets for an extended period of time. A typical investment strategy to generate higher returns over time is to reinvest profits or dividends into additional shares of stock. How long an investor chooses to hold onto his investment is up to the individual. However, investments are typically held for a period of multiple years enabling the investor to take advantage of perks such as interest, dividends, and stock splits. Additionally, since the market is fluid and prices will inevitably

fluctuate, long term investors are less concerned with downtrends in the market expecting prices to ultimately rebound and recoup any losses they may have experienced.

Trading typically requires more effort on behalf of the trader. Unlike investing, trading involves more frequent market activity via the buying or selling of stock, commodities, currency pairs, or other instruments with the end goal of outperforming a traditional buy and hold investment approach. Profits from trading are generated by entering the market at a lower price and selling at a higher price within a relatively short period of time.

2.5 Efficient Market Hypothesis

The efficient market hypothesis, developed by Eugene Fama, is a controversial theory stating that it is impossible for an individual trader to outperform the market as share prices always incorporate and fully reflect all relevant information. It is important to understand the fundamental difference between trading and investing when considering the significance of the efficient market hypothesis. This distinction between trading and investing has stemmed from this polarizing theory.

Evidence exists both supporting and rejecting the efficient market hypothesis. During 2012, Eugene Fama and Kenneth French published a study showing that the distribution of abnormal trades were in accordance to what would be expected of inexperienced traders.^[13] However, many financial moguls such as Warren Buffet have continually produced above average returns, contradicting the efficient market hypothesis.^[14]

¹³ E. F., K. R., and Fama, "Size, value, and momentum in international stock returns, by Fama, Eugene F.; French, Kenneth R.," *Journal of Financial Economics*, 01-Jan-1970. [Online]. Available: <https://ideas.repec.org/a/eee/jfinec/v105y2012i3p457-472.html>. [Accessed: 26-Apr-2018].

¹⁴ I. Staff, "Efficient Market Hypothesis (EMH)," *Investopedia*, 28-Sep-2016. [Online]. Available: <https://www.investopedia.com/terms/e/efficientmarkethypothesis.asp>. [Accessed: 26-Apr-2018].

2.6 Fundamental vs Technical Analysis

Fundamental analysis is a method used when assessing the value of a security.^[15] Looking at qualitative and quantitative factors of a company can help investors determine whether the price of the stock is correct. For example, if the price is steadily increasing, but through fundamental analysis it is determined that the company is not performing well, then the price is being driven up by investors rather than being driven up by the company doing well. That would be a good indicator that shorting the stock is a good idea. There are a variety of things that one can look at when using fundamental analysis, but common factors include: earnings, profit margins, return on equity, price to earnings ratio, and price to book.^[16]

Technical Analysis is a trading technique employed to attempt to predict a security's future movement by analyzing statistics gathered from trading activity.^[17] This differs from fundamental analysis because a trader who uses technical analysis is making decisions based on the movements of the stock rather than the intrinsic value of a company. A well known technical analysis concept is the idea of support and resistance. Support is a price level where a downtrend is likely to pause. This is because demand levels will be high enough to stop the price from being driven down. Resistance is basically the opposite; as the price increases, more people will be selling their shares, and there will not be enough demand to keep the price increasing.

¹⁵ I. Staff, "Fundamental Analysis," *Investopedia*, 20-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/f/fundamentalanalysis.asp>. [Accessed: 26-Apr-2018].

¹⁶ "5 Important Elements in Fundamental Analysis," *EuroInvestor*. [Online]. Available: <http://www.euroinvestor.com/ei-news/2012/02/12/stock-school-5-important-elements-in-fundamental-analysis/15694>. [Accessed: 26-Apr-2018].

¹⁷ I. Staff, "Technical Analysis," *Investopedia*, 24-Apr-2018. [Online]. Available: <https://www.investopedia.com/terms/t/technicalanalysis.asp>. [Accessed: 26-Apr-2018].

Though fundamental and technical analysis differ from each other, that does not mean that they cannot be combined when creating a strategy. For example, fundamental analysis could be used to pick stocks that fit a certain criteria, and technical analysis could be used to trade them.

2.7 Portfolio Management

Portfolio management is a methodology followed by investors to avoid high exposure in a particular market or stock through proper asset allocation and diversification.^[18] An investor who subscribes to the efficient market hypothesis may wish to take a passive approach to portfolio management by investing in an index fund. Conversely, those who believe they can outperform the market actively manage their portfolios using technical analysis to select their holdings and the continual rebalancing their portfolios. An investor can rebalance his portfolio whenever he sees fit, however, typically investors rebalance their portfolio quarterly, bianually, or yearly.

Since it is impossible to always predict winners in the market, it is important for an investor to diversify his portfolio. A properly diversified portfolio allows an investor to reduce his exposure to any particular market in the event an asset begins to perform poorly. Additionally, proper diversification allows an investor to capture the returns of all sectors with less volatility at any given time.

¹⁸ I. Staff, "Portfolio Management," *Investopedia*, 03-Dec-2015. [Online]. Available: <https://www.investopedia.com/terms/p/portfoliomanagement.asp>. [Accessed: 26-Apr-2018].

2.8 Trading Platforms and Brokerage Accounts

Every trader needs an avenue to reason about a market, test his hypotheses, and place his trades in order to enter or exit positions to make a profit. A trading platform is a piece of software run locally or from a web server that allows traders to chart symbols from different financial instruments and do analyses over different time periods. A brokerage firm is simply an intermediary that connects buyers and sellers of a financial instrument. Often, the same trading platform will also allow the user to place trades, in which case they need their own brokerage firm, or at least a connection to one. For comparison, something like Yahoo Finance could be considered a charting platform, but not a brokerage. An application like TradeStation which allows the user to analyze charts and place trades is a combination of a brokerage and a charting or trading platform.

2.8.1 TradeStation

TradeStation made its debut in 1991 as an all in one platform which provides users with real-time and historical market data, advanced financial analysis tools, and a means to facilitate trades. Upon installation, TradeStation comes with a large number of pre-defined indicators, trading strategies, and analysis tools which individuals can then modify or use to create their own tools.^[19] The platform can be leveraged by both manual traders and automated strategy developers. TradeStation supports the development, testing, optimizing, and automation of trading. Users can choose to run these strategies on a simulated account before trading live.

¹⁹ “Award-Winning Trading Tools and Technology,” *TradeStation*. [Online]. Available: <https://www.tradestation.com/technology/>. [Accessed: 26-Apr-2018].

Figure 2.1 TradeStation environment with chart analysis window of \$AAPL

2.8.2 Other Alternatives

Unlike TradeStation, the other trading platforms listed below require a separate brokerage account that users must link to the platform in order to execute real trades. However, if a user wishes to only work with a simulated account, a brokerage account is not required.

QuantConnect

QuantConnect offers a web environment to develop, backtest, and run trading algorithms. It is possible to trade with a paper money account, but in order to execute real trades the platform requires the integration of a brokerage account. For traders that are relatively new to developing automated strategies, QuantConnect boasts an active community where users can ask questions

and receive help from other members. The platform currently allows traders to write their algorithms in C#, Python, and F#.

A potential drawback of QuantConnect is that it requires users to develop their strategies within the QuantConnect ecosystem. Should a more advanced user require more flexibility in how he develops his strategy, one might consider Zipline Live described below.

Zipline Live

Zipline Live provides a powerful API (Application Programming Interface) for users to build trading strategies on using Python. With Zipline Live, users are able to access current market data to feed into their systems. Like QuantConnect, Zipline Live will require a brokerage account in order to execute real trades. Zipline Live provides much more flexibility than QuantConnect since users are able to develop their systems directly on their computer rather than through a web interface.

2.9 Common Analysis Tools on Trading Platforms

Whichever trading platform a trader chooses to use, there are a handful of basic tools that one should expect to see on any platform. One of the most basic tools that is often taken for granted is the ability to view information in multiple different time frames. Another is the ability to add indicators to charts. Additionally, for any trading platform that allows traders to develop their own systems, there ought to be an optimization tool available for use. Further, it is important that there are analytical tools as well, such as walk-forward analysis, which is featured in TradeStation. Another basic part of trading system development is the usage of metrics;

without these, it is hard to say whether one system is better than another. Finally, screeners are a good addition to any trading platform, as they give the user the ability to pick assets based on many criteria. All of these tools are described in detail in the following sections, 2.8.1-2.8.6.

2.9.1 Time Frames

On a trading platform, traders will be able to view the charts of any particular financial instrument on different time frames. For example, they can view how an asset is traded on one, five, fifteen, thirty and sixty minute bars. Additionally, one can utilize longer time frames such as hours, days or weeks. The best traders will analyze a number of different time frames before placing a trade in order to draw conclusions from trends of different sizes. Traders use a technique referred to as “multiple time frame analysis”, which consists of monitoring one currency pair, stock or derivative over multiple time frames. Three periods is the most typical number to read, too many charts and the data will be redundant, but too few and there could be missing information.

Regardless of how long one intends to hold his position in the market, a trader should take into account a long-term time frame, a medium-term time frame, and a short-term time frame. The exact lengths of these time frames will, however, depend on how long a position is held. For example if the position is maintained for months, there will not be as much value in looking at minute or hour bars. The chosen long-term time frame should establish an overarching, dominant trend. Traders should not enter their positions on the long-term frame, however, they should remember when choosing their position that if they hold too long, the assets value will follow the longest term trend. If they want to short a long-term bullish trend, do

not hold for very long. When viewing the medium-term time frame, there will be apparent deviations from the larger trend. This will present opportunities to profit against the broader trend. The short-term time frame is where traders should be placing their trades, because this is where every small variation in price can be viewed. The long-term trend should not even be discernible in the shortest time frame, but remember that the shortest charts will eventually follow the longer ones.

2.9.2 Indicators

An indicator is a mathematical calculation based on a security's price, volume, or open interest.^[20] In technical analysis, traders use indicators in an attempt to predict future price movements. Each indicator attempts to uniquely identify a phenomenon, and often times traders will use multiple indicators in combination in order to define a set of rules for entering or exiting a position. This section details several different indicators as well as how traders employ these indicators within their strategies. Having a basic understanding of these may lead to inspiration for a new strategy that gives a trader the edge over the rest of the market.

Volume

Volume is an extremely important indicator to be aware of when developing trading strategies. Markets with high amounts of volume are referred to as liquid markets. A liquid market ensures a trader will be able to execute his trades in a timely fashion. On the other hand,

²⁰ I. Staff, "Technical Indicator," *Investopedia*, 18-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/t/technicalindicator.asp>. [Accessed: 29-Apr-2018].

an illiquid market, a trader may get stuck in a position due to a lack of interest amongst other traders.

Traders use volume in technical analysis to measure the relative worth of a market move. If a market is making a strong price movement, then the strength of the movement directly correlates to the volume for that period. The higher the volume during a price move, the more significant the move.^[21] Additionally, volume may be used as an indication of which direction the price will move. In a bullish market, an increase in volume over time may guarantee a bullish pattern in the future. During a bearish market, low volume may suggest profit taking whereas high volume on the downtrend suggests shorts piling in.

