Predicting the Price of a Stock

An Interactive Qualifying Project submitted to the faculty of

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1. Abstract

The recession due to the pandemic has led to high rates of inflation. This has caused increased volatility in the stock market. The goal of this IQP was to create models that can make short term predictions for stock prices, taking into consideration the volatility with the effects of the recession. We designed predictive models to help investors make informed decisions. Historical stock prices were used to make predictions, which were tested on future data and using virtual stock trading platforms.

2. Acknowledgements

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We would also like to thank our university, Worcester Polytechnic Institute, for giving us the platform to conduct this project.

3. Executive Summary

We started our study by choosing different sectors to analyze within the stock market. The five sectors we chose were: technology, industrial, cyclical consumer, materials and agriculture. Analyzing different sectors is necessary to get a full comprehension of the market and to adjust the models accordingly. We then chose 20 stocks within our sectors and removed the 5 most volatile stocks.

Using historical data, we started analyzing the trends in the market and building out models. The models we built included a prototype model which used predictive analyses which applied linear trend lines, fourier analyses and error bounds. Our second model included exploration using moving averages and normalization. Our last model took into account market influences in the predictions from indexes like NASDAQ or Dow Jones.

We further investigated other buy/sell signals by analyzing volume, Relative Strength Index (RSI) and Bollinger bands. These signals indicate whether the stock is overbought or oversold and provide further insight into the market.

We tested our models using future data. We also performed virtual stock trading to experiment and evaluate our predictions in real time. The virtual stock trading also helped in picking out the sectors that are doing well in the market at present.

4. Introduction

Having foresight in the stock market as an investor or a trader is the key to making money. People have been trying to find ways to predict the market from its very inception. Stock price analysis has thus been a critical area of research due to its high reward. Stock price prediction can be very tricky and incorrect predictions can be very expensive, especially with short-term investments. It is difficult to predict the future and the market has become more and more volatile recently.

The recent unforeseen COVID-19 pandemic sent the whole world in turmoil. Bans on travel and other global events such as wars in Ukraine and Afghanistan caused economies around the world to collapse which sent the stock market into distress. The fiscal and monetary policies implemented during the pandemic led to inflation which is currently at an all time high in several countries, including the United States. This contributed to the already increasing volatility in the market. Investors and traders need help in predicting short-term stock prices now more than ever due to this volatility. The volatility also increases the difficulty of making short term predictions. However, having some insight in stock trends may help in the investing process and enable investors and traders to have the upper hand.

There are several factors that affect the price of a stock like the current price, the direction of movement in the recent past and the historical pricing. There are also external factors that cause variation of prices of a stock like the state of the overall market and in turn the economy, changes or business decisions made within the company, insider trading, acquisitions by a company and public perspective of the organization and political events or decisions to name a few.

In this project, we use predictive modeling to estimate the short-term future prices of stocks. Predictive modeling uses mathematical concepts and analyzes patterns in current and historical data to forecast future behaviors and trends. There are various types of predictive modeling like decision trees, logistic regression, time-series analysis and neural networks. Our research uses time-series analysis, which analyzes past trends and systematic patterns in data over time.

5. Background

The project focuses on short term prediction of prices in the stock market. To fully comprehend the aim and scope of this project, it is important to understand what a stock is, how the stock market works, and other terms used while describing the market.

A stock is a type of investment in a company. Companies will issue stock shares in order to raise money, finance their own operational needs, and to fuel growth for the business. Investors buy those stock shares for the opportunity to generate a return on their investment. Owning a stock is synonymous to owning a small portion of the company. The more stocks you have, the bigger the share of the company you own.

The stock market is where you can buy or sell shares for companies that are listed publicly.
A stock market is often used as an indication to understand the current state of the economy. The supply and demand of a stock is what determines the price of a stock. The mediator that allows for this buying and selling of shares is called the stock exchange. When the market is on the rise, and the economy is doing well, the market is referred to as a bull market. A bear market is one where the economy is declining and the market is falling. Since the pandemic, we have been in a bear market.

The stock market is divided into different sectors depending on the kind of industry the organization or company is a part of. It helps investors compare the kind of stocks that are making the most money and thus helps make decisions on the kinds of stocks to invest in the current market. The sectors we chose to make our stock portfolio from include technology, industrial, basic materials, agricultural and the consumer cyclical sector. Models may need to be adjusted to different sectors to fit them better.

There are several groups of stocks, known as market indices which are often used to track how particular sectors are doing within the stock market. Examples of such indices include the Dow Jones Industrial Average (DJIA), the S&P 500, the Vanguard Total Index (VTI) and the Nasdaq composite index. They work by measuring a weighted average value of the collection of stocks

within the index. These indexes can prove to be very useful when trying to predict stock prices, as they help bring in market influence into predictions.

Volatility is a very commonly used word in the stock market and is heavily used in our paper as well. Volatility refers to the uncertainty or risk associated with the price of a stock. Higher the volatility, greater the standard deviation of the price of the stock over a certain period of time. Lower the volatility, lower the risk and standard deviation of the price of the stock. A volatile market is one where the market rises and falls with no direction over a period of time. We are currently in an incredibly volatile market.

6. Stock Portfolio

To help analyze and improve our models, we picked 20 stocks within each of the five sectors. All stocks chosen were in the $20 to $100 price range. Penny stocks were avoided due to the risks associated with them, like low liquidity and scams as well as their lack of historical data. Larger stocks are avoided as well due to the significant risks associated with their capital as well as the large amount of money needed for a meaningful investment in such stocks. We then removed 5 of the most volatile stocks within each of the sectors. The volatility of the stocks was calculated using the weighted standard deviation of the stock, using the historical data from the last two years. The goal was to study a set of stocks that could provide meaningful and applicable data to make our predictive models.

The following 5 sectors were chosen: Technology, Consumer Cyclical, Agricultural, Industrial and Basic Materials. These sectors were chosen because of the diversity in terms of investment and so we could analyze how different sectors are doing in comparison with each other.

6.1. Technology Sector

The technology sector consists of stocks that relate to the research, development, or distribution of goods and services based in technology. The sector contains businesses that depend on software, computers, manufacturing of electronics or relating to information technology services. This sector is heavily dependent on innovation which drives the industry. The technology sector is very important for all other sectors, as companies require the innovations from the technology sector to manage their logistics, databases and provide information to help make strategic business decisions. This sector is considered one of the most attractive investments, with high risk and high rewards. Below is a description of the 20 stocks initially chosen. Out of the 20 stocks, the 5 volatile stocks that were removed were Digital Ocean Holdings Incorporated, Impinj Incorporated, Ultra Clean Holdings Incorporated, TeraData Corporation and Informatica Incorporated.

- ➔ **Akamai Technologies (AKAM)** is an American content delivery delivery network, cybersecurity and cloud service company providing web and internet security services.

- ➔ **Altair Engineering, Inc. (ALTR)** is an American multinational information technology company headquartered in Michigan. They provide software and cloud solutions for simulation, high performance computing, data analytics and artificial intelligence.
- ➔ **Agilysys, Inc. (AGYS)** is a developer and marketer of proprietary enterprise software and other products for the hospitality industry.
- ➔ **DigitalOcean, Inc. (DOCN; Volatile)** is an American cloud infrastructure provider. The company provides on-demand infrastructure and platform tools to other businesses to build, deploy and scale software applications. They began publicly trading on 24th March 2021.
- ➔ **Informatica, Inc. (INFA; Volatile)** is an American software development company with products in the fields of enterprise cloud data management and data integration. They began publicly trading on 27th October 2021.
- ➔ **Impinj, Inc. (PI; Volatile)** is a manufacturer of radio-frequency identification devices and software.
- ➔ **Mandiant, Inc (MNDT)** is an American cybersecurity firm which scales intelligence and expertise through its platform to deliver current intelligence, automation of alert investigation among other other security products.
- ➔ **Marvell Technology, Inc. (MRVL)** is an American company which develops and produces semiconductors and other related technology.
- ➔ **Netgear, Inc. (NTGR)** is an American computer networking company which produces networking hardware for consumers, businesses and service providers.
- ➔ **Oracle Corporation (ORCL)** is an American multinational computer company which sells database software and technology, cloud engineered systems and enterprise software products.
- ➔ **PC Connection, Inc. (CNXN)** provides IT services to small and medium-sized businesses, enterprises and public sector markets. Its products go under the brand name ‘Connection’.
- ➔ **PDF Solutions, Inc. (PDFS)** produces software, hardware and semiconductor-based intellectual property to provide advanced data management and analytics that support the manufacturing and testing of integrated circuits and systems on chips used in electronic devices.

- ➔ **ScanSource, Inc. (SCSC)** is an American company and a leading hybrid distributor in connecting devices to the cloud and accelerating growth across hardware, software, connectivity and the cloud.
- ➔ **Teradata Corporation, (TDC; Volatile)** is an American software company that provides cloud database and analytics-related software, products and services.
- ➔ **The Hackett Group, Inc. (HCKT)** offers digital transformation including implementation of enterprise cloud applications, workflow automation and analytics that enable digital performance.
- ➔ **Ultra Clean Holdings, Inc. (UCTT; Volatile)** is a developer and supplier of critical subsystems, components and parts, and ultra-high purity cleaning and analytical services primarily for the semiconductor industry.
- ➔ **Micron Technology, Inc. (MU)** is an American producer of computer memory and computer data storage including dynamic random-access memory, flash memory, and USB flash drives. Its products are marketed under the brands 'Crucial' and 'Ballistix'.
- ➔ **Varonis Systems, Inc. (VRNS)** is a software company that developed a security software platform that allows organizations to track, visualize, analyze and protect unstructured data.
- ➔ **Zendesk, Inc. (ZEN)** is an American company that provides software-as-a-service products related to customer support, sales, and other customer communications.
- ➔ **ZoomInfo Technologies, Inc. (ZI)** is a go-to-market software, data, and intelligence platform for more than 30,000 companies worldwide.

6.2. Consumer Cyclical Sector

Cyclical stocks are stocks that are affected by the macroeconomics of the overall economy. They are stocks of companies providing for consumer wants. If the company does well, the economy also tends to do well. This sector is more volatile to economic conditions and includes non-essential needs. This includes non-essential needs like traveling and luxury goods.

The five main categories of the cyclical sector are real estate. Consumer cyclicals, construction, basic materials and financial services. Real estate includes mortgage companies, property management and real estate invesments. Consumer cyclicals include retail stores, auto parts,

residential construction/lodging, restaurants and entertainment. Construction includes real estate development and the up and down scaling of properties used for businesses. Basic materials are the building materials and paper products. Financial services are asset management companies, brokers, insurance agencies and banks.

This sector is volatile in comparison to other sectors such as agriculture since it is a secondary expense. In this research, 20 cyclical consumer stocks were chosen, but the 5 most volatile stocks of the chosen stocks were eliminated from stocks studied going forward. The eliminated stocks were AEO, BBBY, CHEWY, CROCS, W. Listed below are the stocks that were chosen.

