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Active Trading in the Stock Market Using Implied Volatility

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Active Trading in the Stock Market Using Implied Volatility

An Interactive Qualifying Project Report
Submitted to the Faculty
of the
WORCESTER POLYTECHNIC INSTITUTE

by:

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Advising:

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Abstract

Beginner traders and investors have a hard time gauging the volatility of the market. Because of this, it is easy to make the wrong business decisions which might lead to a higher risk of loss. This project combines the use of non-traditional market indicators and common technology to provide market movement predictions. We researched common market indicators and combined the findings with the Chicago Board Options Exchange’s (CBOE) Volatility Index (VIX) to create an efficient analysis of future trends for a security, index or a sector. Since the market is wholly dependent on investment sentiment and emotion, delving into VIX, the “fear gauge” proved to be an extremely interesting and valuable topic in our research. From these methods, we also developed a simple web application to display the results and provide the common investor an indication of the market movement. We hope that this project will allow beginner investors and traders to easily assess and validate their positions in the market as well as to point out potential trends for the market. Finally, through our research, we hope to increase the usage of VIX and guide traders to the correct prediction and hopefully reduce market risk and loss.
Acknowledgements

We would like to thank our advisor, Professor Dimitrios Koutmos for not only guiding on this project but for helping us discover our passion in the finance world. Through his exciting stories of trading and firsthand experience as a derivatives trader, we were able to draw interest in trading and stocks. We would also like to thank the StackOverflow community for providing us with QA on this project. Finally, we would like to thank the developers of the Python Panda’s module, Yahoo Finance, AngularJS, and Django development teams. Without the advice, guidance, and support from all the teams and people mentioned, this project would not have been possible.
Introduction

As Christine Lagarde perfectly coined it, “Markets love volatility.” Until automation is perfected and capable of making sound investment decisions, the free market is dominated by humans and their intuition for a financial advantage. Emotions and common sentiments across a population play a critical role in the market movement. Analyzing the common thinking or sentiment of a population towards a certain trend or idea would be the logical concept to look out for in a market where buying and selling, determines the outcome. In this paper, we will be largely focusing on the role of human emotions namely fear, which is the primary unit for emotion in the market. A lack of fear indicates a strong confidence in a position, on the contrary, an abundance of fear results in instability in a position. We can use levels of fear to gauge how investors think, make decisions, and react to events in the economy. In our study, we will be using the Chicago Board Options Exchange Volatility Index (VIX) which is termed the “investor fear gauge,” to determine and gauge future market, sector, stock, and equity performance. And how these common practices can be applied to predict trends, automate trends, and hopefully educate the public on the use of volatility as a trading strategy. In the next couple of pages, we will be introducing financial and business terms which are necessary to understand further technical details and strategies.

The stock market is one of the most crucial components of today’s world as it creates a financial backbone for capitalist societies. Stocks allow companies to grow and gain liquid assets to use in order to make a profit and increase sales and production. At the same time, the market provides a tool for investors to own shares in a company and hold a position in today’s capitalist world. Although the market functions in a sophisticated and seemingly unpredictable manner, its basic movements are caused by the idea of supply and demand. Shares in a company rise or fall
in value based on the number of shares being bought and sold. If more shares of stock are being bought, then being sold in a company at any given time the stock price will rise and the stock price will decline if the opposite trend occurs. Since the market is constantly shifting up and down in this way, many investors try to predict the future trends in the market in order to invest and make potentially large sums of money. Before these prediction models can be analyzed, it is first important to understand basic market terminology and market analysis tools such as the ones discussed below.

**Background Information**

**Debt Ratio**

Debt Ratio is the percent of debt a company holds in comparison with the total assets owned by the company (Debt ratio = total debt / total assets). For companies, the debt ratio is an important tool used to find a balance between profits and borrowed money. A good debt ratio allows companies to grow with borrowed money while still being profitable without too much volatility. The debt ratio is further used by investors as an indicator to determine the financial risk companies hold. In order to determine whether the debt ratio of a company is high or low, it must be compared to the debt ratios of its competitors and indice average. If the debt ratio of one company is higher than that of another in the same index, the company with a higher debt ratio potentially is a more volatile investment.

**Book Value Per Share**

Book Value per share is the total value of a company's equity owned by each share of stock. This is determined by taking the total shareholder equity and dividing it by the total number of shares. The book value per share can be used to determine how valuable each share in a company actually is and this can then be compared to the actual price of the company's stock.
Doing this allows investors to determine the inflation in a company's stock price and compare the actual stock value to other competitors.

**Price to Book Ratio**

The **price to book ratio** or P/B ratio is the actual stock price divided by the book value per share. P/B ratio is a good tool to determine whether or not a stock is under or overvalued. If the P/B ratio is low, a company may be undervalued or it may have flaws that cause investors to shy away from investing in the company. If a company holds a high P/B ratio it may be inflated in the market and could pose a risk if the company were to go bankrupt as its assets would not cover its stock value. In order to determine if the P/B ratio is high or low, it is important to compare it with ratios of similar companies as is done with many other ratios in investing.