Volume Weighted Average Price

The Volume Weighted Average Price (VWAP) is calculated by adding up the dollars traded for every transaction and then dividing by the total shares traded for the day ^[22]. Typically investors are satisfied when they buy shares below the VWAP signifying an efficient trade was made. A disadvantage of using the VWAP can take effect when data becomes stale as a result of calculating the VWAP too far in the past. For this reason, traders typically limit VWAP calculation to one day of trade data.

²¹ I. Staff, "Volume," *Investopedia*, 09-Nov-2017. [Online]. Available: <https://www.investopedia.com/terms/v/volume.asp>. [Accessed: 26-Apr-2018].

²² I. Staff, "Volume Weighted Average Price - VWAP," *Investopedia*, 25-Jul-2015. [Online]. Available: <https://www.investopedia.com/terms/v/vwap.asp>. [Accessed: 26-Apr-2018].

Kaufman Efficiency Ratio

The Kaufman Efficiency Ratio is a measure of efficiency. It is calculated by dividing the price change by the absolute sum of the price movement.^[23] The result is a number between 0 and 1, with high values indicating a more efficient trending market. A higher efficiency means that during a time period, the price moves mostly in one direction.

Moving Average Convergence Divergence

The Moving Average Convergence Divergence (MACD) indicator is a trend following indicator that shows the relationship between two moving averages of prices. It is calculated by subtracting a long term exponential moving average from a short term exponential moving average.^[24] For strategies, a trader can plot a signal line over the MACD to function as a trigger for buying and selling. Traders will also often look for other indicators to use in conjunction with the MACD.

Bollinger Bands

Bollinger Bands are volatility bands placed above and below a moving average. The bands will automatically widen and contract when volatility increases and decreases, respectively.^[25] Bollinger Bands can be used to identify a variety of different patterns, and because they are so dynamic, traders use this indicator in a large variety of places.

²³ “Kaufman's Efficiency Ratio (ER) « ETF HQ,” *ETF HQ*. [Online]. Available: <http://etfhq.com/blog/2011/02/07/kaufmans-efficiency-ratio/>. [Accessed: 26-Apr-2018].

²⁴ I. Staff, “Moving Average Convergence Divergence - MACD,” *Investopedia*, 13-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/m/macd.asp>. [Accessed: 26-Apr-2018].

²⁵ “Bollinger Bands,” *StockCharts.com*, 18-Sep-2017. [Online]. Available: http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:bollinger_bands. [Accessed: 26-Apr-2018].

Keltner Channels

Similar to Bollinger Bands, Keltner Channels are volatility based lines set above and below an exponential moving average. Instead of using the standard deviation like the Bollinger Bands, Keltner Channels use the Average True Range (ATR) to set the position of the lines. The exponential moving average dictates direction and ATR determines channel width.^[26]

2.9.3 Optimization

A trading system may be composed of several trading strategies. As is discussed in Chapter 4, there are many different types of strategies. Each of these strategies is essentially a set of rules that determine what actions to take regarding a financial instrument. One such strategy could be based on the simple moving average (SMA) of a stock. SMA is the sum of the prices of a financial instrument over a past number of bars, divided by the number of bars. In order to calculate SMA, one has to determine the number of bars over which the SMA is calculated; this is called an “input.” A trading strategy could be based on several conditions, therefore requiring several inputs. One example of such is a strategy that buys when the 9-day SMA crosses above the 25-day SMA. The two inputs in this case are set to 9 and 25, but they each could be any number. A lot of the time, it could be unclear to the trader what the best input is for his trading strategy.

One method of determining the best input is called “optimization.” Optimization tries many values in a range for an input, keeping track of the best ones by testing how the strategy

²⁶ “Keltner Channels,” *StockCharts.com*, 20-Dec-2017. [Online]. Available: http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:keltner_channels. [Accessed: 26-Apr-2018].

would perform on past data. This is typically performed using some computer software, such as TradeStation's Strategy Optimization tool. Another key aspect of optimization is how it determines what the "best" input value is. One might want it to simply maximize the amount of money that a strategy makes, as that is generally what a trader's goal is. However, that might not guarantee the best performance in the future. For this reason, there are many different rules that a trader can use for picking the best input when optimizing. Some other rules include: maximizing the percentage of winning trades, maximizing the win-to-loss ratio of trades, maximizing the number of consecutive winning trades, and minimizing maximum adverse excursion. Picking which rules to optimize for is largely up to each trader's preference. There are many other rules than the ones listed above, though none of them guarantee future performance. This is due to an idea called "overfitting," which is when a system or strategy is optimized to perform well on past data, but does not perform well in the future. When optimizing and testing a trading system, it is important to keep overfitting in mind and to ensure that the results can translate well into the future.

2.9.4 Walk-Forward Analysis

One way to combat overfitting is to use a process called "walk-forward analysis." Walk-forward analysis is a technique that optimizes a system using data from a sample in a time frame, then tests the performance of the system using data from outside of that sample. This technique can also be used with systems that are currently in-use to verify that they are still performing well. For example, the system could be optimized over 7 weeks, then tested on the most-recent week of data. If it performs as well as expected, the system stays in use. The next

week, walk-forward analysis is performed again, but the time frame is shifted forward by one week. This continues on, each week the time frame stepping forward, hence why it is called “walk-forward analysis.”

2.9.5 Expectancy, Expectunity, System Quality, and Sharpe Ratio

Another key to evaluating a trading system is to quantify it using metrics that allow comparison to other trading systems. Four such metrics for this purpose are called “expectancy,” “expectunity,” “system quality,” and “sharpe ratio.”

The first metric, expectancy, is the simplest. Expectancy is the profit or loss per each dollar risked on each trade of a trading system. This must be computed based on current trading data for a trading system, whether this is from real trading or backtesting. It is better to have a high, positive expectancy. A negative expectancy would mean that a trading system is expected to lose money, based on its past performance. This would clearly be bad. Based on the definition,

in order to calculate expectancy, the amount risked for each trade needs to be known. One definition of “risk” is the amount that a trader is willing to lose on any given trade. For example, if the trader buys a share worth \$40 and decides that he will exit the trade to preserve his capital only if the share drops to \$30, then the risk for this trade is \$10. This definition might not work, however, for some trading systems, since a system does not necessarily have an exit rule that is that clear-cut. It could be based on several indicators, and the amount lost on each trade might vary widely. In this case, it makes more sense to use either the average loss, or the maximum loss across all of a system’s trades. Using the average loss is probably closer to the risk that a system might see over most trades, but a higher expectancy calculated using the maximum loss is

much more meaningful. Whichever value is chosen, it is then used to calculate the R Multiple for each trade. The R Multiple for a trade is the profit or loss for the trade divided by the Risk for the trade. From here, expectancy of a system is simply equal to the average of all of its R Multiples.

The next metric is expectunity, which is based on expectancy. Expectunity is annualized expectancy, or the profit or loss per dollar risked per year. This should give a general idea of how a trading system performs over a full year. Expectunity is calculated by multiplying the expectancy of a trading system by the total number of trades it made, divided by the number of years over which those trades were executed.

Third, system quality is a metric that can be used as a reference for how well a trading system will be able to perform using different position sizing rules. A higher system quality number indicates that a trading system could be more flexible with its rules, while a lower number may mean that it needs a more strict approach. The system quality metric for a system is calculated by dividing expectancy by the standard deviation of its R multiples, and finally multiplying this by the square root of the total number of trades that the system made.

Finally, sharpe ratio is the most widely-used metric for calculating risk-adjusted return. Sharpe ratio can be used to determine if a system is worth trading, because it is inherently benchmarked against risk-free assets, such as U.S. Treasury bonds. U.S. Treasury bonds are

“risk-free” because it is extremely improbable that the United States’ government would not honor these contracts. If this situation arose, it probably would not matter because there would have to be a much larger issue at-hand, like a nuclear war. Risk-free assets have a sharpe ratio of 0, simply due to the definition of sharpe ratio. A negative sharpe ratio means that it would be more profitable to invest in risk-free assets than to invest money in a particular trading system. A positive sharpe ratio means that a trading system is more profitable than risk-free assets. To calculate the sharpe ratio for a trading system, the return of the best risk-free investment is subtracted from the average return of the trading system. That value is then divided by the standard deviation of the trading system’s returns, resulting in the sharpe ratio of this system. Sharpe ratio can be used to analyze the potential risk-return characteristics of a trading system; and although it is no guarantee of returns, combining it with other metrics can give a trader the information he needs to decide whether or not to put a system into action.

2.9.6 Stock Screeners

A stock screener allows traders and investors to query a large amount of market data and filter the results based on some user-defined criteria. For example, some commonly used filters for screening include price, volume, market capitalization, price-to-earnings ratio and many more. Incorporating a stock screener into a trading or investment strategy will significantly benefit the individual as it requires forethought to identify which components of a stock matter

most to the individual. Strict rule-based strategies are helpful in avoiding personal biases and emotional trades.

Stock screeners have a variety of uses in trading and investing. A screener may be used by day traders in order to identify potential stocks to trade for that day or by portfolio managers to build an initial portfolio or find stocks to rotate into their portfolio. There are many free stock screeners available online provided by services such as Yahoo Finance and the Nasdaq. While most free screeners are generally the same, some offer more filter criteria than others.

Figure 2.2 Yahoo Finance screening for mid-cap technology stocks

2.10 Order Types

When placing a trade manually or automatically, traders must understand the various types of orders at their disposal. Understanding the benefits and drawbacks of each type of order will help traders maximize their profits.

2.10.1 Market Order

Market orders are trades that ensure a long or short position is entered, but do not guarantee the trader a price. For example, if a market order for a long position is placed while a share is priced at \$5.00, but by the time the order is received by the broker the price has risen to \$5.50, the share will be purchased for \$0.50 more than originally intended. This is called “slippage,” the amount of money lost between the expected price and the price of the filled trade. Slippage is important to take into account, especially for markets that fluctuate quickly.

2.10.2 Limit Order

In order to remove slippage from their trades, traders often use limit orders. Limit orders ensure that the order is filled at a particular price or better, but do not ensure that the order will be inevitably filled. Limit orders will often fill very quickly in high volume markets, but in lower volume markets it may be difficult to ensure an exact price, especially if there is a large breadth between bids and asks.

2.10.3 Stop Order

There are also two kinds of stop orders, which are similar to market orders, however allow traders to specify a price at which the order will be executed. Stop-loss orders execute a market buy or market sell when the asset reaches a particular price. However it is important to note that these orders do not ensure that the order is filled at their specified price, because it is a market order. One major drawback of stop-loss orders is that if there is a large gap in the orderbook, there could be larger losses than expected. Suppose an investor purchases a stock which closes the day at \$10.00 a share, and he sets a stop loss for \$9.00, expecting 10% loss if the stop-loss fills. If the value crashes down to \$5.00 before the market opens the next day, there would be a 50% loss when the stop-loss triggers. To combat this risk of selling an asset far below the specified price, many seasoned investors will use stop-limit orders. Stop-limit orders are similar to stop-loss orders, but they execute a limit order instead of a market order when the asset reaches the specified price. Because a limit order is used, the order will only execute at the specified price or better, so the benefit of a stop-limit order is that if the market price of your asset crashes far below the stop-loss price, but then quickly recovers, the stop-loss will not fill at the bottom.