- ➔ **American Eagle Outfitters (AEO; Volatile)**: This company was founded in 1977. It is a retailer of textile goods including clothing, accessories and personal care products. It has merchandise in 880 stores shipping to 28 countries. It has 260 locations. The company targets people in high school and university as well as young adults of both genders.
- ➔ **Bath and Body Works (BBWI):** Bath and Body Works originally specialized in scented candles. It is now a distributor of fragrances, body care and personal hygiene products. It is internationally licensed and operates internatinally. Formerly known as L brands. Products are sold in its 1,755 stores with an additional 338 partner stores.
- ➔ **Bed Bath and Beyond (BBBY; Volatile):** The company sells a wide range of domestic merchandise. They sell general home consumables including bedding, bath related items and kitchen accessories. It has stores in all 50 states in addition to Canada, Mexico and Puerto. It originally was a discount store chain, but after financial difficulties it shifted to a specialty store.
- ➔ **BJ's Restaurant (BJRI):** BJs is a casual dining restaurant in the US. It serves pizza, beer and other entrees and desserts. It operates 213 restaurants in 29 states. Some locations include microbreweries. Originating in California, it now has 214 locations. Operation names include BJ's Restaurant & Brewery, BJ's Restaurant & Brewhouse, BJ's Grill, and BJ's Pizza & Grill.
- ➔ **CarMax (KMX):** CarMax is a distributor of used vehicles originating in Virginia. It operates in two sectors. One is financing sales, the other is distributing the vehicles with protection services.it provides reconditioning of vehicles.It offers financing alternatives

to a wide range of customers. To combat competition, the company is targeting both online and in-store retail markets. They offer vehicle delivery and contactless pickup.

- ➔ **Cheesecake Factory (CAKE):** They are a restaurant franchise. It distributes cheesecakes and operates 220 full-service restaurants serving other entrees and menu items. They also distribute their cheesecake in their partnering Barnes & Nobles Cafes. They are viewed as a hangout eatery, featured in shows on television.
- ➔ **Chewy (CHEWY; Volatile):** The company is an online retailer of pet related goods. The company hired former employees from Amazon, PetSmart, Whole Foods Market Basket and Wayfair. It was bought by PetSmart for 3.35 billion dollars. It was recognized for their customer service and one of the top employer brands in 2019 and 220.
- ➔ **Crocs (CROCS; Volatile):** Crocs is a foam clog brand. It was designed in Quebec City. It was originally intended to be a boating shoe but was marketed as a multi-functional shoe. With the introduction of croc charm, known as jibbitz, it became a popular way to accessorize, increasing their shoe sales. The company experienced drastic ups and downs within the last two decades with rising and falling trends.
- ➔ **Columbia Sportswear (COLM):** Columbia is an American Company manufacturing outerwear, sportswear and footwear. It also sells outdoor equipment and accessories. The company's headquarters is in Orgeo. Their rapid sales growth is largely due to their sales in jackets and rain coats. It was America's largest ski apparel brand in 2001.
- ➔ **eBay (EBAY):** EBay is an American e-commerce company based in California. It is a platform connecting business to consumers. It is the middle group in the distribution of selling consumer goods. One of its main competitors is Amazon. It differs with the addition of auction-style sales in addition to their "buy now" options.
- ➔ **Funko (FNKO):** Funko is an American company, manufacturing and distributing collectibles. They are best known for their vinyl figures and bobbleheads. They produced licensed plushies and action figures with companies such as Warner Bros, Nickelodeon and Disney. Their connection to games, shows and movies makes them popular amongst kids and young adults.
- ➔ **H&R Block (HRB):** They are an American tax preparation company operating in Canada, US, and Australia. They operate in 12,000 retail tax offices. They offer payroll, consumer tax software, tax preparations and business consulting services. Originally a

software company, it has expanded into financing, mortgage loans, banking and business services.

- ➔ **Hilton Grand Vacations (HGV):** The company is based in Florida with regional offices in Nevada, Hawaii, New York, and Florida. Hilton Grand Vacations was a subsidiary of Hilton WorldWide until it was turned into a publicly traded company. As of 2019, it has 55 properties in 5 countries. It manages, develops, markets, operates timeshare and vacation related services.
- ➔ **Movado Group (MOV):** Movado is a luxury watch company. They are known for their signature minimalist style and are best known for their "movement". "Movement" is a term used to refer to their automatic watches, powering the watch with the movement of the wrist rather than the more common, quartz battery.
- ➔ **Planet Fitness (PLNT):** Planet Fitness is a company franchising and operating of fitness centers. They have 2,039 clubs and they are the largest fitness club by number of members and location. They are known for their vast number of locations and is popular amongst casual gym goers, but is also criticized for certain marketing choices and there atmosphere.
- ➔ **Starbucks (SBUX):** Starnucks is the world's largest coffeehouse chain. Its roastery services are headquartered in Seattle, Washington. It has 33,833 stores in 80 countries, half of which are located in the United States. They introduced a variety of coffee experiences, such as hot drinks, cold drinks, and lattes, diversifying the market. This is attributed to their success as a modern coffee chain.
- ➔ **Trip Advisor (TRIP):** Trip advisor is an online travel company. It provides a website and mobile app that allows customers to compare prices while shopping. It offers hotel reservations, transportation, housing, and information on attractions and resturants. Its headquarters is in Needham, Massachusetts.
- ➔ **Yeti (YETI) :** They are an American manufacturing company specializing in outdoor products. They are best known for their stainless steel drinkware and coolers. They are a rapidly growing company in premium products with a wide range of target customers. They are looking to release their own line of bags and luggages in the near future.
- ➔ **Zumiez (ZUMZ):** Zumiez is an American clothing store. THey sell apparel, footwear, accessories, and hard goods. They target men and women who are particularly interested

in action sports. These sports include, but are not limited to skateboarding, skating and motocrossing. It operates 726 stores in the US, Canada, Europe and Australia.

- ➔ **Wayfair (W; Volatile):** Wayfair is an American company based in Boston, Massachusetts. They sell furniture and household goods online. It was formerly known as CSN stores and was a platform connecting summer with over 11,000 global suppliers. In the last decade, they have expanded into Canada, UK and Germany. They are the #1 fastest-growing private e-commerce company in Massachusetts.

6.3. Industrial Sector

The industrial sector consists mainly of companies that produce and distribute capital goods to other businesses. Capital goods are used in producing other goods, rather than being sold directly to the consumers. Companies in this sector also do other kinds of businesses such as transportation where they provide companies with passengers, products, transportation services, and related management services. Some of them also offer some commercial and professional services for other businesses. Performance of companies in the industrial sector are closely tied to the economy. Their activity tends to decline during recession and rises during expansion, though some of its sub sectors may perform differently. The Dow Jones Industrial Index has historically been weighted heavily to this sector. Here's the 20 stocks selected in this sector:

- ➔ **ABM Industries Inc (ABM)** is an American facility management company. ABM provides facility services in areas such as electrical and lighting, energy, facility engineering, HVAC and mechanical, janitorial services, landscape and grounds, parking and transportation. ABM's services also include energy efficiency and sustainability such as building improvements, electric vehicle charging stations, and renewable energy solutions.
- ➔ **Altra Industrial Motion Corp (AIMC)** is a global designer and manufacturer of a wide range of motion control and power transmission solutions. Most Altra products are used on industrial machinery, such as fail-safe brakes for elevators and forklifts, gearboxes on conveyors, heavy duty brakes on mining equipment, clutches for beverage capping equipment, etc. Altra is the parent company of several power transmission industry

brands, including: Ameridrives, Boston Gear, Warner Electric, TB Wood's, Stieber Clutch, Twiflex, Matrix International and Wichita Clutch.

- ➔ **Astec Industries Inc (ASTE)** designs, engineers, manufactures, and markets equipment and components primarily for the road building, aggregate processing, geothermal, water, oil and gas, and wood processing industries in the US and internationally. The Company's products are used in each phase of road building, from quarrying and crushing the aggregate to application of the road surface.
- ➔ **BlueLinx Holdings Inc (BXC)** is a US wholesale distributor of building and industrial products. They provide the foundation for residential and commercial construction, remodeling and repair, manufacturing, manufactured and modular housing, and homeowner projects. BlueLinx maintained both branded and private-label SKUs across product categories such as lumber, panels, engineered wood, siding, millwork, metal building products, and other construction materials.
- ➔ **BWX Technologies Inc (BWXT)** is a US supplier of nuclear components and fuel. They strive to provide safe and effective nuclear solutions for global security, clean energy, environmental restoration, nuclear medicine and space exploration. In addition, BWXT joint ventures provide management and operations at more than a dozen U.S. Department of Energy and NASA facilities.
- ➔ **EnPro Industries Inc (NPO)** is a leading, US based Industrial technology company that designs and manufactures materials science enabled products for technology intensive sectors. The company serves industries such as semiconductor, aerospace, power generation, heavy-duty trucking, agricultural machinery, chemical processing, pulp and paper, and life sciences from 61 primary manufacturing facilities located in 12 countries, worldwide. It is organized under three segments - Sealing Technologies, Advanced Surface Technologies, and Engineered Materials.
- ➔ **Fortune Brands Home & Security Inc (FBHS)** is a US manufacturer of home and security products. Their portfolio of businesses and brands includes Moen and the House of Rohl; outdoor living and security products from Therma-Tru, Larson, Fiberon, Master Lock and SentrySafe; and MasterBrand Cabinets. Accordingly, Fortune Brands has three reporting business segments: Water Innovations, Outdoors & Security and Cabinets.

- **Gibraltar Industries (ROCK)** is a manufacturer, processor, and distributor of metals and other engineered materials for the building products, vehicular, renewable energy, residential, agricultural-technology, and infrastructure markets. The Company serves customers in a variety of industries including renewable energy (solar) developers, institutional and commercial growers of food and plants, home improvement retailers, wholesalers, distributors, and contractors.
- **Graco Inc (GGG)** is a US designer and manufacturer of fluid-handling systems and products. They have 3 main divisions of Contractor Equipment, Lubrication Equipment, and Industrial Products. Graco serves a wide variety of markets, including painting, anti-corrosion, fluid transfer, gluing and sanitary applications, automotive, aeronautic, body refinish, wood, building and construction, and marine.
- **Griffon Corp (GFF)** is a multinational conglomerate headquartered in New York City. The company conducts its operations through five wholly-owned subsidiaries: The AMES Companies, ClosetMaid, Clopay Building Products, CornellCookson, and Telephonics Corporation. Griffon oversees the operations of its subsidiaries, allocates resources among them and manages their capital structures.
- **Helios Technologies Inc (HLIO)** is a global technology leader in highly engineered motion control and electronic controls technology for diverse end markets, including construction, material handling, agriculture, energy, recreational vehicles, marine, health and wellness. The company operates under 2 business segments, hydraulics and electronics.
- **Icahn Enterprises LP (IEP)** is an American diversified holding company engaged in seven primary business segments: Investment, Energy, Automotive, Food Packaging, Real Estate, Home Fashion and Pharma.
- **Kimball Electronics Inc (KE)** is a contract manufacturer of durable goods electronics serving a variety of industries on a global scale. The company offers services in 4 markets: Automotive, Industrial, Medical and Public Safety. Kimball Electronics provides end-to-end engineering, design and manufacturing solutions, including contract Electronics Manufacturing Services (EMS), Diversified Contract Manufacturing Services (DCMS), and Automation, Test & Measurement services to their customers.