**Revenue**

**Revenue** is a term used in finance that represents the amount of capital a company is making. Increased revenue generally means a company is growing and successfully accumulating profits. Decreased revenue over an extended period of time results in a company failing and losing funds. When compared to stocks, generally increased revenue correlates to an increase in share value, while decrease revenue cause shares to depreciate.

**Earnings per Share**

**Earnings per share** (EPS) represents the amount of profit produced by a company for each of its individual shares. EPS is calculated by taking a company's total net income and then subtracting the outgoing stock dividends (EPS = (net income - stock dividends) / (weighted average of shares)). This provides the value of all the company's shares, which then can be divided by the number of shares to achieve the company's EPS. By calculating the total value for
each company share, EPS provides an important standard for determining the actual price of the stock. This being said, EPS alone is not dependable when predicting share price or the growth of a company as it does not take into account the total equity used by the company to produce their net income. For example, if two companies achieved the same EPS value but one of the companies used double the equity to achieve their income then that company would be less efficient at making a profit than the other.

**Return on Equity**

*Return on equity* (ROE) demonstrates the total returns a company makes off of the total equity shareholders have in the company. ROE can be calculated by simply dividing the total net income by the shareholder equity. ROE is commonly used in investing to compare companies within an indice. Doing so allows an investor to determine the profitability of companies that share similar financial grounds.

**Dividends**

*Dividends* are generally cash payments made by a company to its investors based on a certain percentage of pay per share of stock owned. These are generally made by companies when cash funds are low and they need more liquidity to fund projects within the company. Often times these dividends provide an incentive for investors to hold more shares in the company as they see the company is rewarding its investors for being a shareholder.

**Price to Earnings Ratio**

The *Price to Earnings Ratio* (PE ratio) is one of the most common values analyzed by investors when predicting which companies provide potentially lucrative investments. The PE ratio is determined by comparing the total market value of a company per share with the earnings
that company achieves per share of stock. When the PE ratio of a company is high, investors see the company as having a high value since the price of each share cost more than the number of earnings the company is making. This means the company may be doing very well and is potentially in a growth period as shareholders expect good returns from the company, or it can also mean a company is in a earnings deficit period and the stock value is significantly inflated compared to the company’s current success. Often times when the PE ratio is low, it means the value of shares in a company is either undervalued by investors, or the company is in a period of high earnings and is potentially on the verge of growing. In order to determine if the PE ratio of a company can be categorized as high or low, investors often compare the PE ratio of a company to the PE ratios of the company’s competitors or average PE ratio of its indice.

Moving Average

Moving averages are commonly used when investing as they provide an estimate of future stock prices and changes in a stock's momentum. These moving averages can be taken over any period of time such as ten days or even fifty depending on the relationship the investor is searching for. The moving average is determined by adding up each of the closing periods over the course of the desired time and then dividing it by the total time. For example, a ten-day moving average would be determined by adding up the closing price of a stock for each day over the previous ten day period and then dividing the number by ten. Doing this for consecutive days creates a moving average plot line that eliminates most of the insignificant noise and occurrences in actual stock price plots. By examining the moving average line investors can determine the momentum of a stock's price and predict future prices. Another strategy often used by investors is taking two different moving averages and comparing them with one another to determine where they cross. For example, if a twenty and a five day moving average are taken and
compared, investors can use the relationship of the two to find a trend in the share price and determine buy or sell periods based on the two moving averages.

**Linear Regression**

*Linear Regression* is another tool commonly used by investors to help analyze and form prediction models within the stock market. Linear regression helps with this because it is able to form a trend line for stocks or indices that show the general direction a stock moves in. This allows investors to compare the regression trend line with actual stock price to see how stock prices will move in the future taking into consideration that the stock price should mostly shift in the direction of the trend line. Prior to analyzing the stock trend line, it is also important to check the P value achieved following the regression to be sure that the trend line holds significant meaning for the desired stock.

**Volatility Index**

The *Volatility Index* (VIX), also known as the Fear Index, is an analytical tool developed by the Chicago Board Options Exchange (CBOE) that measures the sentiment investors have for the S&P 500. VIX is able to do this by looking at the mean out of money put and call options. While the actual equation is extremely sophisticated and takes many variables into account, options prices and changes are often the key factors in determining VIX. The basic idea behind VIX is that as the market goes up and down, VIX will react and go up and down in the polar opposite direction. This is because as the stock market becomes bearish, investors have more fear in the market and this causes VIX to rise as the market value declines. In a bullish market the exact opposite occurs as the market rises, VIX falls since people feel comfortable with their stance in the market and are more likely to invest.
For investors, VIX is a very important tool to analyze stock prices and determine if an investment is a safe investment or a volatile one. Options trading is known for using VIX the most as the value of options changes based on how volatile an option is. When comparing VIX to indices and stocks within the indices it is possible to use VIX to predict price shifts as certain stock patterns may follow a rise or fall in VIX. For this reason, VIX is a common tool used with other relationships to form stock prediction and analysis models.

Scope of Project

With this project, we hope to accomplish three main goals. We hope to educate the reader with simple yet crucial market concepts, trading strategies, and common indicators to watch for. We also hope to educate the reader about volatility and the importance of emotional sentiments in the market. Finally, we present the beginner trader a simple web application to use for gauging and indicating market movement, and how these movements might affect their current or future portfolios.