2.10.4 Other Types of Orders

A few more uncommon orders that experienced traders may use are Day Orders, Fill Or Kill Orders, Immediate Or Cancel Orders and Not-Held Orders. Day Orders are limit orders that expire if they are not filled the day they are placed. Fill Or Kill orders tell the brokerage firm to perform a transaction completely when it is received or cancel it, if it cannot be completely

filled. Fill Or Kill orders are good for purchasing large amounts of a security, and ensuring that it is placed at a desired price. Immediate Or Cancel orders instruct the brokerage to fill the order immediately, as much as it can, and cancel the rest of the order. If you want to scalp as much as you can of a cheap asset, Immediate Or Cancel orders are useful. Not-Held orders are when an investor wants to give the floor trader the discretion to seek a better price than the current market price. So if an investor believes that the floor trader may have better judgement than themselves, this type of order can be used. However, the investor may suffer losses from this type of order in a sudden market shift.

2.11 Buy & Hold

Someone who believes that he cannot systematically beat the market should use a buy and hold strategy. Generally speaking, this type of strategy involves selecting a diverse portfolio of stocks, ideally they will not be prone to large swings in price and will have low correlation with each other. This report will not go into much detail, but Modern Portfolio Theory is important to know for investors employing a buy and hold strategy. Modern Portfolio Theory is a theory on how investors can construct portfolios to optimize expected return based on a given level of market risk, given that risk is an inherent part of a higher reward.

2.12 Trading Systems

Every trading platform will give traders the ability to place trades manually, but ever since computers became accessible to the general public, more and more digital trading platforms have given users the option to program their own strategies and trade automatically.

Some of the major advantages of automated trading systems are that programs do not deviate from their rules, they can trade all day without getting tired or needing breaks, they can analyze more data at once, and they do not have emotions like greed and fear. However, automated trading systems are not without their drawbacks. For example, human traders are much better at analyzing fundamentals and accounting for them, for example an earthquake in Tokyo might affect the price of the yen, but a robot will not be able to take this into account. Additionally, manual traders gain experience over time, and may be able to “master the charts” and draw conclusions and make predictions based on their own intuition rather than technical analysis. There is also the possibility that a human trader is able to realize when a market is behaving erratically or unreasonably, and can decide not to place trades, or profit off of the instability. A robot cannot make these intuitive judgements. Finally, if trading automatically, the trading system may eventually stop performing as expected due to market changes. Markets change over time, and manual traders have the ability to adapt on the fly, but automated traders may need to retire old systems and write new systems entirely.

2.13 Manual Trading

For all traders, it is important to hold one’s self to a set of rules and follow them strictly. If a trader does not follow his own rules on when to enter or exit a trade, then he does not have a trading system, he is just making a bet. This is especially key for manual trading. Often times, emotion can get in the way, leading a trader to justify why something did not go as expected, rather than exiting the trade and readjusting his strategy. Given that it is possible to justify almost

anything, this can be a dangerous mindset to find one's self in. This is a reason that some people pay professionals to manage their own money.

A trader must avoid making emotional mistakes when trading his money. If he is capable of avoiding such mistakes, then he is on the right path to having a positive trading system. One way to go about this is to practice manually trading by paper trading. Paper trading is when a trader follows along with an asset in real-time, writing down the trades he would make at the time on paper. In this way, a trader can test a strategy and practice the trading mindset without risking money.

2.14 Automated Trading

For some traders, having an automated system is much more appealing than manually trading. Automated systems provide many advantages that manual trading does not. Platforms that support automated trading systems will often allow traders to backtest the system as if it were making real trades, but on past data. This allows a trader to accurately debug and optimize a system. This is not feasible with a manual system, because it is difficult to remove a trader's knowledge of what actually happened. Additionally, an automated trader will always do exactly what its rules specify it to do. This means that a trader does not have to have a strong will power to successfully use an automated trader. An automated system does not have to deal with emotion, and it will operate with precision. Another benefit to using an automated trading system is that it can put buy or sell orders in much faster than a manual trader could.

2.15 Monte Carlo analysis

Monte Carlo analysis is a method of determining probable outcomes of a trading system based on its past performance. Monte Carlo analysis uses random variables in an attempt to model the unknown factors in the market. Monte Carlo analysis plots the actual sequence of trades as it falls around the 95% and 5% confidence intervals of these random variables. One important aspect of Monte Carlo analysis is that it assumes a perfectly efficient market, so, for example, performing it on a system that is subject to a large amount of emotion would not necessarily be beneficial to a trader. Monte Carlo analysis can be useful for traders who are trying to determine the risk in their system. If the system falls out of the Monte Carlo analysis significantly, then it is a risky system. A trader must determine what his goals are before deciding to trade his system, meaning that if he does not want to lose a lot of money in a short period of time, he will want to reduce the risk of the system. Monte Carlo analysis can help a trader make this decision, but it is still a subjective decision. Therefore, utilizing multiple analysis techniques would be more beneficial than relying on Monte Carlo analysis alone.

Figure 2.3 Example of Monte Carlo analysis on an unreliable system

Above is an example of Monte Carlo analysis that has been performed on a system that overall made a profit, but it does not look very reliable. The Monte Carlo analysis was performed using a software called Market System Analyzer. The red line in the picture above represents the 5% confidence interval, the grey line the 50%, and the green line the 95%. During the first third of the system's trades, it was within the 5% and 95% confidence intervals, but in the middle section it fell significantly out of those intervals. From a statistical standpoint, this is very unlikely, which indicates that Monte Carlo analysis may not be a good predictor for this system. Another factor one could look at is the average loss compared to commission. The average loss including commission is about \$5 on this system. With a commission of \$8, that means that the average loss was made at a price above the entry price. So, putting in more equity to this system would decrease the average loss and could change the system entirely. In summary, Monte Carlo analysis is very useful for analyzing the risk of a system, but there are other metrics that are useful to determine how to improve a system.

Chapter 3: Methodology

This section details the approach a trader must follow in order to scientifically develop a strategy to trade on the financial markets. Although these may seem like guidelines, it is important to incorporate a unique perspective when developing a system. These can form a good starting point for building a system, but it is important to experiment with different ideas. The following methodology describes the approach used in this IQP to develop the automated systems.

3.1 Research

Before investing in the financial markets, it is important for a trader to understand everything there is to know about the markets. Knowing the terms and how to read a chart are the bare minimum. Following the news, especially economic news, is extremely important as well. Knowing the reasoning behind market activity will provide a trader with an advantage over those who do not. Making smart, and informed decisions can go a long way to maximizing returns on trades. Additionally, knowing common strategies that people use to trade can give a trader the upper hand on the markets. For example, if a trader knows that a common strategy is to buy after a certain pattern shows up, the trader can watch for the pattern and make a countermove that benefits themselves. The last aspect to consider when trading on the financial markets is that one must treat everything as a lesson so that he may learn from his mistakes or victories.

3.2 Systematically Beating the Market

The first step in creating a trading or investing strategy is determining whether or not the efficient market hypothesis is a legitimate limitation on potential returns (whether or not a trader can systematically beat the market). An active manager is a money manager that takes the stance that he can beat the market. Thus, an active manager would make trades with his money, and consistently move money between assets to try to maximize profits over a period of time. A passive manager is a manager who believes that the market is efficient and he cannot beat it. Thus, a passive manager would invest his money into low risk long term investments. Studies show that less than 25% of active managers outperform passive managers. Yet some people still believe that they are capable of outperforming the market. If it were easy, then everyone would be making money. But that is not possible, because someone must be getting a worse deal: if a person follows the strategy “buy low and sell high”, then someone else sold low and someone else bought high!

3.3 Finding an Edge

The final step of creating a successful system, if a trader believes he can systematically beat the market, is to find an edge. An edge is anything that can give the trader an advantage over the rest of the market. It is not an easy task, however, so a successful trader must constantly be looking for the next thing that will give them an edge. It is possible for a system to stop working for some period of time, and then eventually it might start working again. So having a variety of strategies that can be employed at different times will provide a resilient trading

system. A trader must constantly keep an eye out for improvement, if one system stops working, then he must substitute it for another.

Chapter 4: Trading System Development

In this chapter, the ideas and implementation details of each system are described. Each system was developed by an individual member of the group, starting with a hypothesis, followed by a methodology, and, lastly, the specific implementation details of the system. A brief overview of the system performance is mentioned before discussing the next system. However, a more in depth analysis of the system performance is described in the following chapter.

4.1 Pre-Market Gaps

While the general population may see the stock market as a get rich quick scheme, outperforming the market and generating a profit can require a lot of time and effort. Long term exposure to the market invariably introduces risk: policy changes, earnings reports, the economic calendar, and many other factors may positively or negatively affect a long term investment. It is ultimately the investor's responsibility to keep up with current events to ensure an investment is safe and performing as expected.

As a university student with limited time, an intraday strategy was appealing since short term positions require less maintenance than positions lasting for an extended period of time. For this reason, this system will never hold a position overnight despite potentially losing money when selling a position prior to market close.

4.1.1 Hypothesis

In general, more advanced investors and traders profit from the behaviors exhibited by amateurs. A perfect example of this is a technique referred to as stop hunting. Stop hunting is a

strategy that attempts to force some market participants out of their position by driving the price of an asset to a level where many individuals have chosen to set their stop-loss orders.^[27] For this reason, if one were able to understand the patterns more advanced traders follow, it may be possible to make winning trades by entering and exiting alongside experienced traders.

Day trading provides a perfect opportunity to test this hypothesis. New traders are often attracted to financial markets through the allure of producing exceptional returns in a short time frame. Of course the opposite usually occurs, with experienced traders buying at their desired price, waiting a bit, and dumping their shares while taking a profit. The amateur traders enter the market just before the experienced traders exit the market and subsequently watch their investment decline. In a panic, they sell their shares which are purchased by the experienced traders and the cycle continues.

4.1.2 Methodology

The most important aspect of this strategy is the pre-market screening done between the hours of 9:00 AM - 9:30 AM. Pre-market data usually comes at a premium and requires a monthly payment to a service which offers access to such data. The screener utilized by this strategy is FinViz Elite which costs \$39.50/month and provides access to pre-market data in addition to many other features.

The screening criteria is used to identify stocks in the pre-market that have a high chance of continuing to breakout after a pre-market gap. The goal of the pre-market screen is to identify stocks that other experienced day traders are interested in. Since this strategy performs poorly

²⁷ I. Staff, "Stop Hunting," *Investopedia*, 21-Apr-2018. [Online]. Available: <https://www.investopedia.com/terms/s/stophunting.asp>. [Accessed: 26-Apr-2018].

when volatility is relatively stagnant, an ATR of greater than 0.5 for the past 14 days is applied. Average volume and current volume also play a large role in identifying stocks that the strategy would be successful trading. In order to provide a liquid market, an average volume of over 300k during the recent 3 month period is applied. Additionally, a current volume of over 100k is desired to ensure there is enough interest in a particular stock during the pre-market. Lastly, a gap filter between 4% and 10% is applied to identify potential big movers when the market opens. A limit of 10% has been used for the gap filter since it has been observed that stocks gapping more than 10% have a lower chance of continuing to breakout when the market opens.