- ➔ **Kirby Corp (KEX)** is the largest tank barge operator in the US. Products transported by Kirby include petrochemicals, black oil, refined petroleum products and agricultural chemical products by tank barge. Through Kirby's diesel engine services segment, Kirby is an after-market service provider for medium-speed and high-speed diesel engines, reduction gears and ancillary products for marine and power generation applications.
- ➔ **MasTec Inc (MTZ)** is an American multinational infrastructure engineering and construction company. The company provides engineering, building, installation, maintenance and upgrade of energy, utility and communications infrastructure. They offer services in the renewable energy, electric power, oil and natural gas, water and sewer, and communication industries.
- ➔ **Mercury Systems Inc (MRCY)** is a global commercial technology company serving the aerospace and defense industry. It designs, develops and manufactures open architecture computer hardware and software products, including secure embedded processing modules and subsystems, avionics mission computers and displays, rugged secure computer servers, and trusted microelectronics components, modules and subsystems.
- ➔ **Owens-Corning Inc (OC)** is an American company that develops and produces insulation, roofing, and fiberglass composites and related materials and products. It is the world's largest manufacturer of fiberglass composites. Owens Corning operates in three segments: Insulation, Roofing, and Composites.
- ➔ **Proto Labs Inc (PRLB)** is a US company that provides rapid digital manufacturing of low-volume 3D printed, CNC-machined, sheet metal, and injection-molded custom parts for prototyping and short-run production. Markets like medical devices, electronics, appliances, automotive and consumer products use these parts.
- ➔ **Robert Half (RHI)** is a global human resource consulting firm and is credited as being the world's first and largest accounting and finance staffing firm, with over 345 locations worldwide. The company operates through three segments: temporary and consultant staffing, permanent placement staffing, and risk consulting and internal audit services.

6.4. Basic Materials Sector

This Sector is involved in consists of companies that are involved in the discovery, development, and processing of raw materials. These materials are substances that are considered naturally

occurring such as wood, stone, gold, and oils. Companies within this sector engage in the exploration, and processing of these materials in order to produce commodities for or with them. In this aspect, they are subject to supply and demand in the same way as consumer goods are. Not all businesses that work with basic materials are included in the sector, instead most industries rely on companies in this sector for the raw materials they need to manufacture their goods. For instance a metal mining company would be a processor, that is within the basic materials sector, while a Jewelry company would be a retailer/wholesaler after purchasing from the metal mining company.

- ➔ **Alcoa Corp. (AA; Volatile):** The company works through three major segments, which are bauxite, alumina, and aluminum. They produce and sell the products in the United States, Spain, Australia, Iceland, Norway, Brazil, Canada, and internationally. They are the world's largest bauxite miner and alumina refinery by production volume while also being in the aluminum smelting and casting business.
- ➔ **Avient Corp (AVNT):** Avient works with three different sectors which are Color, Additives and Inks; Specialty Engineered Materials; and Distribution. The Color portion goes into thermoplastics; dispersions for thermosets; and specialty inks that are used in numerous markets such as medical and food packaging. Engineered materials help with formulations, services, and solutions for designers, assemblers, and processors of thermoplastic materials. Lastly distributions give tons of commodity grade resins to custom injection molders and extruders.
- ➔ **Chase Corp (CCF)**: A specialty chemicals company that produces and sells protective materials for an array of applications worldwide. Operating by three segments: Adhesives, Sealants and Additives; Industrial Tapes; and Corrosion Protection and Waterproofing.
- ➔ **Commercial Metals Comp (CMC)**: They reuse/recycle steel and metal products as well as fabricate them and related materials. The company processes scrap metals to various consumers and provides service in the US, Poland, China, and internationally. They also fabricated steel products for construction of buildings and rebar by-products to construction companies.

- ➔ **Corteva Inc. (CTVA)**: They are a part of the agriculture business that functions in two segments, Seed and Crop protection. The first offers trait technology to help control characteristics of plants while assisting farmers for optimal yields of production. The second helps create products that protect plants from diseases and pests while enhancing crop health.
- ➔ **Enviva Inc. (EVA)**: Enviva creates and sells utility-grade wood pellets. These are used for substituting coal in different power plants and generations. They operate in the United Kingdom, Europe and Japan.
- ➔ **H.B. Fuller Corp (FUL)**: Operating with three different segments: Hygiene, Health and Consumable Adhesives; Engineering Adhesives; and Construction Adhesives. The first produces and supplies specialty industrial adhesives for numerous uses in an array of different markets. The second instead produces and supplies high performance industrial adhesives. And the last of course provides products for various construction needs such as tile setting, roofing, heating and ventilation.
- ➔ **Green Plains Inc. (GPRE)**: Produces, markets and distributes ethanol in the US and internationally through three segments: Ethanol production, Agribusiness and Energy Services, and Partnership.
- ➔ **Huntsman Corp (HUN)**: They make and sell differentiated chemical products used in a range of applications worldwide by operating in four segments: Polyurethanes, Performance Products, Advanced Materials, and Textile Effects.
- ➔ **Innospec Inc. (IOSP)**: Sells different chemicals and fuel additives through three segments. Fuel specialties have products that improve fuel efficiency and reduce emissions for different vehicles. Performance chemicals sell items to the personal-care industry. And oilfield services develop and market the products.
- ➔ **Kaiser Aluminum Corp (KALU)**: By purchasing primary and scrap aluminum, they process it into specialized value added products to industrial consumers. Almost all revenue is generated in the US and from Canada since they are also located there.
- ➔ **Livent Corp (LTHM)**: A pure-play lithium producer with a low-cost lithium carbonate production due to resources from Argentina. They should be benefiting from the increased lithium demand from higher electric vehicle adoption since they are key

components in EV batteries.They also operate downstream lithium hydroxide plants in the US and China.

- ➔ **Materion Corp (MTRN)**: They are a producer of engineered materials based in the US. These materials are used in electrical, electronic, thermal, and structural applications. They have four different segments, that being Performance Alloys and Composites, Advanced Materials, Precision Coatings, and Other.
- ➔ **Newmont Corp (NEM)**: They engage in the exploration and production of gold while also doing copper, silver, zinc, and lead. They are organized in five geographic regions, that being north and south america, Australia, Africa, and Nevada.
- ➔ **Olympic Steel Inc. (ZEUS; Volatile)**: Olympic steel is known for providing metals processing and distribution services in the US. Having three segments: specialty metals flat products, carbon flat products, and tubular and pipe products. They work with a large amount of carbon, aluminum, and stainless steel flat-rolled sheet, coils, plates, bars, and fabricated parts that serve several different industries such as industrial and automobile.
- ➔ **Sensient Technologies Inc. (SXT)**: Senscient produces and sells natural and synthetic colors, flavors, and flavor extracts, having widespread facilities and customers operating across various different markets.
- ➔ **Steel Dynamics Inc. (STLD; Volatile):** They operate scrap-based steel minimills with almost 13 million tons of annual steel production capacity. They make steel products for construction, automotive, manufacturing, and transportation end markets. In addition they sell recycled ferrous and non ferrous metals.
- ➔ **The Mosaic Comp. (MOS; Volatile):** The leading producer of primary crop nutrients phosphate and potash in North America and Internationally. Owning and operating mines that produce concentrated phosphate crop nutrients while also producing and selling potash for a number of uses. Selling its products to wholesale distributors, retail chains, farmers, cooperatives, independent retailers, and national accounts.
- ➔ **UFP Industries Inc. (UFPI)**: With three main customer categories: retail, industrial, and construction, UFP produces and sells lumber and treated wood products. They design, manufacture, and market wood and wood-alternative products in North America, Europe, Asia, and Australia.

- ➔ **Warrior Met Coal Inc. (HCC; Volatile):** Produces and exports non-thermal metallurgical coal for the steel industry. By operating two underground mines in Alabama, they sell the coal to different blast furnace steel producers located primarily in Europe, South America, and Asia. A byproduct of the coal production is a natural gas that is extracted and also sold.

6.5. Agricultural Sector

The agricultural sector comprises companies that are involved with raising crops or animals, providing goods to farms (example machinery and fertilizer), and research/discovery of new ingredients and food products. As of 2020, Agriculture contributed towards $1.055 trillion to the Gross Domestic Product of the United States. The workforce within agriculture of 2020 consisted of 19.7 million full and part-time jobs being 10.3% of the United States total employment. The agriculture sector is ever growing largely due to the current rapid growing human population. A key indicator to help track how the agriculture sector is doing is by tracking the Dow Jones, which contains multiple big agricultural stocks.

- ➔ **Ingredion (INGR):** Ingredion is a producer of mainly starches, stevia, and non-GMO sweeteners. They were founded in 1906, an American based company in Illinois with a revenue of 6.894 billion in 2021. They are a leading global ingredient company with a focus on health.
- ➔ **Verde Agri-tech (NPK):** Verde Agri-tech is a UK based company with its focus on producing potash fertilizers. It produces multi nutrient fertilizers and operates in Brazilian Potash mines.
- ➔ **Cal-Maine Foods (CALM):** They are a fresh egg producer based in Jackson Mississippi, founded in 1969. Their eggs are mainly sold to midwester, southeastern, mid-Atlantic, and southwestern states. They are responsible for approximately a quarter of the egg consumption in the US.
- ➔ **Dole (DOLE):** It is one of the world's largest fruit and vegetable producers with 38,500 full and part-time workers. It supplies over 300 products to 75 different countries.

- ➔ **Vital Farms (VITL):** Vital Farms is poultry and dairy focused company, with its goal to bring ethically sourced food to table. They have publicly stated that they align themselves with conscious capitalism, to be environmentally and ethically concerned when conducting business.
- ➔ **Tejon Ranch (TRC):** Tejon Ranch is based in California and uses traditional ranching techniques to raise cattle, grow crops, and take care of the land. Biggest crops they grow include pistachios, grapes, and almonds. They make their own wine as well.
- ➔ **Alico (ALCO):** Alico is based in Florida, being one of the biggest citrus producers in the US. It owns around 69,000 acres of land in Florida. It also cares a lot about conservation of local wildlife.
- ➔ **Post Holdings (POST):** Post Holdings is a consumer packaged goods holding company. Some companies owned by POST include Weetabix, Foodservice, Post Consumer Brands, and Refrigerated Retail. They are based in St. Louis; currently employing 11,400.
- ➔ **Fresh Del Monte (FDP):** Mainly focusing on vegetables and fruits Fresh Del Monte sells their goods in over 90 countries. They own 6,700 farms worldwide and employ over 40,000 workers. Their values include excellence, passion, care, trust and creativity.
- ➔ **Adecoagro (ARGO):** They have produced 2.6 million tons of food and renewable energy each year. The business focuses on sugar, ethanol, energy, dairy, rice, and crops. Their values include transparency, trust, efficiency, innovation, sustainability, and safety.
- ➔ **Archer Daniels Midland (ADM):** Archer Daniel Midland is one of the top nutrition companies for humans and animals. Their purpose is to “unlock the power of nature, to enrich the quality of life”. Their headquarters are in Chicago Illinois with their net profit of 2020 $64 billion.
- ➔ **Darling Ingredients (DAR):** Darling Ingredients are part of many markets including health, nutrients, bioenergy, and services. They have been named one of 50 sustainability climate leaders. In 2020 their net sales hit $3.572 billion.
- ➔ **Pilgrim’s Pride (PPC):** Pilgrim’s Pride is recognized as a leading global provider of food products, including well recognized brands. They are known for their poultry and pork products.
- ➔ **Andersons (ANDE):** The Andersons does business in grian, plant nutrition, ethanol, consumer retail sectors, and logistics. Their goal is to expand into new markets using

their patented cutting edge technology. They also strive to create larger and better quality crops for its consumers.