Multidisciplinary and global importance

For the IQP project, WPI’s goal is to spread the importance of cross-disciplinary studies. While working on this project, through research and from the guidance from Dimitrios Koutmos, we taught ourselves market fluctuations, common psychology, financial analysis of businesses, advanced statistics, and other econometric principals. We also applied automation in our project by building a web application to put to use the data analysis that we research throughout the course of our IQP.
Review of Literature

Literature of VIX

VIX is one of the most widely discussed tools in economics, as many investors use it to form stock analysis and prediction models. In economics it is generally believed that as VIX moves up the market moves down and vice versa. Although this is true, strangely there is not a lot of scholarly sources that prove this phenomenon as true. Pierre Giot is one of the few who specifically addresses this in his article on volatility and actual stock returns. In the study, Giot uses several historical data sets to analyze periods of a bearish and bullish market to evaluate how VIX behaves during these periods in order to find the relationship between the market and VIX. As expected Giot study showed that VIX shifted opposite of the market during most circumstances. That being said, Giots article also went into detail about how bearish and bullish markets had slightly different relationships with VIX. According to the study, during periods of low volatility investors and options traders are more likely to take aggressive positions by raising volatility of options. Doing so causes VIX to stay low for a shorter period of time than when it is high because when the VIX is high investors are more stagnant with their shares as they do not want to react off of the fear of VIX. Due to this difference in VIX behavior, the relationship between stock returns during high and low VIX periods differ slightly.

As explained thoroughly by Giot, VIX and market returns are strongly tied together and the relationship between the two should be analyzed closely prior to making investments. When forming stock prediction models it may be ideal to use a VIX relationships with returns in order to see how stocks react in certain VIX standpoints. Fully understanding how VIX and stocks
move with each other is crucial for any investor to be successful in today's sophisticated stock market.

**Literature of stock return predictability**

Stock prediction is something investors have been trying to achieve since the market first began. Many people believe it's impossible to predict the market and while it may be true that it is impossible to predict the market all the time, it might still be possible to predict the shifts in stock value more than half the time. In investing if it's possible to correctly predict stock value even just sixty percent of the time, it's possible to make huge amounts of money by buying and selling shares. In order to achieve this goal investors have created complex algorithms and built costly super computers to analyze data at rapid speed in order to gain an edge on other investors and hedge funds. Even with the expensive equipment and complex equations that extend pages long, it seems as though no one has been able to make a failproof stock prediction model and if it does exist it's unlikely that it would be shared by its creator as it could provide immense monetary gains.

One of the key investment strategies utilized by many prediction models is simple moving averages. Studies have been done that test how the stock market behaves in comparison to moving average trendline. The basic theory behind the moving is that if the market line crosses above a moving average trendline it is likely that the market will rise and it’s a good time to buy. When the market price crosses downward past the trendline it is likely the market will drop and it’s a good point to sell. This basic method of using moving average trend lines to predict stocks has been used extensively over the course of the market and many articles have been written throughout history on the advantages of using moving averages. Once such article dating back to the 1960's that was published in *The Journal of Financial and Quantitative*
Analysis examined the trendline method explained above extensively. The article discussed how short-term moving averages did not result in accurate prediction models but when done over a long period of time using long-term moving averages a predictability model was able to be generated that often accurately predicted market movements. The article also went into detail about a prediction method using monthly moving averages over a yearly period to create a trendline that shifted monthly. This then was used with buy and sell thresholds to predict how to react to market movement. For example, if the market moves upwards past the trendline by five percent it was time to buy and when it moved below by five percent it was time to sell. Although alone this prediction method is only marginally successful, when applied to more sophisticated models that take other variables into account as well the moving average trendline, it can provide a reasonable money making prediction method.

Gaps in Literature

Unfortunately for many, dedicated investors and educated finance scholars don't provide much literature on basic stock prediction models or tools easily available to the average investor. As previously stated, there are many complex prediction models that utilized expensive computers to form algorithms and other stock predictability methods that are not feasible for most small hedge funds or investors. Due to this many average investors believe it is impossible to make prediction models without prior education and funds. Many of these average investors shy away from attempting to predict stocks due to most of the tools and literature being very sophisticated and difficult to learn. Along with this in order to find a tool that provides easily accessible data to run simple prediction models such as the moving average trendline model, companies may charge thousands of dollars for tools such as the Bloomberg terminal. Other sites
such as yahoo finance provide a wide array of data but can be cluttered and is not always an ideal place to focus on forming investment models and strategies. Due to this gap in simple investment literature and technology, this IQP's focus is to provide common investors with the necessary tool for forming basic stock prediction models and investment strategies without an extensive background in finance education.
Technical details with VIX: Derivation

As an investor, the name of the game is to guess the price for the following day, week, or whatever term seems best. However, the probability of guessing a price is extremely low. As volatile human reaction and emotion is, stock price fluctuation is similar. However, instead of trying to guess the price, there is a much higher probability of guessing the trend. It’s either increasing, decreasing, or remaining stagnant. And guessing the trend as any of those directions can be profitable. The Volatility Index (VIX) as introduced in the beginning of this paper, presents us with opportunity for market gains and hence it is an integral component in our trading strategy as well as our web application.