Figure 4.1 Pre-market screening on Finviz

Once a list of stocks has been selected, the price and volume are analyzed in addition to any news reports that may indicate the price of stock will continue to rise when the market opens. The strategy is applied to these symbols via a 2-minute candlestick chart. Each bar is analyzed and the information regarding the last green and red bar is constantly monitored. Leveraging this information, the strategy executes buy and sell orders which will be described in the section below.

4.1.3 Entry/Exit Conditions

This strategy performs best on 2-minute bars – 1-minute and 5-minute bars were also tested but on average drastically reduced the profit factor of the strategy. There are several conditions considered in determining whether or not to enter the market. A combination of daily highs, candlestick patterns, and volume weighted average price are analyzed in the entry code.

The strategy first looks at the high of the previous day and compares that to the price at market open. It is not uncommon for traders to look at a variety of timeframes to help determine which position should be taken at the present time. Based on historical trading data, it has been determined that it is unwise to expect a stock to continue trending upward after a gap if its opening price for the current day is not greater than the high of the previous day. For this reason, the strategy prevents entering a market where this occurs.

Perhaps the most important component of this strategy, aside from the pre-market screening, is the constant monitoring of the previous green and red bars. The color of the bar is determined by its opening and closing price. When the close is greater than the open, the bar is represented with green. Conversely, when the close is less than the open, the bar is represented with red. At any given time, only the most recent green and red bars are tracked. When the open of the next bar breaks the high of the previous red bar the system considers entering the market.

The last condition that must be met for the strategy to enter the market depends on the difference between the open of the current bar and the VWAP. When building the strategy, it was apparent that the majority of losing trades resulted in a stock channeling between a small price difference. In order to prevent the strategy from entering into conditions like this, the VWAP can be leveraged to determine “false” breakouts. During a long period of channeling,

using VWAP data from the previous hour of trading will yield a value relatively close to the actual price of the stock. Therefore, taking the difference between the open of a bar and the current VWAP value should produce a number close to zero. Based on this behavior, it can be assumed that a larger gap between the open of the current bar and the VWAP indicates a potential breakout. Incorporating this logic into the entry condition drastically reduced the amount of losing trades as shown below in figures 4.2 and 4.3.

Figure 4.2 Entries prior to VWAP filter

Figure 4.3 Entries after applying VWAP filter

4.1.4 Results

Depending on the available capital for each position returns vary. Allowing more money to be allocated in a position can drastically improve the overall returns. Initially, 15% of the capital was provided as purchasing power for each position. It is important to note that this does equate to a \$15,000 risk since a stop loss is used to prevent completely losing the entire position. Based on these parameters, the system made a 5% return over the course of a two month period executing 133 in total as shown in figure 4.4. The largest loss was \$1,717.60 with a max drawdown of \$2,801.24.

Figure 4.4 Pre-market gap strategy with 15% available capital per position

Increasing the available capital per position to 50% produced a return of 21.86% over the same two month period and 133 trades as shown in figure 4.5. However, the largest losing trade increase to \$5,689.60 and max drawdown to \$9,189.24.

Figure 4.5 Pre-market gap strategy with 50% available capital per position

4.2 Whole Breakouts

This system is a breakout system, meaning that it looks for quick bursts in price movement, and typically trades on a short to medium time period.

4.2.1 Hypothesis

This strategy trades around the type of numbers commonly referred to as “The Wholes.” The Wholes are numbers such as 1, 5, and 10 that seem appealing to people. In a scenario where a stock is decreasing in price, many amateur investors will settle on The Wholes as exit points to preserve the rest of their capital, while many others will eye these prices as good entry points; they may think, “\$10.00 is the lowest I will hold,” or “Wow! \$10.00 is a great deal!” Similarly, there are many investors that will set stop-losses near The Wholes. Large investors tend to be aware of this; and they can abuse this fact by selling shares, thereby dropping the price below

trader's stop-losses, then buy the shares that those stop-losses are selling at a discounted price. Finally, the stock will increase in price, as the larger investors expected the whole time, and those investors will cash in on the profits from the shares that they were originally holding plus the shares that they purchased from other traders' stop-losses.

The end result of such behavior is the formation of predictable patterns when there is a lot of price-action in stocks. A stock that is worth, for example, \$10.50 and decreasing may see a lot of investors buying shares when it finally drops to \$10.00. This increase in buying pressure tends to either stop a decrease or result in an increase in price. At this point, one of two things tends to happen. The price either "bounces off" the \$10.00 level, due to an increase in buy orders, or it breaks below it due to traders selling lower and lower. Around this time is where this trading system comes in. The goal for this system is to detect this sort of price-action around The Wholes and subsequently enter when it seems clear which direction the price is going.

4.2.2 Methodology

In order to actually put this system to work, it is important to first identify what "Whole" increment to use. Depending on the stock, it could be \$1, \$10, or some other similar number. Generally, it is easy to estimate what will work best for a given stock. For instance, if some stock is currently worth \$12.75, one could guesstimate that \$0.50 or \$1.00 could work. To find the interval that works best for a symbol, a good method to use is to use an optimization tool. After optimising, it is generally a good idea to use Walk-Forward Analysis to ensure that whatever value chosen could work in the future.

Next, it is key to decide at what point some price action near the Whole level should be considered to be “testing” it. A strict rule, only considering it “testing” if the price crosses over the level, could be used; but this may not catch moves that are just barely out of reach. Less strict rules could be used, but if they are too loose then it could catch moves that are not even close. One rule that could be used is if the price is within some percentage of the Whole increment relative to the nearest Whole level. The exact percentage could be optimized for, but the goal is a rule that is consistent and strict, while not too strict.

Third, after a level has been tested or broken through, the next step is entering a trade. It may not be apparent which direction the price will go in, as this system is based on the idea that the price could break-out up or down at any Whole level. A rule such as entering when the price has crossed over the Whole level plus or minus some percentage of the Whole increment could help. As usual, the exact percentage could be determined with optimization. Waiting for the price to move a certain amount before entering a trade will make choosing the correct trade more likely. In addition to choosing when to enter a trade, it is important to choose a position sizing strategy. Going all-in on every trade can be very profitable when a system makes winning trades, but it hurts a lot more when it loses. If a system makes a trade that increases its capital by ten percent, then a trade that decreases its capital by ten percent, then the system lost money overall. This applies, of course, for any amount of money that is put into a trade, but it hopefully illustrates the point that losing hurts more than winning helps.

Finally, the system has to exit a trade somehow. “Buy low, sell high” is a great idea, but determining when “high” is can be difficult. Also, not all trades are going to be profitable. It is key to choose an exit strategy that minimizes losses and maximizes gains. It may mean that not

every trade sells at the exact peak value, but rather over all of a system's trades it exits at an ideal point. There are many different exit strategies, and which one to use is entirely up to personal preference, though it usually aligns with which one happens to make the most money!

4.2.3 Entry/Exit Conditions

The actual implementation of these rules for this project follow. To determine the Whole increment, optimization is used to determine what could work best for each symbol. For example, when backtesting over 500 days on \$AMD, optimization determined that \$0.50 achieved the greatest returns in that period. In contrast, over 500 days on \$SPY, optimization determined \$1.50 to achieve the greatest returns. Which interval to use depends on the symbol, so there is no one-size fits all rule for this. Next, the system decides that a level is being tested if the price moves within ten percent of the Whole increment of the level. Third, it enters a trade when the price moves ten percent away from the Whole level. Finally, it uses a Parabolic SAR rule, combined with simple moving average. If the two indicators align to signal an exit, then the system exits the trade, regardless of profit or loss.

In addition to these rules, a profit target exit strategy was included in this system. This is because the system occasionally would stay in a profitable trade, only for it to gap in the opposite direction, resulting in a loss. The profit target is optimized for the best value to avoid losing still-good profits.

4.2.4 Results

The system was tested on stocks over one year, utilizing all of its equity for each trade, starting with \$100,000. It earned \$28,945.55 in this time period, which is 28.95%. The percentage of winning trades was 32.92%, while the ratio of average winning trade to average losing trade was 2.7. Looking at the equity curve, figure 4.6, the system has its ups and downs.

Figure 4.6: Whole Breakouts Equity Curve

As a day-trading system, it trades very frequently; and given that it loses more frequently than it wins, it tends to swing back and forth fairly consistently. However, looking at the Monte-Carlo Analysis, figure 4.7, the actual sequence of trades fits mostly within the two confidence intervals. This generally indicates that the Monte-Carlo Analysis is a good measure of a system's ability to perform, and since the system won more than it lost overall, this is a good sign.

Figure 4.7: Whole Breakouts Monte-Carlo Analysis from Market System Analyzer

4.3 Kaufman Efficiency Day Trader

For trend following systems, it is possible that once a position has been entered, the trend could flip at any moment. This is not ideal. Ideally, a system should enter a position only when it is confident that the market conditions will continue to fit its entry conditions. In the case of a trend following system, when it buys in, one would hope that the price of the stock will climb, then the system exits.

4.3.1 Hypothesis

Once a trend has been discovered, a trader can measure the efficiency during the trend to determine the strength of the trend. A higher efficiency might indicate that a trend is stronger, and is more likely to continue in its current direction. A lower efficiency would indicate less confidence, and there would be a lower chance that the trend will continue.

4.3.2 Methodology

To measure efficiency, the Kaufman Efficiency Ratio is used. It is calculated by calculating the price change over a period and dividing it by the absolute sum of the price movements during that period.

In determining which stocks to pick, a screener was used. The goal was to find stocks that are likely to increase in price, so that way the system is more likely to enter into a winning trade. A CAN SLIM Screener was selected from aaii.com. Very basically, the CAN SLIM screener is designed to find stocks that have performed well last year and are performing well this year.

The position sizing strategy is fixed fractional, meaning that it will risk the same percentage of account equity on each trade. So if the system makes money on one trade, then it will be able to risk more money on the next trade because the overall account equity has gone up.

4.3.3 Entry/Exit Conditions

The system will enter a trade based on two conditions. The first condition is that it has detected an upward trend. The second condition is that the measured efficiency has to be above a certain threshold. This system was developed into two main versions. One version will sell when it has made a profit, or if a stop loss is triggered. The other version will sell only when it has made a profit.

4.3.4 Results

The version that has stop losses in general did not perform very well. Often times it would enter in at the right moments, but the stop losses would always trigger at inopportune times. The problem was that adjusting a stop loss would just shift the problem from one spot to another. With a less sensitive stop loss, it would stay in trades too long, and with an over sensitive stop loss, it would exit too fast. Every system has tradeoffs to make, but in this system both situations were performing negatively, so the system was tested without any stop losses.