- ➔ **Bachoco (IBA):** Bachoco is a poultry processing company based in Mexico. They focus on producing feed, breeding and feeding chickens, then processing those chickens. Bachoco owns and operates in over one thousand facilities making them one of the largest poultry businesses in the world.
- ➔ **John Deere (DE; Volatile):** John Deere is an American agricultural machinery company. Products they create include heavy equipment, diesel engines, forestry equipment, and lawn care equipment. Being in business for over 180 years they pride themselves on knowledge of the business inside and out.
- ➔ **Intrepid Potash (IPI; Volatile):** Intrepid Potash is a fertilizer company based in Denver, Colorado. Owning three mines, they are the largest producer of potassium chloride.
- ➔ **Nutrein (NTR; Volatile):** Nutrien is a producer of potash, nitrogen, and phosphate owning over two thousand facilities in 7 different countries worldwide. They have taken the first step in environmental sustainability by reducing emissions and practicing sustainable harvesting practices.
- ➔ **Bunge (BG; Volatile):** Bunge operates by buying grains, oilseeds, and soft seeds from farmers, then storing, transforming or selling these goods to their customers. They provide in depth value chain analysis to be as transparent with the customer as possible.
- ➔ **Calavo Growers (CVGW; Volatile):** Calavo Growers focuses on fresh vegetables and fruits sold to restaurants and grocery stores. Top items they produce are avocados, tomatoes and Hawaiian papayas. As of the second quarter of the 2022 fiscal results showed a total revenue of $331.4 million.

7. Predictive Models

7.1. Prototype Model

7.1.1. Auto-Correlation

To start our modeling, we find the autocorrelation period of each stock. Autocorrelation is a mathematical function used to compare a time series with a delayed copy of itself over

successive time periods. The autocorrelation value is found by shifting the time series by a factor of k as we check the correlation between the initial and the delayed time series. The correlation value can range between -1 and 1, with 1 representing a perfect positive correlation and -1 representing a perfect negative correlation. Thus, the time series is shifted until the correlation reaches 0. Here, the number of data shifted (k) is our autocorrelation period. The k most recent data samples of the time series are referred to as the **relevant time period** as these data shall be used for our predictive modeling and any data older than that shall be discarded. Here's the statistical formula used to calculate the **autocorrelation** of a time series.

$$r_k = \frac{\sum_{t=k+1}^{n} (y_t - \bar{y})(y_{t-k} - \bar{y})}{\sum_{t=1}^{n} (y_t - \bar{y})^2}$$

Where y_t is the original time series, y_{t-k} is the shifted time series and $\bar{y}$ is the average of the dataset.

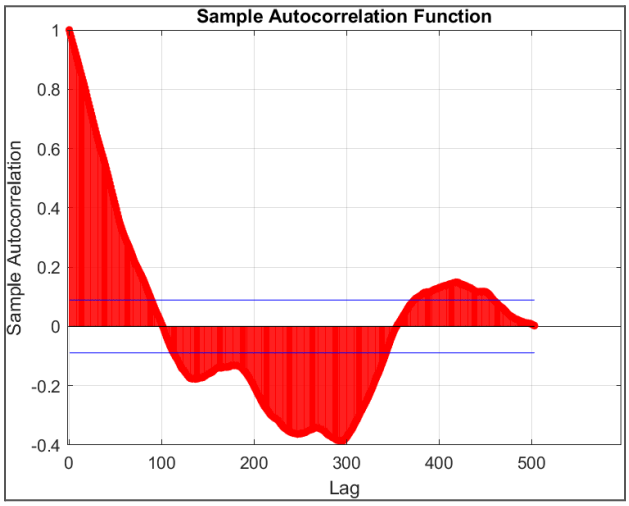

Figure 1: A graph of the autocorrelation function applied on a stock.

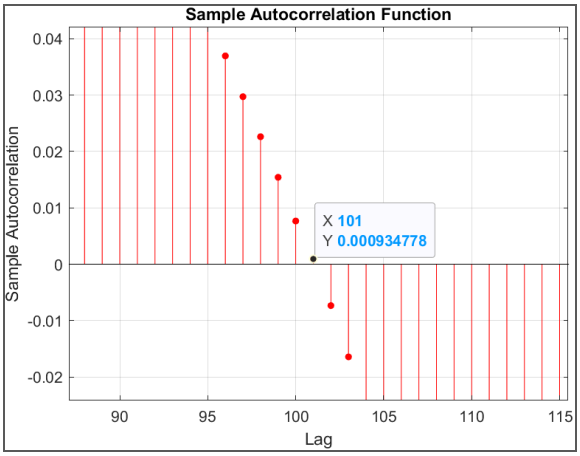

Figure 2: Zoomed in plot of the above sample autocorrelation plot, which shows that the lag value is 101. Therefore, the number of days in the relevant period is 101.

Autocorrelation was performed in MATLAB using the built in autocorr function and the relevant time period was calculated by looping through the function values.

7.1.2. Linear Trendline

A linear trendline is a best-fit straight line that shows whether the relevant value has been increasing or decreasing over time. It is the line that minimizes the sum of squared differences from every point to it. The **line of best fit** is applied to the range determined by the autocorrelation to analyze the trend in stock prices in the relevant time period. The linear line of best fit is described by the equation shown below, where b is the slope of the line and a is the intercept (i.e., the value of Y when $X = 0$).

$$\hat{y} = bX + a$$

Technology Sector

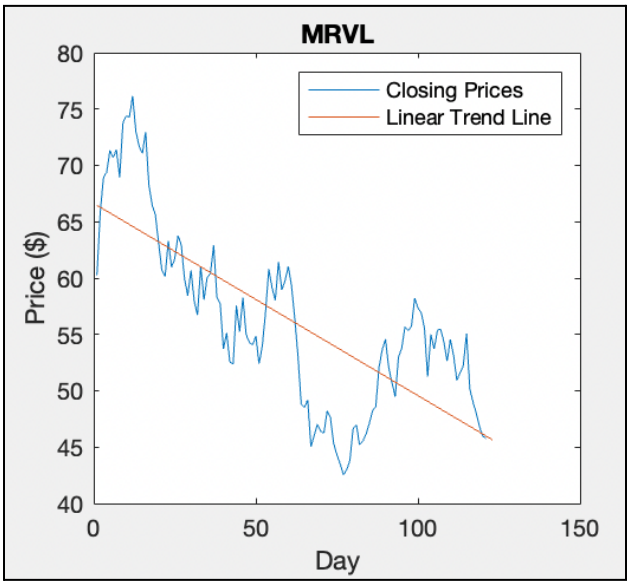

Figure 3: A graph of the closing prices of a technology stock for the relevant period calculated by autocorrelation, along with the linear trendline.

Consumer Cyclical Sector

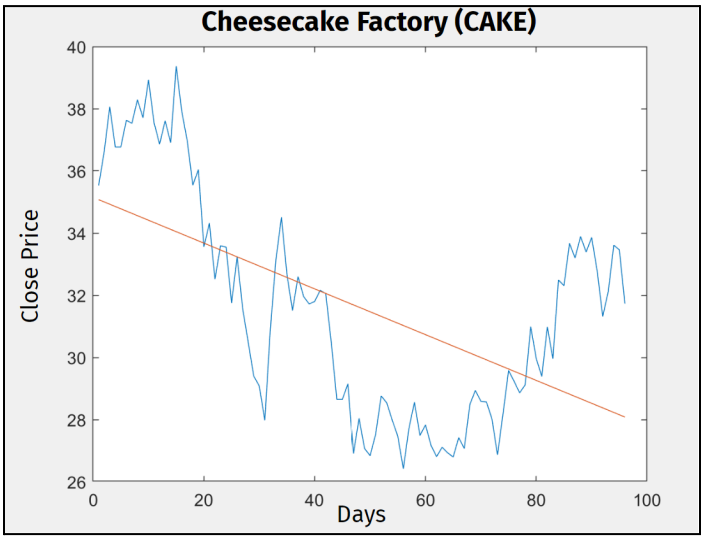

Figure 4: A graph of the closing prices of a consumer cyclical stock for the relevant period calculated by autocorrelation, along with the linear trendline.

Industrial Sector

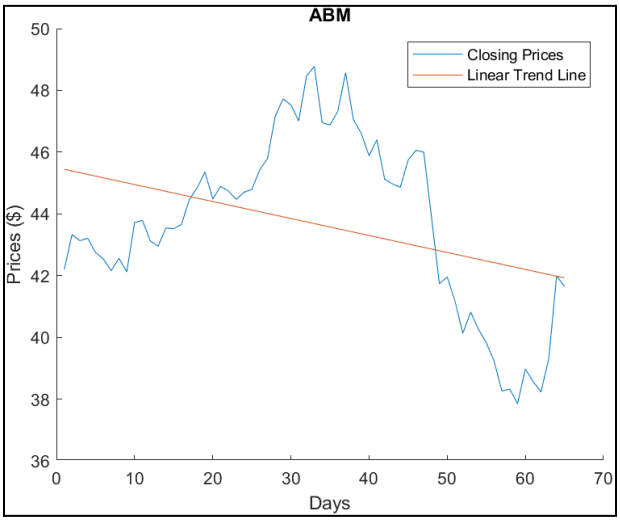

Figure 5: A graph of the closing prices of an industrial stock for the relevant period calculated by autocorrelation, along with the linear trendline.

Basic Materials Sector

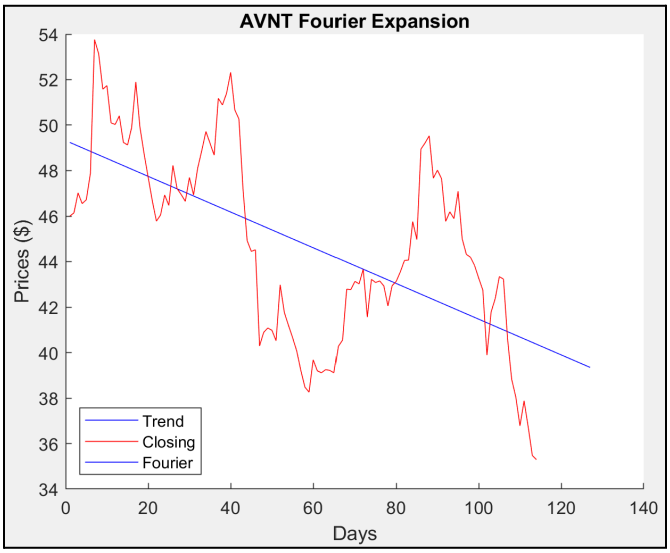

Figure 6: A graph of the closing prices of a Material stock for the relevant period calculated by autocorrelation, along with the linear trendline.