Common Indicators

Candle-Sticks

Common signals give us hints about the market to suggest bearish or bullish movement. In the case that it is bearish, we can watch for momentum of the stock or index and determine the next course of action based on a risk analysis model. The oldest tradition for trying to determine the movement of stock prices goes back to rice trading in Japan using the candlestick pattern. The Japanese would use the candlesticks charts since it represented the market, security, or equity very well.

The candlestick works so well because it uses open, high, low, and close prices for the day to “guess” the position of people. And based on the efficient market hypothesis, this method is extremely valuable because all known information for a market, security, or equity is shown
through the price. The shape and shading of the candlestick indicate valuable detail and is much easier to decipher than regular stock prices due to its graphical nature. The basic principle is if a stock happens to be bearish and closes lower than the initial opening price of that stock, the shadow of the candlestick is filled. Conversely, if the stock performed well and the close is higher than the open, the body of the candlestick is not shaded, indicating a bearish position for the day. If the body of the candlestick is long, it implies that there was higher trading pressure. If the body is short, it shows that there was low pressure and hence minimal price fluctuation.

There are hundreds of patterns to watch out for. The most common of which is the Doji pattern, which occurs when the stocks open and close prices are nearly equal. The way most people tell if it is a Doji pattern is if the candlestick looks like a cross figure. This pattern indicates that there will be a reversal in the trend. If the past several days were bullish, there is a high probability the
trend will reverse and vice versa.

Figure 1 Candlestick structure details. Bullish is when the close is higher than the open, bearish is when the close is lower than the open price.

Candlesticks provide a great segue into our main concept of research: moving averages and the VIX. As discussed in the introduction, moving averages are simple yet extremely effective for analyzing trends and trying to predict trends. To predict a trend using moving averages, we are going to look at crossovers between the trend. Again, this is a visual cue, so it works well with traders as well as a solid technical indicator for automated machine processing.

**Linear Regression Line**

Based on the mean reversion theory, we can assume that when a stock or security oscillates in one direction, there is a high probability that it will reverse and come back to its "mean." A simple yet effective indicator for a trend is monitor the oscillations of a trend line
around the mean reversion. To find the line that best describes our stock price data, we will use a Linear Regression line which is also referred to as the "best fit" line since it tries to fit the data points. An example of the linear regression line is shown below in Figure 2 with the analysis of

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Figure 2 Example of best fit line (picture taken from http://jazzbumpa.blogspot.com/2011/01/stock-market-assesment-part-1.html)

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the S&P 500. Here we can see that over its lifecycle, S&P 500 has oscillated quite a bit, however the best fit line does accurately depict the mean line. All the cycles revert around this line. The linear regression line, if investigated further can be used as a trend as well. However, the inspection would have to zoom into the different time periods of the stock. For example, if we look at the current level timeframe of the chat (all existence of S&P 500) we can see that the
trend line suggests an increase in the price. We know that historically this is accurate, as with most indices and stocks, since the annual average return is a positive return of about 7%.

(Vanguard Research, 2012)

**Moving Averages**

The concept with moving averages is analyzing the crossovers between other moving averages and/or the stock line itself (0-day moving average). For best results (short, intermediate, and long term) we have found that 50 day, 20 day, and the 5 day moving averages work best. The idea for determining trends with moving averages is simple, if a lower day moving average crosses from under through and upward a price line or a moving average line, there is a high chance that there will be an upward trend, indicating a bullish market. The figure below indicates an example of moving average crossovers with the Volatility Index (VIX). As the red rectangle indicates on the chart, the 5-day moving average first crossed the 20 day and 50 day moving average on a downward curve. Interestingly enough, it comes back and crosses again on an upward trend, this results in nearly a 6-point increase in closing price. Downward trends work in a similar fashion as shown by the green rectangle in the figure below. If the moving average trend line crosses the higher trend lines on a downward slope, it indicates a decreasing trend for the future.
Figure 3 CBOE Volatility Index (VIX) 6 months’ view along with simple moving averages. This chart was made on the Yahoo Finance platform.
VIX Moving Averages

Now that we have a clear understanding of predicting trends using moving averages, we will cover how we used this in our methods. Since VIX is the fear gauge, we can analyze the trend lines of VIX moving averages to estimate the future sentiment. If there is an upward trend, it shows that general sentiment is fearful, and we should be expecting a bearish position in the future. Since, VIX is inversely related to stocks, indices, and equities, if there is a downward trend, this implies a confident sentiment in the population, so there will be a bullish cycle in the future. To prove this theory, we will use the Dow Jones Industrial Average to demonstrate the correlation of VIX. Our assumption of the inverse relation between VIX and common indices and stocks is proven by the figure below. The pattern is, as VIX begins to spike, DJI starts on a downward trend. However, when VIX begins to decline, DJI starts to go on an upward trend. As

Figure 4 VIX and DJI chart with moving averages for VIX. The time range for this chart is 1 year. This is a rate of change chart in order to better scale the two indices.
you can see, VIX is acting almost like a moving average trend line, since there is a delayed reaction between ticks on the DJI and the VIX. This provides evidence for our strategy to use VIX as an indicator for predicting the future market position.