The system without any stop losses performed well situationally. The only exit condition was that it would sell when it has made a profit, so if the price of the stock was going up there was not an issue, it would make money easily. The part of this system that is not appealing is the drawdown. For example, on a stock that has doubled in price over the past year, the system made about 8%, with a maximum drawdown of 1%. But on an ETF that is extremely volatile and has gone down substantially in the past year, it had realized gains of about 1.7%, and had a position in the market that was open for 8 months, and was down 5.6%.

Based on these results, the second version of this system is definitely viable, but selecting the right stocks is extremely important. It is easy to do in hindsight, but one can not know ahead of time if a stock is going to perform well. Pairing this strategy with a screener is almost essential. Additionally, it would be a good idea to manually monitor some of the trades that this system makes, because often times when it has entered a trade, it will miss other opportunities between when it buys and sells.

As a final test, the system was run on the symbol SPY with an initial equity of \$100,000. It wound up making 26% in a year, with an open trade worth -\$2,600, so adjusted it made about

23%. The SPY symbol was up about 18% over the past year when this test was performed. One thing to note with this set of results was that when the initial equity was only \$10,000 the system did not perform well because it was losing a lot of money to commission. Increasing the starting equity improved its performance by a huge magnitude (it went from making \$267 to making \$26,000).

Figure 4.8 Detailed Equity Curve of Kaufman Efficiency Trading System

Figure 4.9 SPY Symbol over the Past Year

As can be seen in these figures, the equity curve of the trading system heavily resembles the SPY symbol. This indicates that the performance of the system is dependant on the underlying symbol choice. One difference that should be noted is towards the end, the SPY symbol takes a big dip that the system manages to avoid.

Figure 4.10 Examples of Successful Trades

In the above figure, one can see a series of successful trades. This is close to optimal performance. One aspect that the system could have done better with is not buying at the peak on the left side of the image, and instead buying at the dip right after it. Another inefficiency is when it buys and sells rapidly, such as on the left side of the image, trades labeled 1 through 6. The issue with this is that while it is making money, it is spending money on commission more than it needs to. It makes 6 trades where it could have made 1 trade (A to B) and still make the same amount but spending less on commission.

Figure 4.11 Example of Drawdown in System

In the above figure, one can observe a single trade that is subject to a large amount of drawdown. The profit was roughly \$0.4 per share, while the maximum drawdown on that trade was roughly \$1.4 per share. While the trade was still open, there were potentially 6 other buying opportunities that the system missed because it was still in a trade. 5 out of 6 of these would have been executed and were likely to make profits. The point of this is to show that this system is

imperfect. If it buys right before a dip, then it will miss all of the trades that could have happened in the dip.

4.4 Forex Stop and Reverse

4.4.1 Hypothesis

Theoretically, the ideal stop and reverse system for day trading currencies should be able to anticipate every change from bullish to bearish and vice versa. It would short or long the currency based on the predicted direction. One common method to design a stop and reverse system is to calculate channels where resistance and support lines lie, and place trades when those lines are being tested. Some common examples are Keltner Channels, Bollinger bands and Parabolic SAR. However, an obvious drawback from this design is that when the price of a currency fluctuates heavily and breaks out from those support and resistance lines, the system will have the exact wrong order placed, and you will either suffer heavy losses or have your stop orders filled. In order to account for this drawback, this system was designed to detect breakouts and breakdowns from resistance in order to profit from these deviations as well. It is a stop and reverse system designed to profit from everyday long and short channel trading, but also predicts and properly trades breakouts and breakdowns.

4.4.2 Methodology

Development started by optimizing and comparing a few different common stop and reverse systems, primarily Keltner Channels and Bollinger Bands, but also Parabolic SAR. EURUSD was used for testing, as it is the highest volume currency pair so it should be a great

baseline. Higher volume should mean a more stable market with more predictable channels. After backtesting 6 months with all three stop and reverse systems, while the Bollinger Bands strategy had more winning trades, the Keltner channel generated more profit, still with a greater than 50% success rate. All backtesting was done with \$10 for round trip commission plus slippage.

Figure 4.12 Equity Curve - EURUSD 60 min bars (8/13/2017 - 2/14/2018)

For further confirmation that keltner channels would be a more promising strategy, testing was done and optimized with various stop-loss strategies, including currency trailing and percentage based stops. Based on these results, the bollinger band strategy could not be improved over basic keltner channels with any stop loss or profit taking strategies tested.

To advance the strategy with a method for detecting breakouts and breakdowns from the regular channel day-trading, the system was tested with a number of indicators that predict

strong market trends, including RSI, momentum and MACD. Before every trade placed by the optimized channel strategy, it would check these indicators for bullish or bearish trends, then reverse the channel strategy's decision if triggered. For example, if the Keltner channels want to reverse the position at the top of the channel, but the Momentum indicator shows a strong bullish trend, it will override the short. The goal was to find which of these indicators would have the greatest success rate at predicting these trends. Using MACD resulted in <50% profitable trades, even after thorough optimization, so MACD did not look like a promising indicator. RSI (Relative Strength Index) however, did predict breakouts and breakdowns >50% of the time. RSI is an indicator that interprets when a security's recent price performance signals that it is overbought or overvalued. There were also good results with momentum, with many profitable trades in initial testing. Momentum is used to show when the rate of growth of a security's price is accelerating or decelerating. Testing followed through with optimization of both a momentum based breakout detection, and a RSI based one. After a few days of tweaking time frames and optimizing variables, Momentum became a clear favorite, with more predictions and profitable trades on several time frames, including 15 minutes, 30 minutes and 60 minutes. Out of these three time frames, 60 minutes turned out to be the most profitable once accounting for slippage and commission. Shorter time frames would lose too much money from commission, more trades would mean less profit.

4.4.3 Entry/Exit Conditions

This system will place its first trade at the top or bottom of an optimized keltner channel; long at the bottom or short at the top. After that, it remains in the market, and when the price

reaches the top or bottom of a channel again, it will decide whether to maintain its position based on momentum. If momentum is bullish at the top, or bearish at the bottom, i.e. the price is accelerating at the edge of a channel, the system will maintain the current position. If the price is decelerating based on momentum at the top or bottom of the channel, it will reverse the position, going short at the top and long at the bottom.

Figure 4.13 Example Positions - EURUSD 60 min bars

4.4.4 Results

The final optimized design produced 16.9% profit over 6 months of backtesting, with 53.7% profitable trades. The average winning trade made \$517.26, whereas the average losing trade lost \$260.74. All testing was done with \$10 commission. This system also turned out to be profitable trading GBPUSD, but with only 48.54% profitable trades. The GBPUSD system made 22.6% profit, but was much more risky due to fewer profitable trades, and larger average losses. Based on these results, there is indication that the concept of this system can be implemented on any currency with a high volume that lends itself to thorough technical analysis.

Additionally, Monte Carlo analysis showed that this system had a 90% chance of >4% return, 80% chance of >8% return, and 70% chance of >10% return over the tested 6 months. This is a very strong indication of the profitability of this system even when accounting for random variation. Using a Monte Carlo analysis of the max drawdown of the system over 6 months, the mean drawdown turned out to be 3.82% of the portfolio, with a 10% chance of greater than 6% drawdown. This does indicate some level of risk that the investor needs to take into account.

Chapter 5: Results

After developing the systems, each was backtested against various securities pertaining to the individual systems. After collecting all of the trades made by the systems, the results were combined to form a system of systems. The results are detailed below in this order: Pre-Market Gaps, Whole Breakouts, Kaufman Efficiency Day Trading, Forex Stop and Reverse, and finally the results for the System of Systems.

Each trading system's results are presented in a table, which contains various information, including but not limited to: starting equity, percentage of equity traded, return on equity, expectancy, expectunity, system quality, and sharpe ratio. These values were calculated using a free trial of Market System Analyzer, which is software created by Adaptrade Software. The starting equity for each trader's individual system was \$100,000; when these are combined into a system-of-systems, the starting equity is simply the total starting equity of each of the individual systems, which equals \$400,000. Each system also lists the percentage of equity traded. This number describes a fixed percentage of the equity that is used to purchase assets on each trade. So if a system lists percentage of equity traded as 100% and it makes \$50,000 on its first trade, then it will use \$150,000 on its next trade. Similarly, if it uses 10% of its equity and it makes \$50,000 on its first trade, then it will trade \$15,000 on its next trade, leaving \$135,000 outside of the trade. Return on equity, however, is based on the starting equity. Increasing or decreasing the percentage of equity that a system trades can increase or decrease the return on equity, but the metric is calculated based on the final equity and the starting equity.

The next metric, expectancy, is one that describes how much a system is expected to earn for each dollar risked per trade. Recall that risk is the amount of money that a trader is willing to

lose before exiting the trade to preserve his capital. It is common to use a system's average loss or maximum loss as the risk for each trade. So if a trading system has an expectancy of \$0.50 and it risks \$2,000 on each trade, then it is expected to make \$1,000 on average for each trade. Similarly, expectunity measures this value over one calendar year. It is simply the expectancy multiplied by the average number of trades that a system makes over one calendar year. So if the above system makes one trade each day, its expectunity would be $365 * \$0.50$, or \$182.50. This is meant to give the trader an idea of how a system might perform over the long-term. If this system continues to risk \$2,000 on each trade, then it would be expected to earn \$365,000 each year!

Another useful metric that is included is system quality. This number is meant to rate the overall quality and versatility of a trading system. It is dimensionless, so on its own it can be hard to decipher. However, when comparing the system quality of one trading system to that of another, it can be easier to understand. Generally, a higher system quality is better, but on its own it does not necessarily mean one system is better than another; it is important to analyze all aspects of a system before deciding if it is better than another. Even a system that seems better in backtesting may not perform well when trading in real-time. Of course, the system quality can help determine this, as can the sharpe ratio.

As expectunity is a measure of the reward for one dollar of risk, the sharpe ratio helps determine if the risk is worth taking. The sharpe ratio of a trading system is a measure of its risk-adjusted return; it is inherently benchmarked against risk-free assets, so a negative or zero sharpe ratio indicates that it would be better to invest in risk-free assets, like U.S. Treasury bonds. All of the trading systems featured below have sharpe ratios that are greater than zero.

This is great because it means that these systems were better investments than risk-free bonds for backtesting. If results such as these persist when testing in real-time, it could mean the system is worth trading.

Sharpe ratio, system quality, and expectancy are just a few of the metrics that are helpful when analyzing a system. Just because a few of these numbers look good on paper, however, does not mean that a system is guaranteed to perform well. Instead, it is essential to take every aspect of a trading system, from its most basic rules to the metrics discussed above, into consideration when evaluating it. Only then is it possible to make comparisons between systems.

5.1 Pre-Market Gaps

Starting Equity	\$100,000
Percentage of Equity Traded	15%
Return on Equity	5.037%
Trading Duration	February 12th, 2018 - April 5th, 2018
Number of Trades	133
Maximum Open Positions	3
Win Ratio	2.524
Expectancy (Average Loss)	0.41
Expectancy (Max Loss)	0.02
Expectunity (Average Loss)	373.77
Expectunity (Max Loss)	20.58
System Quality	1.2295714
Sharpe Ratio	5.355

The Pre-Market Gaps strategy began trading on February 12th, 2018, and made its final trade on April 5th, 2018, which is a span of 52 calendar days. In total, it made 130 trades. The expectancy for this system based on the average loss was \$0.41, and based on the maximum loss the expectancy was \$0.02. These values multiplied by the number of opportunities gives expectancy. The number of opportunities calculated for this system was 912.5. So, this system's expectancy based on the average loss was \$373.77, and based on the maximum loss was \$20.58. Lastly, this system's quality was calculated to be 1.2295714.