Agricultural Sector

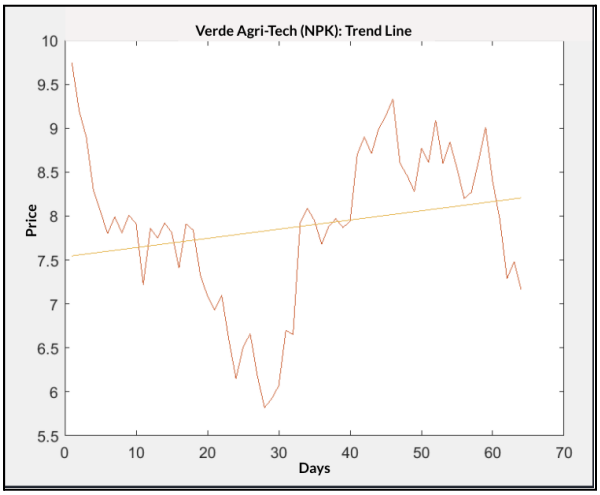

Figure 7: A graph of the closing prices of an agricultural stock for the relevant period calculated by autocorrelation, along with the linear trendline.

The trendline was calculated in MATLAB using the polyfit function and plotted against the number of days in the relevant period.

7.1.3. Fourier Expansion

It is unwise to predict a stock with a linear trend line alone due to the volatility of the stock. The stock is never going straight up or straight down as a trendline would show. As a result, applying the fourier model would take into **account the variation** and the course in which the stock moves. Thus, a fourier expansion model was used to model the stock prices. The equation for a fourier expansion is shown below:

$$f(x) = \frac{1}{2}a_0 + \sum_{n=1}^{\infty} a_n cos(nx) + \sum_{n=1}^{\infty} b_n sin(nx)$$

Where,

$$a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx$$

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)cos(nx)dx$$

$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)sin(nx)dx$$

$$n = 1, 2, 3, \ldots$$

A fourier series is the sum of sine and cosine waves. The curve is better at accommodating stock trends than a linear model. The overall correlation of the fourier model to the actual stock prices was higher, concluding that it is a better fit.

Technology Sector

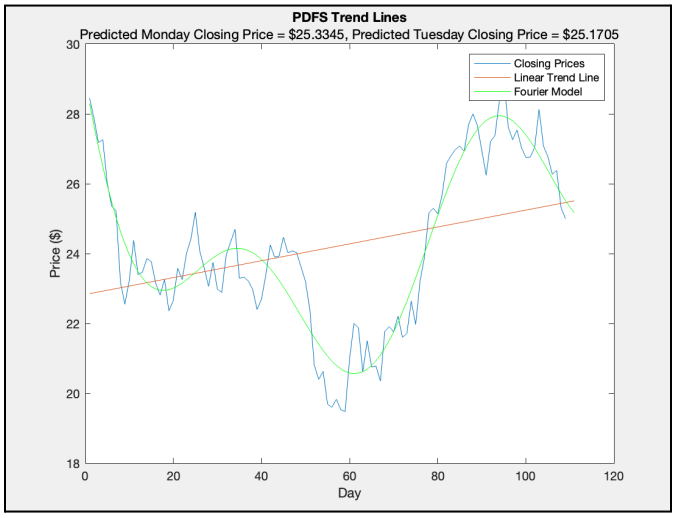

Figure 8: Fourier model being applied to the closing prices of a Technology stock in the relevant period.

Consumer Cyclical Sector

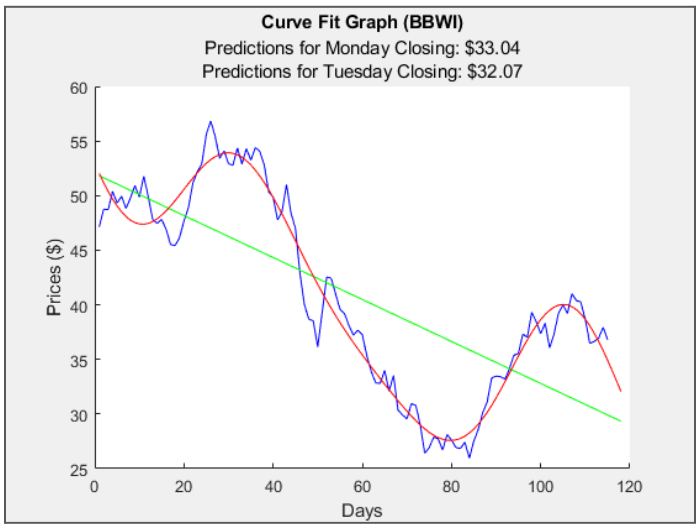

Figure 9: Fourier model being applied to the closing prices of a consumer cyclical stock in the relevant period.

Industrial Sector

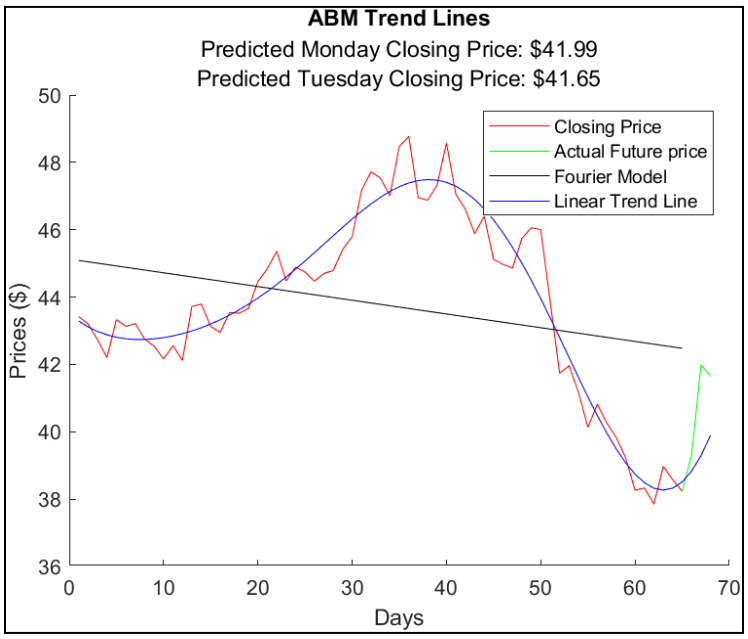

Figure 10: Fourier model being applied to the closing prices of an Industrial stock in the relevant period.

Basic Materials Sector

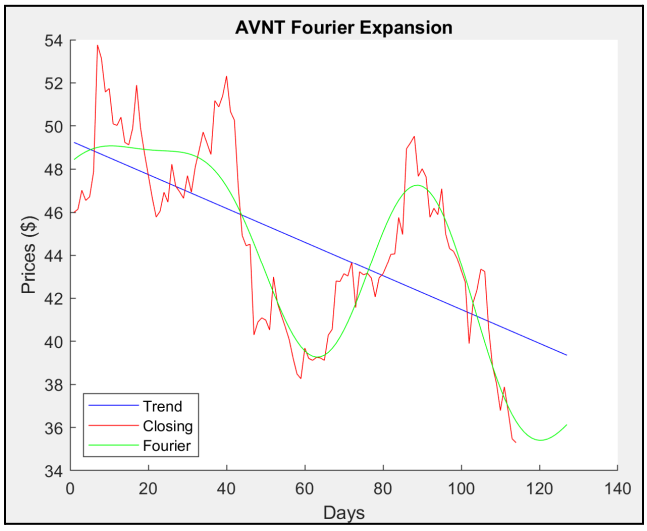

Figure 11: Fourier model being applied to the closing prices of a Basic Materials stock in the relevant period.

Agricultural Sector

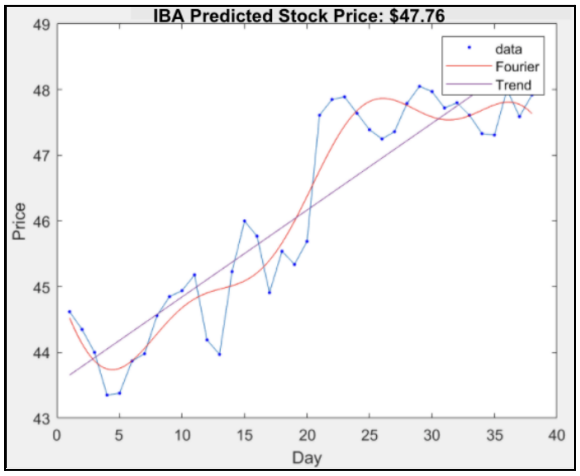

Figure 12: Fourier model being applied to the closing prices of an Agricultural stock in the relevant period.

The fourier expansion was performed in MATLAB using the fit function with 'fourier2' applied on the time values below 50 and 'fourier3' on the rest of the values.

7.1.4. Error Bounds

It is nearly impossible for a model to precisely pinpoint and predict what the future closing price of a stock is going to be. Instead it is important and more practical to be given the range in which the future closing price might fall within. After applying all steps from the previous sections, an error bound can be projected along the model in order to give us the **upper bound**, the predicted highest value the closing price can be, and the **lower bound**, the lowest the stock can be predicted to go. By taking the Fourier model created from the stock prices and trend line, the absolute difference was taken between that and the actual closing price. This then gave an array of values that were averaged in order to give us the standard error between the model and the actual price. Adding this onto the fourier model to create the upper bound, and subtracting the error from the fourier to produce the lower bound. The equation for this process is shown below

where e is the error produced, N is the number of closing prices, Y is the actual closing price, and $\widehat{Y}$ is the fourier model's predicted value.

$$e = \frac{\Sigma |Y - \widehat{Y}|}{N}$$

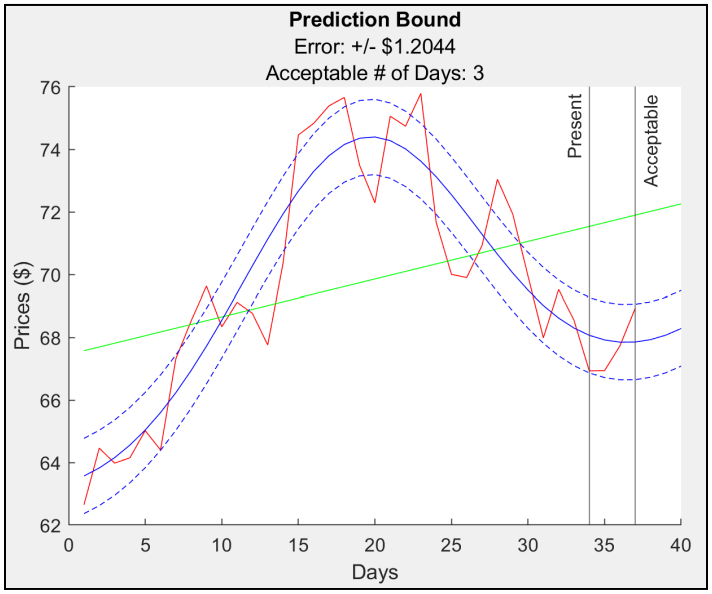

Figure 13: Example of Error bounds for the stock - AVNT

The process is then executed within MATLAB by defining "`error`" and adding it onto the fourier model "`yh`" to get "`upperErrorLine`", and subtracting from the fourier to get "`lowerErrorLine`" . This creates the bounds around the previously made fourier expansion in blue. The model/bounds were extended into the future to record the number of days the actual closing price that we consider as future values stay within the bounds we created. Below are the recorded number of days the model holds the true closing price. This test was conducted for three future days.