The incorporation of VIX moving average trend lines will be able to provide evidence for a trend further out in time from the occurrence. In the following paragraphs, we will show examples of that. As the orange arrow shows in the figure below, we can spot a trend out weeks out in advance. The 5 day moving average where the orange arrow is pointing to starts to cross the 100 day moving average, this gives us a red alert that the VIX will be in for a trend reversal. The investor or trader must make a decision here. The investor can either wait and see if the 5 day also crosses the 20 day, increasing the assurance that there will be a trend or confirm a position when the 5 day crosses the 100 day. Now that we have the alert, what does this trend

Figure 5 Comparison of VIX and DJI stock lines for the last decade. Note: This is an interesting comparison, since major recessions and interesting market fluctuations occurred during the time range.
reversal tell us? Based on our strategy, if VIX spikes it implies investor fear, meaning that there is a higher probability the market will be bearish. Now the next step would be to figure out if VIX and members of the trader’s portfolio are correlated. Meaning that they co-move with each consistently. If they do, we can trust this strategy and determine our position, if not, we may need to integrate other trading strategies to confirm the trend. Either way, incorporating moving averages with VIX gives us a solid idea of how the market is going to look the next couple days, weeks, and even months.

**Proof of VIX Consistency with Various Indices**

In the next couple of pages, we will show visual charts and comparisons of the ideas and strategies we presented in the previous section of moving average indicators. We have picked three indices from the Dow Jones to experiment with. We will be using the Dow Jones Transportation Average (DJT) which reflects the prices and stock summary of stocks in the transportation sector. The Dow Jones Utility Average (DJU) which reflects prominent securities in the utility sector of the market. And we will also use the Dow Jones Composite Average (DJC) which tracks all stocks from the Dow Jones Industrial Average (DJI), DJU, as well as the DJT. The composite average will be useful in analyzing results and forming a consistent trend line analysis over all major sectors across the Dow Jones.

**VIX and DJC**

The Dow Jones Composite average which includes several sectors from the Dow Jones is an interesting index to analyze with the it’s correlation to VIX. After performing a linear regression with VIX and DJC, we can see that they co-move due to the p-value of 2.52^{-8}. This tells us that we can use VIX to predict the trends of the DJC. Based on Figure 7 below, we can see that as the VIX values begin to drop, the DJC trend line begins to spike. We can conclude by saying that VIX and DJC are inversely proportional. In our web application, we will see the
software pick up on this relationship and suggest a trendline based on the current position and estimation of the VIX trendline by using moving averages. It is interesting to point out that after 2012-2016, the relationship between VIX and DJI seemed to change from being inversely proportional to proportional. When VIX would go down (suggesting lower investor fear), the DJC also went down for a period. At the moment, our software does not have the capability to handle this shift in pattern, which may lead to inaccurate results. However, to improve our accuracy in our software, we will increase the number of times during a time period we run the linear regression and correlation models to determine how the indicator and the stock, security, or index is related.

**VIX and other Dow Jones Indices**

Analyzing the returns of the Dow Jones Transportation (DJT) and the Dow Jones Utility (DJU) index against VIX, we can see that they have a similar pattern as the DJU as shown in figures 6 and 9. They are both inversely proportional to the VIX, so if VIX goes up, indicating high investor fear, we can assume that the DJU and DJT will follow the pattern and decrease, due to instability.

**VIX and Securities**

In order to further prove the consistency and significance of VIX to determine a future trend line, we have also included a chart which shows scaled trend lines of VIX, Apple Inc. common stock (APPL) and Alphabet Inc. common stock (GOOG) as shown in figure 8. We have found that both common stocks follow a similar pattern as the Dow Jones indices that is they are inversely proportional.
Figure 6 VIX and Dow Jones Transportation Average index charted side by side.

Figure 7 VIX and Dow Jones Composite Average index charted together.
Development of Web Application
Goals for the Application

Our primary goal for the application was to one develop a tool to aid our decision in the performance of indices and securities and two to maintain simplicity throughout. After using stock analysis tools and software suites such as Bloomberg Terminal, for the average person and investor who has never used the software, it is overwhelming to pick up or even become functional with the software. We decided to take it on ourselves to design the first version of the software to be as simple as possible, provide just enough indication of a price fluctuation or movement and enough information about the desired security.

Web Application Technology
How it works?

Our web application functions by having users add stocks, securities, indices, or equities to their watch list. The instant the symbol is added, our backend fetches financial and historical data about that stock symbol and stores it locally in our database. It then runs a linear regression on that symbol that was just added compare to the indicators in the watch list. If there are multiple indicators, it runs a regression and determines an aggregate result. If the stock shows a positive relationship with the stock added, our system marks the stock as correlated and uses the indices to predict the future analysis for the stock. At the moment, on our frontend, we have a binary display of this relationship. It tells the user for the next two weeks if the stock is expected to either increase or decrease as an arrow figurehead. A screenshot of the watch list is shown in Figure 10. For example, in figure 10, there are several stocks that are shown, and the VIX is used as an indicator which shows an increase in the last two weeks. Based on the regression results, moving average flags, and comparison to VIX, the stocks are shown their respective predictions.
Backend
For the backend technology to handle the processing, storing, and crawling of stock data, we decided to use the open-source Python 2.7 language (https://www.python.org) and the Django Framework (https://www.djangoproject.com). This decision was largely dependent on Python’s awesome exposure and flexibility with data science and machine learning models and packages. A full list of all modules used will be attached at the end of this paper. Using Django as a backend solution was also a great choice, since it was extremely simple to setup and connect to our frontend client, the results were extremely responsive. Python also remains to be an extremely simple language to pick up, as our solution to the interdisciplinary studies, we wanted scientists, economists, and financial advisors alike to pick up on the logic.