5.2 Whole Breakouts

Starting Equity	\$100,000
Percentage of Equity Traded	100%
Return on Equity	28.95%
Trading Duration	April 7th, 2017 - April 4th, 2018
Number of Trades	161
Maximum Open Positions	1
Win Ratio	2.7
Expectancy (Average Loss)	0.22
Expectancy (Max Loss)	0.03
Expectunity (Average Loss)	35.49
Expectunity (Max Loss)	4.20
System Quality	1.092
Sharpe Ratio	0.3177

The Whole Breakouts strategy began trading on April 7th, 2017, and made its final trade on April 4th, 2018, which is a span of 361 calendar days. In total, it made 161 trades. The expectancy for this system based on the average loss was \$0.22, and based on the maximum loss the expectancy was \$0.03. These values multiplied by the number of opportunities gives expectancy. The number of opportunities calculated for this system was 162. So, this system's expectancy based on the average loss was \$35.49, and based on the maximum loss was \$4.20. Lastly, this system's quality was calculated to be 1.092.

5.3 Kaufman Efficiency Day Trading

Starting Equity	\$100,000
Percentage of Equity Traded	100%
Return on Equity	24.92%
Trading Duration	April 19th, 2017 - March 14th, 2018
Number of Trades	238
Maximum Open Positions	1
Win Ratio	1.191
Expectancy (Average Loss)	1.15
Expectancy (Max Loss)	0.74
Expectunity (Average Loss)	304.62
Expectunity (Max Loss)	195.79
System Quality	11.91499143
Sharpe Ratio	1.099

The Kaufman Efficiency Day Trading strategy began trading on April 19th, 2017, and made its final trade on March 14th, 2018, which is a span of 329 calendar days. In total, it made 238 trades. The expectancy for this system based on the average loss was \$1.15, and based on the maximum loss the expectancy was \$0.74. These values multiplied by the number of opportunities gives expectancy. The number of opportunities calculated for this system was 263.96. So, this system's expectancy based on the average loss was \$304.62, and based on the maximum loss was \$195.79. Lastly, this system's quality was calculated to be 11.91499143.

5.4 Forex Stop and Reverse

Starting Equity	\$100,000
Percentage of Equity Traded	100%
Return on Equity	19.93%
Trading Duration	October 16, 2017 - April 11, 2018
Number of Trades	105
Maximum Open Positions	1
Win Ratio	2.42
Expectancy (Average Loss)	0.79
Expectancy (Max Loss)	0.22
Expectunity (Average Loss)	171.35
Expectunity (Max Loss)	48.52
System Quality	3.02
Sharpe Ratio	1.05

The Stop and Reverse Forex strategy began trading on October 16th, 2017, and made its final trade on April 11th, 2018, which is a span of 177 calendar days. In total, it made 105 trades. The expectancy for this system based on the average loss was \$0.79, and based on the maximum loss the expectancy was \$0.22. These values multiplied by the number of opportunities gives expectancy. The number of opportunities calculated for this system was 216.53. So, this system's expectancy based on the average loss was \$171.35, and based on the maximum loss was \$48.52. Lastly, this system's quality was calculated to be 3.02.

5.5 System of Systems

Starting Equity	\$400,000
Percentage of Equity Traded	78%
Return on Equity	19.73%
Trading Duration	April 7th, 2017 - April 4th, 2018
Number of Trades	634
Maximum Open Positions	4
Win Ratio	1.05
Expectancy (Average Loss)	0.27
Expectancy (Max Loss)	0.02
Expectunity (Average Loss)	172.63
Expectunity (Max Loss)	11.23
System Quality	2.85
Sharpe Ratio	0.79

The System of Systems was a combination of all of our trading systems. It made a total of 634 trades. The expectancy was \$0.27 based on average loss, and \$0.02 based on maximum loss. The total opportunities per year was 628.83. The expectancy calculated was \$172.63 based on the average loss, and \$11.23 based on the maximum loss. The calculated system quality was 2.85.

Figure 5.1 System of Systems Equity Curve

The above figure depicts the equity curve of the combined system of systems. It can be observed that over the past year the system of systems made roughly \$78,920, or 19.73% profits per year.

Figure 5.2 Monte Carlo analysis of the System of Systems from Market System Analyzer

It can be observed in the figure above that the majority of the system's performance falls within the values that the Monte Carlo analysis was confident in.

Chapter 6: Conclusions

A major takeaway from the results of this IQP is that there is a lot of variability in the market and therefore expecting one system to perform well for an extended period of time puts a trader at a severe disadvantage. By combining the systems, the system quality surpassed the majority of the individual systems. This shows that while a trader could just use one of his good systems, he would be better off using a combined system of systems.

Chapter 7: Recommendations for Future Projects

Prior to participating in this IQP, each of the group members had some exposure to trading and investing as a result of buying and selling stocks through Robinhood.^[28] Over the course of this IQP, each of the group members has been able to identify significant growth in his knowledge of trading and investing in addition to an ability to make better informed decisions. The following sections describe the pitfalls experienced early on in the project and what would have improved the process, having overcome these challenges.

7.1 Adhering to a Methodology

During the early stages of developing an automated system it can be tempting to abandon previous work when losing money. Following this behavior can be detrimental to the progression of the system in the long run. Prior to developing an automated system, it should be clear that fully and correctly implementing a methodology will produce results similar to what is expected. While the system is still being developed, the actual returns might be drastically different than what is expected. For this reason, it is important to implement a methodology in stages and avoid becoming too concerned with its performance until fully implemented.

7.2 Identifying Noise

Noise was the number one factor that affected the profitability of the strategies. In trying to identify noise, several indicators were used, but none effectively prevented the systems from entering into noise. In hindsight, had one of the members from the group spent more time

²⁸ "Robinhood," *Robinhood - Invest for Free*. [Online]. Available: <https://www.robinhood.com/>. [Accessed: 29-Apr-2018].

attempting to identify noise, it would have drastically benefitted all of the systems and increased profitability.

References

1. “American Psychological Association Survey Shows Money Stress Weighing on Americans’ Health Nationwide,” *American Psychological Association*, 04-Feb-2015. [Online]. Available: <http://www.apa.org/news/press/releases/2015/02/money-stress.aspx>. [Accessed: 25-Apr-2018].
2. I. Staff, “Money Manager,” *Investopedia*, 02-Jan-2018. [Online]. Available: <https://www.investopedia.com/terms/m/moneymanager.asp>. [Accessed: 26-Apr-2018].
3. I. Staff, “Mutual Fund,” *Investopedia*, 15-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/m/mutualfund.asp>. [Accessed: 29-Apr-2018].
4. C. F. A. A. Hayes, “Exchange-Traded Fund (ETF),” *Investopedia*, 03-Apr-2018. [Online]. Available: <https://www.investopedia.com/terms/e/etf.asp>. [Accessed: 29-Apr-2018].
5. I. Staff, “Foreign Exchange Market,” *Investopedia*, 14-May-2008. [Online]. Available: <https://www.investopedia.com/terms/forex/f/foreign-exchange-markets.asp>. [Accessed: 29-Apr-2018].
6. D. Harper, “Getting to Know the Stock Exchanges,” *Investopedia*, 05-May-2017. [Online]. Available: <https://www.investopedia.com/articles/basics/04/092404.asp>. [Accessed: 25-Mar-2018].
7. C. F. A. A. Hayes, “IPO Basics: What Is An IPO?,” *Investopedia*, 24-Mar-2017. [Online]. Available: <https://www.investopedia.com/university/ipo/ipo.asp>. [Accessed: 25-Mar-2018].
8. “The New York Stock Exchange,” *NYSE: Listings Directory - Stocks*. [Online]. Available: https://www.nyse.com/listings_directory/stock. [Accessed: 26-Mar-2018].
9. S. Seth, “How The NYSE Makes Money,” *Investopedia*, 05-May-2015. [Online]. Available: <https://www.investopedia.com/articles/investing/050515/how-nyse-makes-money.asp>. [Accessed: 25-Mar-2018].

10. J. Folger, "Index Investing: What Is An Index?," *Investopedia*, 05-Dec-2017. [Online]. Available: <https://www.investopedia.com/university/indexes/index1.asp>. [Accessed: 25-Mar-2018].
11. J. Folger, "Index Investing: The Standard & Poor's 500 Index," *Investopedia*, 05-Dec-2017. [Online]. Available: <https://www.investopedia.com/university/indexes/index3.asp>. [Accessed: 25-Mar-2018].
12. I. Staff, "Market Sentiment," *Investopedia*, 18-Jan-2017. [Online]. Available: <https://www.investopedia.com/terms/m/marketsentiment.asp>. [Accessed: 26-Apr-2018].
13. E. F., K. R., and Fama, "Size, value, and momentum in international stock returns, by Fama, Eugene F.; French, Kenneth R.," *Journal of Financial Economics*, 01-Jan-1970. [Online]. Available: <https://ideas.repec.org/a/eee/jfinec/v105y2012i3p457-472.html>. [Accessed: 26-Apr-2018].
14. I. Staff, "Efficient Market Hypothesis (EMH)," *Investopedia*, 28-Sep-2016. [Online]. Available: <https://www.investopedia.com/terms/e/efficientmarkethypothesis.asp>. [Accessed: 26-Apr-2018].
15. I. Staff, "Portfolio Management," *Investopedia*, 03-Dec-2015. [Online]. Available: <https://www.investopedia.com/terms/p/portfoliomanagement.asp>. [Accessed: 26-Apr-2018].
16. "Award-Winning Trading Tools and Technology," *TradeStation*. [Online]. Available: <https://www.tradestation.com/technology/>. [Accessed: 26-Apr-2018].
17. I. Staff, "Technical Indicator," *Investopedia*, 18-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/t/technicalindicator.asp>. [Accessed: 29-Apr-2018].
18. I. Staff, "Volume," *Investopedia*, 09-Nov-2017. [Online]. Available: <https://www.investopedia.com/terms/v/volume.asp>. [Accessed: 26-Apr-2018].
19. I. Staff, "Volume Weighted Average Price - VWAP," *Investopedia*, 25-Jul-2015. [Online]. Available: <https://www.investopedia.com/terms/v/vwap.asp>. [Accessed: 26-Apr-2018].
20. "Kaufman's Efficiency Ratio (ER) « ETF HQ," *ETF HQ*. [Online]. Available: <http://etfhq.com/blog/2011/02/07/kaufmans-efficiency-ratio/>. [Accessed: 26-Apr-2018].