Technology Sector

Stock	Days Valid
AGYS	0
AKAM	0

ALTR	2
CNXN	0
HCKT	0
MNDT	3
MRVL	1
MU	1
NTGR	0
ORCL	3
PDFS	3
SCSC	1
VRNS	0
ZEN	0
ZI	1

Table 1: Number of days the prototype model is valid for the technology sector.

Consumer Cyclical Sector

Stock	Prediction Range
BBWI	3
BJRI	1
KMX	2
CAKE	0
COLM	0
EBAY	0
FNKO	0
HRB	3
HGV	3
MOV	0
PLNT	0

SBUX	1
TRIP	2
YETI	2
ZUMZ	2

Table 2: Number of days the prototype model is valid for the consumer cyclical sector.

Industrial Sector

Stock	Days Valid
ABM	3
AIMC	2
AOS	2
ASTE	0
BWXT	2
FBHS	3
GFF	2
GGG	0
IEP	0
KE	3
KEX	0
MRCY	1
MTZ	1
NPO	3
OC	1

Table 3: Number of days the prototype model is valid for the industrial sector.

Basic Materials Sector

Stock	Days Valid
AVNT	0
CCF	1

CMC	2
CTVA	1
EVA	3
FUL	0
GPRE	0
HUN	3
IOSP	0
KALU	1
LTHM	2
MTRN	0
NEM	3
SXT	0
UFPI	3

Table 4: Number of days the prototype model is valid for the basic materials sector.

Agricultural Sector

Stock	Days Valid
INGR	2
NPK	1
CALM	0
DOLE	1
VITL	0
TRC	3
ALCO	3
POST	2

FDP	1
AGRO	1
ADM	0
DAR	0
PPC	2
IBA	1
ANDE	2

Table 5: Number of days the prototype model is valid for the agricultural sector

7.2. Second Model

7.2.1. Moving Averages

To deal with the volatility to the stock prices, we decided to implement simple moving averages. This is a normal method used to analyze data points by replacing each of the data values in the time series with the average within the past n days. This will help with decreasing the influence of sharp spikes or drops that can affect the prediction model. In application, this method will smoothen out the price curve and create smaller error bounds. The basic formula for the simple moving average looks something like this:

$$SMA = \frac{A_1 + A_2 + \ldots + A_n}{n}$$

Where n is the sample size used for the average period.
The moving average was found in Matlab using the movmean function with as the 2nd parameter [10, 0] to compute the 10 days trailing moving average.

Below are the results that show the validity of the moving averages model for making short-term future price predictions. This test was conducted on a 3 day future period.

Technology Sector

Stock	Days Valid
AGYS	0

AKAM	0
ALTR	0
CNXN	0
HCKT	0
MNDT	1
MRVL	0
MU	1
NTGR	0
ORCL	0
PDFS	0
SCSC	0
VRNS	0
ZEN	0
ZI	0

Table 6: The table shows the number of days the moving averages applied on the fourier model is valid. We see that this model was not able to predict short-term prices well for the technology sector.

Consumer Cyclical Sector

Stock	Days Valid
BBWI	0
BJRI	0
KMX	0
CAKE	0
COLM	0
EBAY	0
FNKO	0
HRB	0
HGV	2

MOV	3
PLNT	0
SBUX	0
TRIP	0
YETI	0
ZUMZ	0

Table 7: The table shows the number of days the moving averages applied on the fourier model is valid. We see that this model was not able to predict short-term prices well for the consumer cyclical sector.

Industrial Sector

Stock	Days Valid
ABM	0
AIMC	0
AOS	1
ASTE	0
BWXT	0
FBHS	1
GFF	0
GGG	1
IEP	0
KE	3
KEX	0
MRCY	0
MTZ	0
NPO	0
OC	1

Table 8: The table shows the number of days the moving averages applied on the fourier model is valid. We see that this model was not able to predict short-term prices well for the industrial sector.

Basic Materials Sector

Stock	Days Valid
AVNT	0
CCF	0
CMC	0
CTVA	0
EVA	0
FUL	0
GPRE	0
HUN	0
IOSP	0
KALU	0
LTHM	0
MTRN	0
NEM	0
SXT	0
UFPI	3

Table 9: The table shows the number of days the moving averages applied on the fourier model is valid. We see that this model was not able to predict short-term prices well for the basic materials sector.

Agricultural Sector

Stock	Days Valid
INGR	0
NPK	1
CALM	0
DOLE	2
VITL	0
TRC	1
ALCO	0
POST	2
FDP	1
AGRO	1
ADM	1
DAR	0
PPC	0
IBA	2
ANDE	1
Mean	0.8
Standard Deviation	0.774596669

Table 10: The table shows the number of days the moving averages applied on the fourier model is valid. We see that this model was not able to predict short-term prices well for the agricultural sector.

10 days future period

Stock	Days Valid
ABM	0
AIMC	1
AOS	0

ASTE	0
BWXT	0
FBHS	1
GFF	1
GGG	0
IEP	0
KE	0
KEX	0
MRCY	0
MTZ	0
NPO	0
OC	0

Table 11: The table shows the number of days the moving averages applied on the fourier model is valid. We see that this model was not able to predict much better for the industrial sector using a 10 days moving average future period

7.2.2. Normalization

Normalization is the adjustment of values, scaling down the distribution of a data set. This allows data sets on different ranges to be **compared on the same scale**. The normalization process was applied to the fourier and dow jones model, allowing for the comparison of the two models. Below are the fourier and dow jones models after normalization.

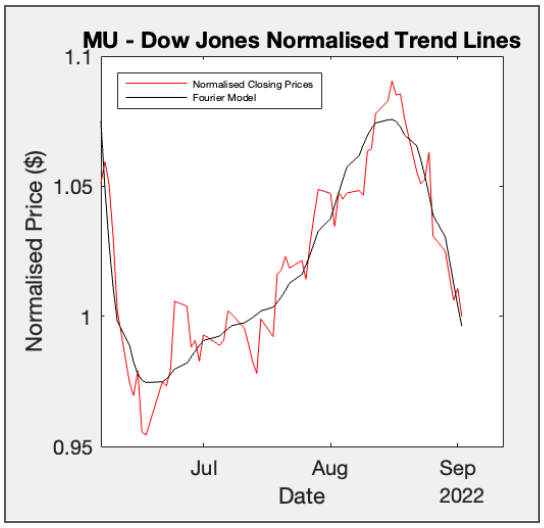

Figure 14: Example of a normalized fourier model as well as the associated closing prices.

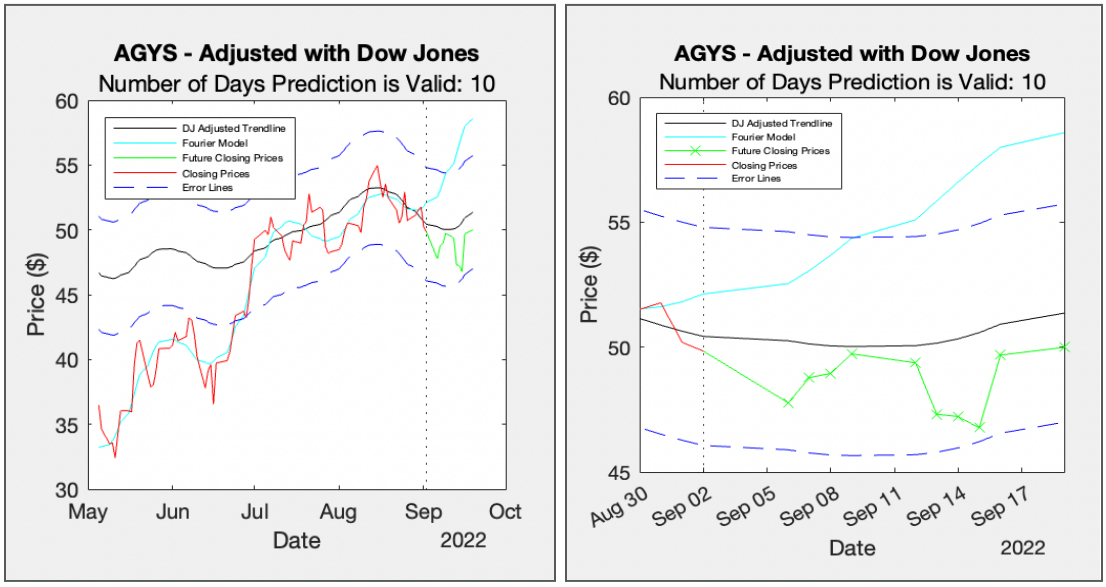

Figure 15: Example of a normalized fourier model with dow jones industrial average index as market influence (left) and zoomed in plot of the closing prices staying within the error bounds (right).

Normalization was performed in MATLAB by dividing the closing prices in the relevant period by the 'current day' closing price, which in our study was the closing price on September 2nd.

7.3. Final Model with Market Influence (Dow Jones / Nasdaq)

The first step was to normalize the dow jones and fourier model to the same scale. Each value along the model was divided by the current day (September 2, 2022) value to normalize it. Next, the correlation between the stock and the dow jones model was calculated. The correlation was calculated using the following equations:

Correlation Equations:

If $\alpha < 0.5$

$$\alpha * DJ + (1 - \alpha) * stock$$

Else

$$(1 - \alpha) * DJ + \alpha * stock$$

There are two versions of the equation to allow for the stock to be more heavily weighted than the DJ in the graph predictions in both sets of cases. The correlation of the prediction models to the actual stock prices, overall increases. Thus, the DJ model was taken into account in all stock market models going forward in this research. Below are the previous model without the DJ taken into account (left) and the model with the DJ taken into account (right).