Frontend
For the frontend, we decided to use Google’s open source framework called AngularJS (https://angularjs.org). The reason was due to prior experience of our group as well as easy integration into the RESTful API from the Django backend. AngularJS also provides a comprehensive framework for reusable components, which is precisely what is necessary to analyze the thousands of securities and equities. Reusing a lot of the functionality, such as the Linear Regression view, shown later in the paper was extremely useful to our core functionality.

Future Upgrades

Technology Stack
In the future, we would want to upgrade the core technology to use web sockets to have live data streaming. For our models to support live data streaming speed, we would also have to integrate our backend system into a distributed system such as Hadoop and change our database to use the NoSQL framework. We hope to make these changes in the next several versions in order for us to fully deliver the potential of the product that we have developed.
Analysis Models

Without a doubt, our models for predicting the trends are not the most optimal. In the future, we will continue to look for potential indicators that might be more accurate. Integrating indicators such as the stochastic oscillator, MACD, or the momentum of a stock or sector might be profitable.

Using the Web application for Portfolio Allocation Decisions

In the next several pages, we will talk and show examples about the design and use of our software. This is version 1 of our release.

Watch List

Figure 10 Watch list view for the web application. Users can add/remove/modify the securities, equities they want to keep track of. Also, the user can add indicators to gauge the watch list by.

We believe that the easiest way for investors and traders to keep an eye out for their portfolios are by keeping a watch list of stocks to monitor. There are two sections to our watch
list. First, we have the indicator section which keeps the indicators used to predict the stocks by (default is only VIX). Second, we have the watch list section which contains the stocks, equities, or the securities that the user wants to keep track. The indicators, as discussed in the technology section, uses a two-week time interval to predict how the stocks in the watch list are going to perform, based on our models for the future 7 days. The user after seeing our prediction can then go on to do more research using other indicators such as the stochastic oscillator, MACD, or the momentum for the stock, to determine a more technical analysis. The user using our software can judge the future performance of their portfolio using strictly the Volatility Index and moving average flags as indicated by the volatility index or another indicator added. Figures 11 and 12 below show the regression tool component of our web application and a bit more detailed page about the stock in the watch list, respectively.

<table>
<thead>
<tr>
<th>Summary</th>
<th>Company Details</th>
<th>Regression Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX and Alphabet Inc are correlated</td>
<td>Stock name: Alphabet Inc</td>
<td>Intercept: 8.03579865730849</td>
</tr>
<tr>
<td>Stock Previous Change: 1.56</td>
<td>Stock Previous Change Percentage: 1.56</td>
<td>P-Value: 0.337506530549149</td>
</tr>
<tr>
<td>Stock Previous Change Percentage: 1.56</td>
<td>Stock Market Cap: 2933025971980</td>
<td>S-SE: 0.000000000000000</td>
</tr>
<tr>
<td>Stock VIX Change: 790.46</td>
<td>Stock VIX Change Percent: 4.81</td>
<td>Standard Error: 0.000000000000000</td>
</tr>
<tr>
<td>Stock high: 829.61</td>
<td>Stock low: 605.68</td>
<td>Standard Error: 0.000000000000000</td>
</tr>
<tr>
<td>Stock open: 820.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 11 Common details for stock or security. Also a summary for the stock or equity based on the indicators.
Figure 12 Users also have the ability to use our linear regression tool to test if two indices or indicators are significant and/or correlated.
Conclusion

Through personal use and through our research we can conclude that using VIX to determine short-term stock market trends is accurate and provides an excellent investment strategy for any investor. Using this knowledge we successfully created an application that allows any user to perform basic regression analysis with stocks and indices, as well as create the framework for other stock analysis strategies such as moving average trend lines. By designing this application we successfully provided a tool for average investors that is cheaper than the alternative options and significantly easier to learn and use. Prior to our design, current databases and stock market tools such as the Bloomberg terminal were far too expensive for smaller hedge funds and average investors. Other online resources such as yahoo finance provide many different databases and tools but they were cluttered and sometimes difficult to use. Our web application should fill this gap for average investors and allow them to make better investments. In the future, our current web application provides a backbone for a potential stock market software that utilizes many more tools and functions similar to the Bloomberg Terminal. In conclusion, through our IQP research and software design, we proved VIX can be used as a simple stock prediction tool, and that common investors can easily form market predictions using unsophisticated methods.

References


Technology References

Data Crawling
We’d like to thank Yahoo Finance team who provided us the API to crawl the financial data.