21. I. Staff, "Moving Average Convergence Divergence - MACD," *Investopedia*, 13-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/m/macd.asp>. [Accessed: 26-Apr-2018].
22. "Bollinger Bands," *StockCharts.com*, 18-Sep-2017. [Online]. Available: http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:bollinger_bands. [Accessed: 26-Apr-2018].
23. "Keltner Channels," *StockCharts.com*, 20-Dec-2017. [Online]. Available: http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:keltner_channels. [Accessed: 26-Apr-2018].
24. I. Staff, "Fundamental Analysis," *Investopedia*, 20-Mar-2018. [Online]. Available: <https://www.investopedia.com/terms/f/fundamentalanalysis.asp>. [Accessed: 26-Apr-2018].
25. "5 Important Elements in Fundamental Analysis," *EuroInvestor*. [Online]. Available: <http://www.euroinvestor.com/ei-news/2012/02/12/stock-school-5-important-elements-in-fundamental-analysis/15694>. [Accessed: 26-Apr-2018].
26. I. Staff, "Technical Analysis," *Investopedia*, 24-Apr-2018. [Online]. Available: <https://www.investopedia.com/terms/t/technicalanalysis.asp>. [Accessed: 26-Apr-2018].
27. I. Staff, "Stop Hunting," *Investopedia*, 21-Apr-2018. [Online]. Available: <https://www.investopedia.com/terms/s/stop hunting.asp>. [Accessed: 26-Apr-2018].
28. "Robinhood," *Robinhood - Invest for Free*. [Online]. Available: <https://www.robinhood.com/>. [Accessed: 29-Apr-2018].
29. J. Folger, "Introduction To Order Types," *Investopedia*, 05-Dec-2017. [Online]. Available: <https://www.investopedia.com/university/intro-to-order-types/>. [Accessed: 17-Apr-2018].
30. Investopedia, "Types of Securities Orders," *Investopedia*, 05-May-2016. [Online]. Available: <https://www.investopedia.com/exam-guide/series-7/securities-transactions/types-orders.asp>. [Accessed: 17-Apr-2018].

31. C. M. Investopedia, "Multiple Time Frames," *Investopedia*, 09-Oct-2017. [Online]. Available:
<https://www.investopedia.com/walkthrough/forex/trading-strategies/long-term/time-frames.aspx>. [Accessed: 17-Apr-2018].
32. C. F. A. E. Picardo, "Stop-Loss Order," *Investopedia*, 22-Dec-2017. [Online]. Available:
<https://www.investopedia.com/terms/s/stop-lossorder.asp>. [Accessed: 17-Apr-2018].
33. I. Staff, "Forex - FX," *Investopedia*, 20-Nov-2003. [Online]. Available:
<https://www.investopedia.com/terms/f/forex.asp>. [Accessed: 17-Apr-2018].
34. I. Staff, "Fill Or Kill - FOK," *Investopedia*, 20-Nov-2003. [Online]. Available:
<https://www.investopedia.com/terms/f/fok.asp>. [Accessed: 17-Apr-2018].
35. I. Staff, "Immediate Or Cancel Order - IOC," *Investopedia*, 29-Dec-2015. [Online]. Available: <https://www.investopedia.com/terms/i/immediateorcancel.asp>. [Accessed: 17-Apr-2018].
36. I. Staff, "Stock," *Investopedia*, 29-Mar-2018. [Online]. Available:
<https://www.investopedia.com/terms/s/stock.asp>. [Accessed: 17-Apr-2018].
37. I. Staff, "Derivative," *Investopedia*, 02-Apr-2018. [Online]. Available:
<https://www.investopedia.com/terms/d/derivative.asp>. [Accessed: 17-Apr-2018].
38. I. Staff, "Not-Held Order," *Investopedia*, 19-Mar-2018. [Online]. Available:
<https://www.investopedia.com/terms/n/notheldorder.asp>. [Accessed: 17-Apr-2018].
39. "Types of Orders," *Investor.gov*. [Online]. Available:
<https://www.investor.gov/introduction-investing/basics/how-market-works/types-orders>. [Accessed: 17-Apr-2018].
40. "What is Forex?," *FXCM UK*. [Online]. Available:
<https://www.fxcm.com/uk/forex/what-is-forex/>. [Accessed: 17-Apr-2018].

Appendix A

Whole Breakouts Code

```
Inputs:
Clear( 3 ),
Increment( 0.5 ),
MALength( 15 ),
FF( 0.02 ),
StartingEquity( 100000 );

Variables:
S( -1 ),
R( -1 ),
it( 0 ),
Cleared( 0 ),
MP( 0 ),
testR( 0 ),
testS( 0 ),
lastS( -1 ),
lastR( -1 ),
ReturnValue( 0 ),
AfStep( 0.02 ),
AfLimit( 0.2 ),
oParCl( 0 ),
oParOp( 0 ),
oPosition( 0 ),
oTransition( 0 ),
MA( 0 ),
ILong( False ),
IShort( True ),
PositionSize( 0 ),
Equity( 0 ),
lastPositiveL( 0 ),
lastNegativeH( 0 );

// Reset looking for entries on the first bar of the day. Helps reduce unwanted trades.
If Date <> Date[1] Then
Begin
    ILong = False;
    IShort = False;
End;

// Current Market Position
```

```

MP = MarketPosition;
ReturnValue = ParabolicSAR( AfStep, AfLimit, oParCl, oParOp, oPosition, oTransition );
MA = Average(Close, MALength);

// Position Sizing
Equity = StartingEquity + NetProfit;
PositionSize = (FF*Equity)/Close;

// Determine if the close is clearing a new support or resistance
While it < Clear
Begin
    If Close[it] > R Then
    Begin
        Cleared = Cleared + 1;
    End;
    If Close[it] < S Then
    Begin
        Cleared = Cleared - 1;
    End;
    it = it + 1;
End;
If L[Clear] > R[Clear] or H[Clear] < S[Clear] Then
Begin
    ILong = False;
    IShort = False;
End;

// Determine if resistance is being tested
If H > (R - 0.1*Increment) Then
Begin
    testR = 1;
    IShort = True;
    ILong = False;
End;

If H > R Or IShort Then
Begin
    If C < R And (Not(oPosition = 1 And MA > MA[1])) And C < (R - 0.1*Increment)
    Then
    Begin
        // Enter short
        SellShort ("TS") PositionSize shares next bar at open;
        IShort = False;
    End;
End;

```

```

End;

// Determine if support is being tested
If L < (S + 0.1*Increment) Then
Begin
    testS = 1;
    ILong = True;
    IShort = False;
End;

If L < S or ILong Then
Begin
    If C > S And (Not(oPosition = -1 And MA < MA[1])) And C > (S + 0.1*Increment)
Then
    Begin
        // Enter long
        Buy ("TB") PositionSize Shares Next Bar at Open;
        ILong = False;
    End;
End;

// Update Support and Resistance levels
If CurrentBar < Clear Or Cleared >= Clear Or Cleared <= -1*Clear Then
Begin
    S = Close - Mod(Close, Increment);
    R = S + Increment;
    If R > R[1] Then
    Begin
        IShort = False;
    End
    Else
    Begin
        ILong = False;
    End;
End;

// Entries
// Also if we have enough info (CurrentBar > Clear)
If CurrentBar > Clear Then
Begin
    // Enter long if we increased our support and resistance this bar
    If Cleared >= Clear Then
    Begin
        If testS = 0 Then

```



```

        Begin
            ILong = True;
            IShort = False;
        End;
    End;
    // Enter short if we decreased our support and resistance this bar
    If Cleared <= -1*Clear Then
        Begin
            if testR = 0 Then
                Begin
                    IShort = True;
                    ILong = False;
                End;
            End;
        End;
    End;

// Exits

If MP = 1 Then
Begin
// If parabolic is decreasing and MA is decreasing then exit long
If oPosition = -1 And MA < MA[1] Then
Begin
    If MarketPosition > 0 Then Sell ("ParaS") All Shares Next Bar at Open;
End;
End;
If MP = -1 Then
Begin
// if parabolic is increasing and MA is increasing then exit short
If oPosition = 1 And MA > MA[1] Then
Begin
    If MarketPosition < 0 Then BuyToCover ("ParaB") Next Bar at Open;
End;
End;

// Reset current bar trackers for the next bar
Cleared = 0;
it = 0;
testR = 0;
testS = 0;

```

Appendix B

Kaufman Efficiency Day Trader Code

```
Input: Period(10), // Distance to look back for EFFRatio
      PSMeth(3),
      Param1(2.0),
      Param2(0),
      BackTest(True),
      StEqty(100000),
      CurEqty(100000),
      TrRisk(1),
      MxLoss(1),
      MaxDD(1000),
      Stocks(True),
      UseUnits(False),
      UnitSize(1),
      UseMinN(True),
      MinN(1),
      MaxN(100000),
      InitMarg(0),
      MargPer(100),
      NATR(20),
      min_ratio(0.35),
      Sell_coeff(1.5),
      Buy_coeff(1.5)
;
```

```
Variables: Position_sizing(0),
          change(0),
          noise(0),
          diff(0),
          ratio(0),
          signal(0),
          open_bar(0),
          ATR(0),
          Par_ret(0),
          AfStep( 0.02 ),
          AfLimit( 0.2 ),
          oParCl( 0 ),
          oParOp( 0 ),
          oPosition( 0 ),
          oTransition( 0 ),
          writesys32(0);
```

```

// KAUFMAN EFFRATIO {
ratio = 0;
diff = AbsValue(close - close[1]);

// calculate efficiency starting after the first 'period' bars of the day
// detects a new day
if(BarDateTime.Day <> BarDateTime[1].Day) then open_bar = currentbar;

if currentbar-open_bar > period then begin
    change = close - close[period];
    signal = AbsValue(change);
    noise = summation(diff,period);
    ratio = 0;
    if noise <> 0 then
        ratio = signal/noise;
end;
// }

// determine position sizing using fixed fractional
if MarketPosition = 0 Then
    Position_sizing = PSCalc32(PSMeth, Param1, Param2, BackTest, StEqty, CurEqty,
    TrRisk,
    MxLoss, MaxDD, Stocks, UseUnits, UnitSize, UseMinN, MinN, MaxN, InitMarg,
    MargPer, NATR);

// Parabolic SAR - currently unused
Par_ret = ParabolicSAR( AfStep, AfLimit, oParCl, oParOp, oPosition, oTransition );

// Entry Condition(s)
ATR = AvgTrueRange(period);

// Only enter when efficiency ratio is above a certain amount
Condition1 = ratio > min_ratio;

// Condition 2 is that the price is going up
Condition2 = Close > Close[1] AND Close[1] > Close[2] AND Close[2] > Close[3];

if Condition1 AND Condition2 then
    Buy IntPortion(Position_sizing{%/high%}) Shares Next Bar at Market; //
    position_sizing is the equity to spend, not the number of shares

// Profit Target (sell when it has made a certain amount of money)

```

```
if MarketPosition <> 0 AND C >= EntryPrice + Buy_coeff*ATR then
    Sell("s") next bar at market;

writesys32 = WriteTrades32(Position_sizing*EntryPrice, 0, 0, period, 1,
    "c:\efficiency_system_"+SymbolName+".csv");
```