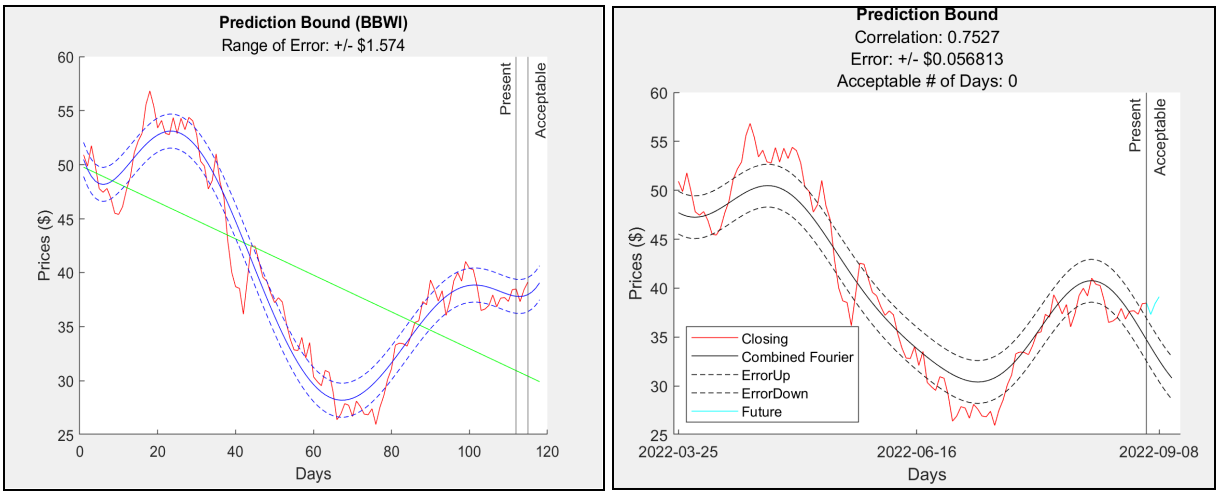

Figure 16: Example of closing prices of stock with fourier model (left) and closing prices of same stock with fourier model and dow jones market influence (right).

Below are the results that show the validity of the market influence models for making short-term future price predictions.

Due to the nature of NASDAQ being more focused on technology based companies, it was not applied to the consumer cyclical sector. Only Dow Jones was used and the index was always weighted more heavily than the Dow Jones. The same was done to the basic material sector as well for the same reason.

Technology Sector

	Number of Days Model is Valid			
Stock	More Weight on Stock - Nasdaq	More Weight on Index - Nasdaq	More Weight on Stock - Dow Jones	More Weight on Index - Dow Jones
AGYS	5	4	10	4
AKAM	5	1	1	0
ALTR	2	1	2	1
CNXN	4	3	4	4
HCKT	10	9	3	2
MNDT	7	5	10	2
MRVL	3	1	10	2
MU	5	5	5	5
NTGR	4	3	4	2
ORCL	2	1	3	2
PDFS	10	1	3	2
SCSC	10	10	10	1
VRNS	10	2	10	3
ZEN	10	6	6	3
ZI	2	1	3	1
Mean	5.933333333	3.533333333	5.6	2.266666667
Standard Deviation	3.261609302	2.972893412	3.418437404	1.334523279

Table 12: The table shows the number of days the model is valid for the different variations of the market influence model. This test was conducted on a 10 day future period. From the mean values, we can infer that the model with more weight on the Nasdaq index performs better than the other variations.

Consumer Cyclical Sector

Stock	Number of Days Valid
BBWI	0
BJRI	0
KMX	3
CAKE	3
COLM	0
EBAY	0
FNKO	3
HRB	1
HGV	1
MOV	1
PLNT	0
SBUX	0
TRIP	3
YETI	2
ZUMZ	3
Mean	1.33
Standard Deviation	1.345185418

Table 13: The model that was applied for the consumer cyclical sector had more weight on the stock than the index. The test period was 3 days.

Industrial Sector

	Number of Days Model is Valid

Stock	More Weight on Stock - Nasdaq	More Weight on Index - Nasdaq	More Weight on Stock - Dow Jones	More Weight on Index - Dow Jones
ABM	0	0	0	3
AIMC	1	1	1	1
AOS	1	1	1	3
ASTE	0	3	0	3
BWXT	3	3	0	3
FBHS	1	0	1	3
GFF	0	2	0	0
GGG	1	1	1	3
IEP	3	3	0	0
KE	0	1	1	3
KEX	0	3	0	0
MRCY	3	3	3	3
MTZ	0	0	0	2
NPO	0	1	0	1
OC	1	1	1	1
Mean	0.933	1.533	0.600	1.933
Std Dev	1.163	1.187	0.828	1.280

Table 14: Number of days the model was valid for different variations of the market influence model in the industrial sector. Looking at the mean values, it can be inferred that the model with more weight on the Dow Jones index performs better than the other variations. This makes sense as Dow Jones is more industrial focused than Nasdaq.

Basic Materials Sector

Stock	Number of Days Model is Valid
AVNT	0
CCF	3

CMC	2
CTVA	3
EVA	3
FUL	1
GPRE	2
HUN	3
IOSP	0
KALU	2
LTHM	2
MTRN	0
NEM	3
SXT	0
UFPI	3
Mean	1.8000
Standard Deviation	1.2649

Table 15: The model that was applied for the basic materials sector had more weight on the stock than the index. The test period was 3 days.

Agricultural Sector

Stock	Prediction Range
INGR	1
NPK	4
CALM	0
DOLE	1
VITL	1

TRC	0
ALCO	0
POST	2
FDP	0
AGRO	2
ADM	2
DAR	4
PPC	0
IBA	3
ANDE	2
Mean	1.466666667
Standard Deviation	1.407463101

Table 16: The model that was applied for the agricultural sector had more weight on the stock than the index. The test period was 3 days.

7.4. Additional Buy/Sell Signals

7.4.1. Volume Analysis

Volume is a number that defines the number of shares of stocks that have been traded over a certain period of time.Volume can be used as a **predictor of the direction** of a stock's price and the **strength of the market**. When both the price and volume of a stock are increasing, this can be viewed as bullish with the volume pushing the price of the stock higher. The opposite can be seen too when volume traded lowers the price usually does as well signaling a bearish market. In our application of volume analysis we tried normalizing the volume traded and stock price in the given period. This however provided sub par results, creating graphs quite difficult to read with the volume being much more volatile than the stock price.

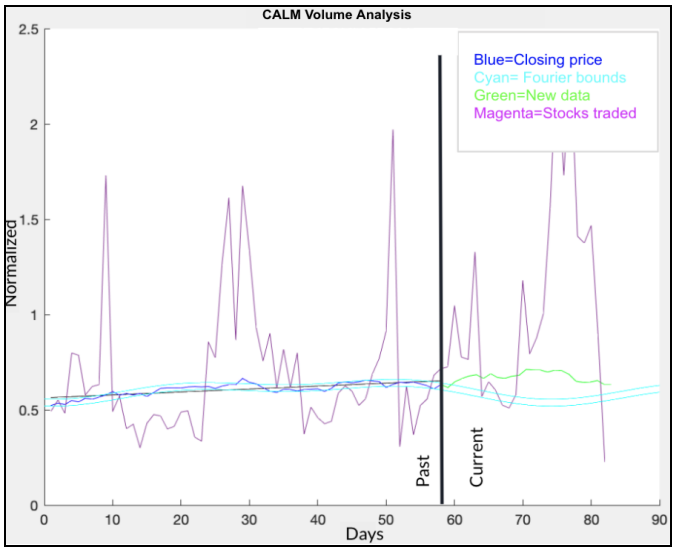

Figure 17: Cal-Maine Foods (CALM) Volume Analysis

7.4.2. Relative Strength Index (RSI)

The Relative Strength Index is a momentum oscillator that measures the speed and change of price movements and is used to **evaluate whether a stock is undersold or overbought**. The RSI values are on a scale of 0 to 100. A stock is considered overbought when the RSI value is above 70 and oversold when the RSI value is below 30. Thus, RSI can indicate upcoming trend reversals and signal when to buy or sell. The Relative Strength Index is calculated using the following formula:

$$RS = \frac{Avg.Gain}{Avg.Loss}$$

$$RSI = 100 - \frac{100}{1 + RS}$$

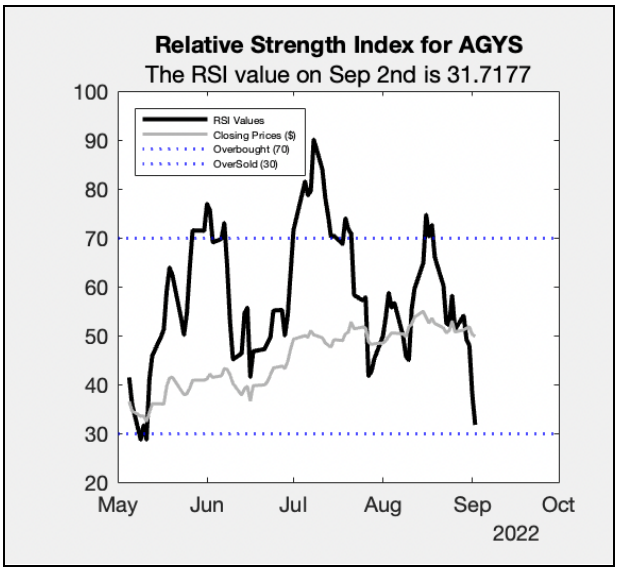

Figure 18: Closing prices of a stock in the relevant period along with the RSI Model Values for those closing prices. The inference of the RSI value on September 2nd, or our 'current date' in the above graph is that the stock is neither overbought or oversold, however looking at the trend, it seems to be tending towards oversold territory, suggesting it might be a good time to buy.

The RSI model was built in MATLAB using the rsindex function from the financial toolbox. The model was built for the relevant period and plotted against the closing prices to see how the index moves.

The RSI index values for September 2nd (which is considered the 'present day') are shown below along with their inferences:

Technology Sector

Stock	RSI Values	Inference
AGYS	31.71	In Between
AKAM	22.43	Oversold
ALTR	18.49	Oversold
CNXN	39.08	In Between
HCKT	28.37	Oversold
MNDT	50	In Between

MRVL	27.74	Oversold
MU	28.85	Oversold
NTGR	26.81	Oversold
ORCL	25.79	Oversold
PDFS	23.17	Oversold
SCSC	29.44	Oversold
VRNS	11.89	Oversold
ZEN	59.74	In Between
ZI	22.33	Oversold

Table 17: RSI values for Technology Sector on September 2nd

Consumer Cyclical Sector

Stock	RSI	Inference
BBWI	39.8734	In Between
BJRI	45.6401	In Between
KMX	37.6673	In Between
CAKE	45.9436	In Between
COLM	43.81	In Between
EBAY	27.4149	Oversold
FNKO	46.4193	In Between
HGV	27.9294	Oversold
HRB	36.5508	In Between
MOV	29.563	Oversold
PLNT	18.5859	Oversold
SBUX	50.6302	In Between
TRIP	39.5913	In Between
YETI	30.2913	In Between
ZUMZ	29.3103	Oversold

Table 18: RSI values for Consumer Cyclical Sector on September 2nd

Industrial Sector

Stock	RSI	Inference
ABM	24.17	Oversold
AIMC	36.26	In-between
AOS	23.87	Oversold
ASTE	35.21	In-between
BWXT	50.58	In-between
FBHS	38.09	In-between
GFF	48.03	In-between
GGG	45.44	In-between
IEP	45.36	In-between
KE	21.92	Oversold
KEX	43.15	In-between
MRCY	32.98	In-between
MTZ	47.06	In-between
NPO	47.01	In-between
OC	44.05	In-between

Table 19: RSI values for Industrial Sector on September 2nd

Basic Materials Sector

Stock	RSI	Inference
AVNT	26.6394	Oversold
CCF	42.1435	Between
CMC	39.3209	Between
CTVA	45.1879	Between