Core Technology Used
- Python 2.7
- Django Web Framework
- AngularJS
- D3.JS charts

Python Modules Used
We’d like to thank the Python open source community for their time and effort in the development of the following open source modules, without which we would not have been able to develop this project:
- Python-dateutil (https://pypi.python.org/pypi/python-dateutil/2.6.0)
- Pandas (http://pandas.pydata.org/)
- Backtest (http://pmorissette.github.io/bt/)
- Googlefinance (https://pypi.python.org/pypi/googlefinance)

Charts and Data Preparation
We would also like to thank the IPython team and Jupyter IPython Notebook teams which allowed us to run simulations of the data and prepare charts.

Appendix
We’d like to show some samples of the code written for this project. Since our library of code written is very large, it would not fit in this document. However, we will provide some samples of our code, including our linear regression model and data crawling, and some parts from our frontend. However, for privacy purposes, we would not like to disclose the code for our models.

```python
#!/usr/bin/python
# -*- coding: utf-8 -*-

"""
This module is used to organize all our analysis of linear regression
"""

from analysis import dataAnalyzer
```
from dataAnalyzer import *
from scipy import stats
from collections import namedtuple
from dateutil.parser import parse as parse_date
import sklearn
from sklearn import linear_model
import numpy as np

class Regression:
    data = {}

    def addData(self, name, data):
        if isinstance(data, DataAnalyzer):
            raise ValueError('Data type has to be of type DataAnalyzer')
        self.data.put(name, data)

    def normalize(self):
        pass

    @staticmethod
    def cutDateWithRange(data, dateRange):
        new_data = []
        for dat in data:
            dataCmp = dateCmp = parse_date(str(dat['Date']))
            if dataCmp in dateRange:
                new_data.append(dat)
        return new_data

    @staticmethod
    def getMatchingDateRange(xData, yData):
        xdate_dat = [parse_date(str(i)) for i in xData.getDataWithKeyNatural(key='Date')]
        ydate_dat = [parse_date(str(i)) for i in yData.getDataWithKeyNatural(key='Date')]

        print 'print date lengths'
if len(xdate_dat) > len(ydate_dat):
    same = set(ydate_dat).intersection(xdate_dat)
else:
    same = set(xdate_dat).intersection(ydate_dat)

same = set(xdate_dat).intersection(ydate_dat)

Range = namedtuple('Range', ['start', 'end'])
r1 = Range(start=min(same), end=max(same))

latest_start = r1.start
earliest_end = r1.end

new_xdata = Regression.cutDateWithRange(xData.getData(),
                                         dateRange=same)

new_ydata = Regression.cutDateWithRange(yData.getData(),
                                         dateRange=same)

xdate_dat = [parse_date(str(i)).strftime('%Y-%m-%d %H:%M:%S')
             for i in
             DataAnalyzer().getDataWithKeyNatural(data=new_xdata,
                                                     key='Date')]
ydate_dat = [parse_date(str(i)).strftime('%Y-%m-%d %H:%M:%S')
             for i in
             DataAnalyzer().getDataWithKeyNatural(data=new_ydata,
                                                     key='Date')]

return (new_xdata, new_ydata, r1)

@staticmethod
def linearRegression(
    xData,
    yData,
    key=None,
    roc=False,
    ):
    if not key:
        raise ValueError('Key not provided.')

    (new_xdata, new_ydata, r1) = \
        Regression.getMatchingDateRange(xData, yData)

    xData.data = new_xdata
    yData.data = new_ydata
if roc:
    yDataArr = yData.getROC(key=key)
    # yDataArr = yData.getROC(key=key)
    xDataArr = xData.getDataWithKey(key=key)
    # xDataArr = np.array(xDataArr).astype(np.float)
    yDataArr = np.array(yDataArr).astype(np.float)
else:
    xDataArr = xData.getDataWithKey(key=key)
    yDataArr = yData.getDataWithKey(key=key)
    (slope, intercept, r_value, p_value, std_err) = \
    stats.linregress(x=xDataArr, y=yDataArr)

lnExt = LinearRegression()

xReshaped = xDataArr.reshape(len(xDataArr), 1)

return (slope, intercept, r_value, p_value, std_err, r1.start, r1.end,)

Code for our web crawling portion of the system.

#!/usr/bin/python
#
# -*- coding: utf-8 -*-

""
This module contains all our data crawling classes.
""

import datetime
import os
import unicodecsv as csv
import yahoo_finance

from __init__ import dir_path
from analysis.dataAnalyzer import DataAnalyzer

from pandas.io import data as web

class StockDataDownload(object):
    def __init__(self):
        """
        Abstract class for retrieving stockData
        """

        self.data = []

def getToday(self):
    """
    Get's todays date
    """

    return datetime.datetime.now()

def saveStockData(self, data):
    """
    Saves the dictionary-data to a CSV file
    Void function, does not return anything
    """

    if not data:
        raise Exception('No data provided.')
        exit()

    self.updateData(data)

    file_name = self.generateFileNameFromStock(self.stockSymbolName)

    toCSV = self.data
    keys = toCSV[0].keys()
    with open(file_name, 'wb') as output_file:
        dict_writer = csv.DictWriter(output_file, keys,
        encoding='utf-8')
        dict_writer.writeheader()
        dict_writer.writerows(toCSV)
def readCSVData(self, csvFile):
    """
    Read's CSV to dictionary data
    Returns list of stock-data objects
    """
    data = []
    with open(csvFile, mode='r') as infile:
        reader = csv.reader(infile)
        headers = reader.next()
        for rows in reader:
            rowDict = {}
            for (h, v) in zip(headers, rows):
                rowDict[h] = v
            data.append(rowDict)
    return data