Appendix C

Pre-Market Gaps Code

```
// Day trading gap strategy leveraging pre-market screens
// Written by, Stephen Andrews.

// Version 1 - Basic strategy implementation
// Version 2 - Added position sizing.

// Date of the gap so we only execute trades for this day
Input: TradingDate(1180213);

// Position sizing inputs
Input: PSMeth(3);
Input: Param1(2.0);
Input: Param2(0);
Input: BackTest(True);
Input: StartingEquity(100000);
Input: CurrentEquity(100000);
Input: TradeRisk(1);
Input: MxLoss(1);
Input: MaxDrawDown(1000);
Input: Stocks(True);
Input: UseUnits(False);
Input: UnitSize(1);
Input: UseMinN(True);
Input: MinN(1);
Input: MaxN(100000);
Input: InitMargin(0);
Input: MarginPer(0);
Input: NATR(20);

Variable: RedBar(Open < Close);
Variable: GreenBar(Close > Open);
Variable: LastRedBar(0);
Variable: LastGreenBar(0);
Variable: AvailableCapital(0);
Variable: EnteredAt(0);
Variable: StopLossAmt(0);
Variable: WriteTrades(0);
Variable: PositionSize(0);

// Track last red bar
```

```

If Close < Open then begin
    LastRedBar = CurrentBar;
end;

// Track last green bar
If Open < Close then begin
    LastGreenBar = CurrentBar;
end;

// Enter when a green candle breaks the high of the previous red candle. Buy when it breaks
the high of the red candle.
If MarketPosition = 0 and Open > High[CurrentBar - LastRedBar] and d = TradingDate then
begin
    AvailableCapital = PSCalc32(PSMeth, Param1, Param2, BackTest, StartingEquity,
CurrentEquity,
                                TradeRisk, MxLoss, MaxDrawDown,
Stocks, UseUnits, UnitSize, UseMinN,
                                MinN, MaxN, InitMargin, MarginPer,
NATR);
    StopLossAmt = Close - (Low[CurrentBar - LastRedBar] - 0.01);
    PositionSize = (0.15 * StartingEquity)/Close;

    // print(GetSymbolName, " Position size (wrong): ", PositionSize, " Position Size
(right): ", PositionSize/Close);

    If (Open - mjr_VWA(Close, 50)) > 0.05 then begin;
        Buy ("Enter") PositionSize shares next bar at market;
    end;
    Print("BUYING --- Open: ", Open, " is breaking the high of last red bar: ",
High[CurrentBar - LastRedBar]);
    Print("Shares to buy: ", PositionSize);

    // Set stop loss 1 cent below low of previous red candle
    //SetStopLoss(Open next bar - (Low[CurrentBar - LastRedBar] - 0.01));
    //Print("Setting stop loss at: $", Open[CurrentBar + 1] - (Low[CurrentBar -
LastRedBar] - 0.01));
    //Print("VWAP: ", mjr_VWA(Close, 50));
end;

If MarketPosition = 1 and EnteredAt = 0 then begin
    StopLossAmt = EntryPrice(0) - (Low[CurrentBar - LastRedBar] - 0.01);
    SetStopLoss(StopLossAmt);
    EnteredAt = 1;

```

```

        Print("Setting stop loss to: ", StopLossAmt);
end;

// Exit: When a red candle breaks the low of the previous green candle
If LastRedBar = CurrentBar then begin
    If MarketPosition = 1 and Close < Low[CurrentBar - LastGreenBar] and d =
TradingDate then begin
        Sell this bar on close;
        Print("SELLING --- Open: ", Open, " is less than the low of last green bar: ",
Low[CurrentBar - LastGreenBar]);
        EnteredAt = 0;
    end;
end;

// Strategy uses stop loss on a per share basis
SetStopShare;
SetExitonClose;

WriteTrades = WriteTrades32(StopLossAmt * PositionSize, 0 , 0 , 10 , 1 ,
"\Mac\Home\Desktop\Trading Systems\Trade Analysis\" + GetSymbolName + ".csv");

```

Appendix D

Forex Stop and Reverse Code - Keltner Floors

```
[IntrabarOrderGeneration = false]

inputs:
    Price( Close) [DisplayName = "Price"],
    LengthKeltner( 28) [DisplayName = "LengthKeltner", ToolTip = "Bars for calculating
keltner channels"],
    NumATRs( 1.5) [DisplayName = "NumATRs", ToolTip = "Number of Average True
Ranges"],
    LengthMom( 6) [DisplayName = "LengthMom", ToolTip =
"Enter number of bars over which to calculate momentum."];

variables:
    Avg( 0 ),
    Shift( 0 ),
    LowerBand( 0 ),
    Setup( false ),
    CrossingLow( 0 ),
    Mom( 0 ),
    Accel( 0 ),
    writesys32( 0);

Avg = AverageFC( Price, LengthKeltner );
Shift = NumATRs * AvgTrueRange( LengthKeltner );
LowerBand = Avg - Shift;
Mom = Momentum( Price, LengthMom );
Accel = Momentum( Mom, 1 ); { 1 bar acceleration }

{ CB > 1 check used to avoid spurious cross confirmation at CB = 1 }
if CurrentBar > 1 and Price crosses under LowerBand then
begin
    Setup = true;
    CrossingLow = Low;
end
else if Setup and ( Price > Avg or Low <= CrossingLow - 1 point ) then
    Setup = false;

if Setup and Mom < 0 and Accel < 0 then
begin
```



```

    Sell Short ( !( "KltMomFloorSE" ) ) next bar at CrossingLow - 1 point stop;
end
else if Setup then
begin
    Buy ( !( "KltMomFloorLE" ) ) next bar at CrossingLow - 1 point stop;
end

```

Forex Stop and Reverse Code - Keltner Ceilings

```

[IntrabarOrderGeneration = false]

inputs:
    Price( Close) [DisplayName = "Price"],
    LengthKeltner( 22) [DisplayName = "LengthKeltner", ToolTip = "Bars for calculating
keltner channels"],
    NumATRs( 1.5) [DisplayName = "NumATRs", ToolTip = "Number of Average True
Ranges"],
    LengthMom( 11) [DisplayName = "LengthMom", ToolTip =
"Enter number of bars over which to calculate momentum."];

variables:
    Avg( 0 ),
    Shift( 0 ),
    UpperBand( 0 ),
    Setup( false ),
    CrossingHigh( 0 ),
    Mom( 0 ),
    Accel( 0 ),
    writesys32( 0);

Avg = AverageFC( Price, LengthKeltner );
Shift = NumATRs * AvgTrueRange( LengthKeltner );
UpperBand = Avg + Shift;
Mom = Momentum( Price, LengthMom );
Accel = Momentum( Mom, 1 ); { 1 bar acceleration }

{ CB > 1 check used to avoid spurious cross confirmation at CB = 1 }
if CurrentBar > 1 and Price crosses over UpperBand then
begin

```

```

    SetUp = true;
    CrossingHigh = High;
    writesys32 = WriteTrades32(100000*EntryPrice, 0, 0, 1.5, 1,
"c:\efficiency_system_"+SymbolName+".csv");
end
else if Setup and ( Price < Avg or High >= CrossingHigh + 1 point ) then
    Setup = false;

if Setup and Mom > 0 and Accel > 0 then
begin
    Buy ( !( "KltMomCeilingLE" ) ) next bar at CrossingHigh + 1 point stop;
end
else if Setup then
begin
    Sell Short ( !( "KltMomCeilingSE" ) ) next bar at CrossingHigh + 1 point stop;
End

```

Appendix E

Excerpts from Stephen Andrew's Trading Journal

Thursday, November 30, 2017

- Bitcoin price continues to surge with discussions of US exchanges to begin offering bitcoin futures.
 - Bitcoin has transitioned from a form of payment to a commodity-like investment.
 - Unlike commodities such as gold, bitcoin has no practical application outside of its domain.
 - Price surge of over 1,100% in 2017 alone.
 - Market cap of 190 billion, nearly four times that of Tesla and now surpassing General Electric.
- Gap trading for quick profits?
- Ken Calhoun's tips for identifying and trading gaps.
 - Candlestick patterns are key.
 - Whole numbers support resistance. Desired entry is after these clear.
 - Be wary of stocks that gap more than 10%.
 - Risk assessment via point spreads based on previous breakout.
 - Two day support stop loss to avoid loss.

Monday, January 15, 2018

- Can't trade cryptocurrencies with TradeStation... Gap strategy it is.
- Market is unpredictable. Successful traders trade with trends. Even if general consensus is wrong, the trend will prevail.
- Benjamin Graham's The Intelligent Investor.
 - Value investing via price-to-earnings ratios, price-to-book ratios, debt-equity, free cash flow, EPS for potential growth.
 - Might be useful to incorporate these into screening criteria.
- Stock screening is vital to a gap strategy.
 - Identify gappers during pre-market hours.

Wednesday, February 7, 2018

- Incorporate sentiment analysis into strategy to identify bearish/bullish attitude?
- Need to pay in order to gain access to pre-market data for screening.

Excerpts from John Bieber's Trading Journal

Thursday, September 7, 2017

- Use MACD indicator for long entry only if it has enough weight relative to security?
- Friend told me to put all of my money in \$AMD. "It's down to \$12 because of market panic over North Korea. Should be up to \$15 by Q3 end." I'll watch it.

Monday, November 13, 2017

- Door-opening robots
- EMA strategy from Quantopian?
- Price difference checker for arbitrage
- Identify daily highs (support/resistance)
 - recent highs/lows
 - trend lines
 - moving averages
 - fibonacci retracements
 - regression channels
- Bollinger bands
- "2 touches make a line, 3 touches make a trend line"

Wednesday, Dec 6, 2017

- “Risk aversion”
- Rules are important
- Look into “short squeeze”
- Random entry/exit can turn a profit with the correct position sizing rule
- Friend told me medical marijuana stocks could be a good idea. Makes sense in the larger scheme.

Excerpts from Theodore Bieber’s Trading Journal

Sunday, September 10, 2017

- Stocks are down because of North Korea news
- Also because of hurricane
- Odds are they will bounce back up about 10%, so picking a few to put money in would be a good idea hypothetically

Monday, September 11, 2017

- Short Equifax/related stocks

Friday, Dec 29, 2017

- A woman’s identity was stolen 15 times after the Equifax breach. This is just one case, there could potentially be millions. The effects could potentially continue for the rest of the affected people’s lives.

Excerpts from Grant Espe’s Trading Journal

Monday, October 30, 2017

- Started testing Ichimoku Indicators and Macd LE on EURUSD

- How will Spain/Catalonia situation affect Euro?
- Look into scientific analysis that can produce replicable results for trading system
- Show creativity and initiative for final project/design

Monday, November 6, 2017

- Oil tends to move markets
- Consumer sentiment directly influences profits from goods
- Trump promotes Powell to fed
 - Not an economist
 - Fed concerned with unemployment and inflation
- Trump visit to China, looking for alternative to TPP

Tuesday, Dec 12, 2017

- Jobs report did well - 4.1% unemployment, 62% Labor participation, 230,000 jobs created
- Fed meeting this week, anticipated to set interest rates
- Janet Yellen final term coming to a close
- President still has to sign tax bill into law
- USD dropped this week, despite good job report because wage growth was not there