def getData(self):
    return self.data

def updateData(self, data):
    self.data = data
    self.dataAnalyzer.updateData(data)

class YahooData(StockDataDownload):
    """
    Stock class to get any data from yahoo
    Implements StockData class.
    """
    stockCache = {}
data = []
start_data = '1900-01-01'
def __init__(self, stockSymbolName):
    super(StockDataDownload, self).__init__()
    self.stockSymbolName = stockSymbolName
    self.dataAnalyzer = DataAnalyzer()
def get_info(self):
    return self.stockSymbol.get_info()

def getHistoricalData(self, end_date, start_date='full'):
    
    Get's historical data on range(end_data, start_date)
    
    If start_date is 'full,' it will get the longest period allowed by the stock API
    
    If Stock exists in cache as an CSV file, it will return the saved data
    
    if self.isStockInCache(self.stockSymbolName):
        full_path = \ 
        self.generateFileNameFromStock(self.stockSymbolName)
        data = self.readCSVData(full_path)
        self.dataAnalyzer.updateData(data)
        range = self.dataAnalyzer.getDateRange()
        max = range[01] + datetime.timedelta(days=01)
        now = datetime.datetime.datetime.today().date()
        if max.date() < now:
            new_data = self.downloadHistoricalStock(start_date=max,
                                                    end_date=now)
            if new_data:
                data = data + new_data
                self.dataAnalyzer.updateData(data)
                date = self.dataAnalyzer.sortByDate()
                self.saveStockData(data)
            else:
                print 'No new data.'
        else:
            data = self.downloadHistoricalStock(end_date, start_date)
            self.saveStockData(data)
        self.dataAnalyzer.updateData(data)
        return data

def downloadHistoricalStock(self, end_date, start_date='full'):
    
    Download historical data with start and end date objects
    

if start_date == 'full':
    start_date = datetime.datetime(1900, 01, 01)

if not isinstance(start_date, str):
    start_date = start_date.strftime('%Y-%m-%d')

if not isinstance(end_date, str):
    end_date = end_date.strftime('%Y-%m-%d')

if len(data) < 01:
    print 'No new data to download for %s with range %s, %s'
    % (self.stockSymbolName, start_date, end_date)
    return None

return data

def generateFileNameFromStock(self, stock):
    """
    Generates the full file name for a given stock, including the entire path
    """

    stock_file_name = str(self.stockSymbolName) + '.csv'
    cache_directory = os.path.join(dir_path, 'cache')
    full_path = os.path.join(cache_directory, stock_file_name)

    return full_path

def isStockInCache(self, stock):
    """
    Check's whether the stock data is already in cache
    """

    full_path = self.generateFileNameFromStock(stock)
    if os.path.isfile(full_path):
        return True
    return False

def getBookValue(self):
    if self.stockSymbol:
        return self.stockSymbol.get_book_value()
    else:
        print "Couldn't retrieve book value."
        return None

def getDataWithKeyNatural(self, key=None):
    if not key:
raise ValueError('Key not provided.')
return self.dataAnalyzer.getDataWithKeyNatural(data=self.data,
key=key)

def getDataWithKey(self, key=None):
    if not key:
        raise ValueError('Key not provided.'
    return self.dataAnalyzer.getDataWithKey(data=self.data, key=key)

def getROC(self, data=None, key=None):
    if not data:
        data = self.getData()
    if not key:
        raise ValueError('Key not provided for rate of change function.'
    self.dataAnalyzer.data = data
    return self.dataAnalyzer.getRateOfChangeData(key=key)

def getStockSymbol(self):
    if self.stockSymbol:
        return self.stockSymbol
    else:
        print "Couldn't retrieve stockSymbol."
        raise AttributeError('No stockSymbol definition."
        return None

class YahooDataManual(YahooData):
    def __init__(self, stockSymbolName):
        super(StockDataDownload, self).__init__()
        data = {}
dataPandas = None
self.stockSymbolName = stockSymbolName
self.dataAnalyzer = DataAnalyzer()
self.advancedData = YahooData(self.stockSymbolName)

def get_info(self):
    return self.advancedData.get_info()

def downloadHistoricalStock(self, end_date, start_date='full'):
    if start_date == 'full':
start_date = datetime.datetime(1900, 01, 01)

if isinstance(start_date, datetime.datetime):
    start_date = start_date.strftime('%m/%d/%Y')

if isinstance(end_date, datetime.datetime):
    end_date = end_date.strftime('%m/%d/%Y')

self.dataPandas = web.get_data_yahoo(self.stockSymbolName,
                                        start_date, end_date)

keys = self.dataPandas.T.to_dict().keys()
values = self.dataPandas.T.to_dict().values()

for (i, tm) in enumerate(keys):
    values[i]['Date'] = tm.to_datetime()

if len(self.data) < 01:
    print 'No new data to download for %s with range %s, %s'
    % (self.stockSymbolName, start_date, end_date)
    return None

return self.data