EVA	51.3239	Between
FUL	57.8844	Between
GPRE	26.3072	Oversold
HUN	29.6072	Oversold
IOSP	49.8253	Between
KALU	41.4894	Between
LTHM	53.6585	Between
MTRN	41.6630	Between
NEM	59.4306	Between
SXT	31.8331	Between
UFPI	60.8764	Between

Table 20: RSI values for Basic Materials Sector on September 2nd

Agricultural Sector

Stock	RSI	Inference
Ingredion	24.146	Overbought
Verde Agri-tech	33.454	In Between
Cal-Maine Foods	55.17	In Between
Dole	20.099	Overbought
Vital Farms	60.319	In Between
Tejon Ranch	27.874	Overbought
Alico	46.974	In Between
Post Holdings	42.123	In Between
Fresh Del Monte	26.771	Overbought

Adecoagro	19.532	Overbought
Archer Daniels Midland	51.983	In Between
Darling Ingredients	62.334	In Between
Pilgrim's Pride	74.382	Oversold
Bachoco	28.654	Overbought
Andersons	36.667	In Between

Figure 21: RSI values for Agricultural Sector on September 2nd

7.4.3. Bollinger Bands

Bollinger Bands are a type of statistical chart that **aids in displaying the prices and volatility** over time of the stock we are interested in. With that they in turn help decide when to make a move by illustrating the relative strength, or momentum, of a stock/investment. Similar to error bounds, once the bollinger bands are created, an upper and lower band is formed by one standard deviation above and below the moving average. This is typically defaulted to 20 days, and located in between the bands. BandWidth decreases as Bollinger Bands narrow and increases as Bollinger Bands widen. Because Bollinger Bands are based on the standard deviation, falling BandWidth reflects decreasing volatility and rising BandWidth reflects increasing volatility. In terms of determining the value of a stock, John Bollinger, who created this indicator, considers the actual closing price of the stock relatively low (attractive) if it is near the lower band, and relatively high (overvalued) if it's near the upper band.

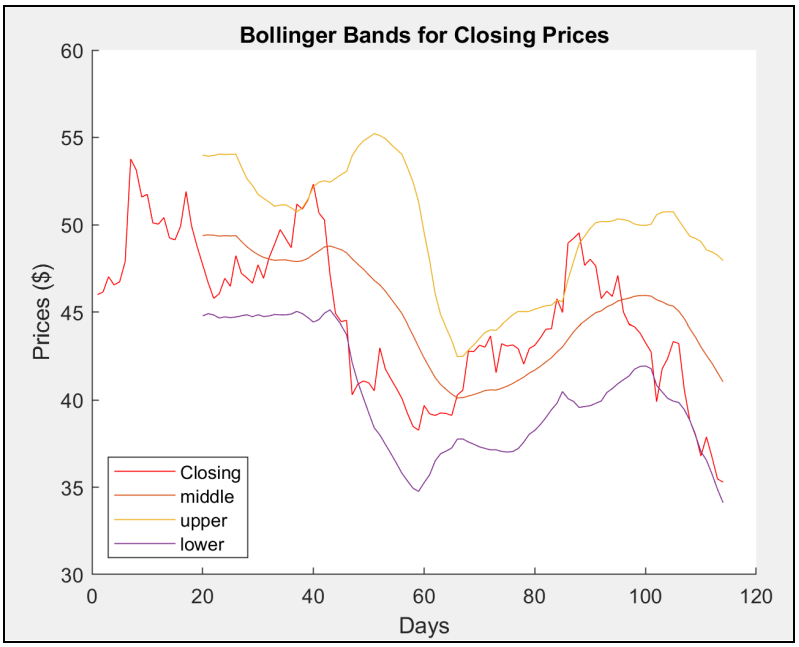

Figure 19: Closing prices within relevant period with Bollinger bands in place created in MATLAB

In MATLAB we used the function [middle,upper,lower] = bollinger(file.Close) that creates an array for the bands of the middle, upper, and lower bounds. We then plotted all three arrays alongside the actual closing price in order to track the attractiveness of the stock at the given time.

8. Virtual Trading

Now that we've done the predictive modeling, it's time to put it into practice by investing in a virtual trading game. For this experiment, we used Market Watch to create a virtual stock exchange game. Each person started with a balance of $100,000 that will be invested in their sector and we can track their performance with the actual stock market. The game lasted from September 28th to November 11th. During this duration, we managed our portfolio according to our predictive models, buying, shorting, selling, and covering whenever the models indicate it might have a good outcome.

Portfolio vs. Market Performance

Sector	Net Change	Percent Change
Technology	$21,819.49	21.82%
Consumer Cyclical	-$14,145.17	-14.15%
Industrial	$9,394.55	9.40%
Basic Materials	$16,975.93	16.98%
Agricultural	$1,565.96	1.57%

Table 22: Portfolio performance over 44 days

Index	Net Change	Percent Change
DJI	$4,064.12	13.69%
NASDAQ	$271.69	2.46%
S&P500	$273.89	7.36%

Table 23: Market performance over 44 days

Comparing the percent change of our portfolios and the market, it can be seen that there were some mixed results. Even amongst the market indices, there were some varieties in their performance with Dow Jones gaining the most and NASDAQ gaining the least. Our portfolios for the Technology, Industrial, and Basic Materials managed to outperform these major market indices, with Industrial being the exception for underperforming compared to Dow Jones. Our other sectors did not fare as well as they either did not make as much profit as the market or they made some losses.

8.1. Technology Sector

The stocks chosen for the technology sector included MU, RBLX, CRM, ANET, AMZN, ZI, PRTA, ORCL, MRVL, ALTR, CNXN, PBI, CLR, PDFS, DNA, HRB and EQRX. They were

invested in at various times throughout the month and a half that this trading was conducted. The investment resulted in a net positive return of 21.82%. The major gains were made by the stocks MU with a $7,354 return , ANET with a $6,389.68 return. Stocks like AMZN and RBLX were shorted and went against our predictions from the market influence model, increasing in value. Majority of the investments for this sector were performed with the input from the Nasdaq market influence model, while keeping an eye on the general trends in the market.

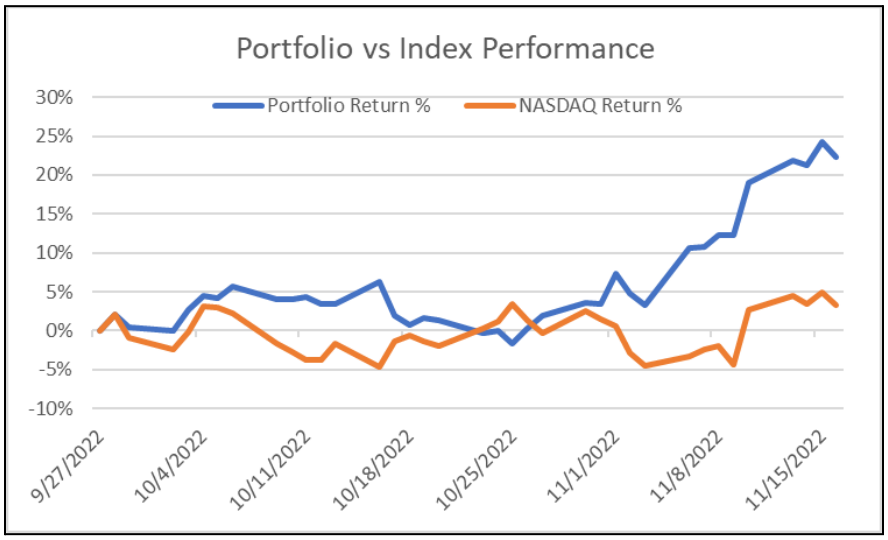

Figure 20: Graph displaying percent change for the technology sector stocks vs the NASDAQ Index over the virtual trading period.

8.2. Consumer Cyclical Sector

For the consumer cyclical sector, AMZN, SHOP, JNJ, KMX, TSLA, and DIS were invested in. The majority of the stocks were volatile due to the nature of the consumer cyclical sector and only KMX was invested in initially which lost money. Thus, KMX was sold in favor of the investment in SHOP and AMZN's potential growth after its stock price went down. Due to AMZN's consistent loss, AMZN was sold and shorted, but AMZN saw a spike in growth the following day. JNJ was bought due to its steady growth but ultimately its growth was minimal in comparison to other stocks' loss. The majority of profit loss was from AMZN, SHOP and TSLA. The investments for this sector were performed with the input from the Dow Jones market influence model, with some input from new on the respective stocks.

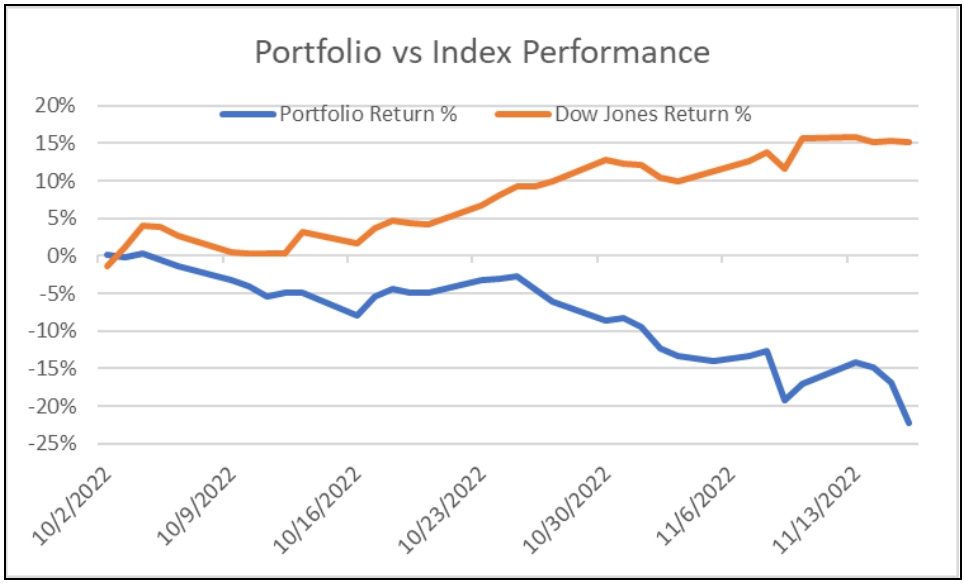

Figure 21: Graph displaying the percent change for the consumer cyclical sector stocks vs the Dow Jones Index over the virtual trading period.

8.3. Industrial Sector

For the Industrial sector, 14 of the 15 non-volatile stocks were chosen to be invested as they appeared to be the most predictable. These stocks were FBHS, OC, MTZ, KEX, KE, IEP, GFF, AOS, ABM, BWXT, AIMC, ASTE, GGG, NPO. They were bought, sold, shorted, and covered whenever it deemed appropriate based on the predictive models. The market has been going down for awhile initially so the portfolio remained static for the most part. Luckily, the market started to go up around October 26th which helped the Industrial sector to end with a net gain of $9,394.55 / 9.4% by the end of the virtual trading period on November 11th.

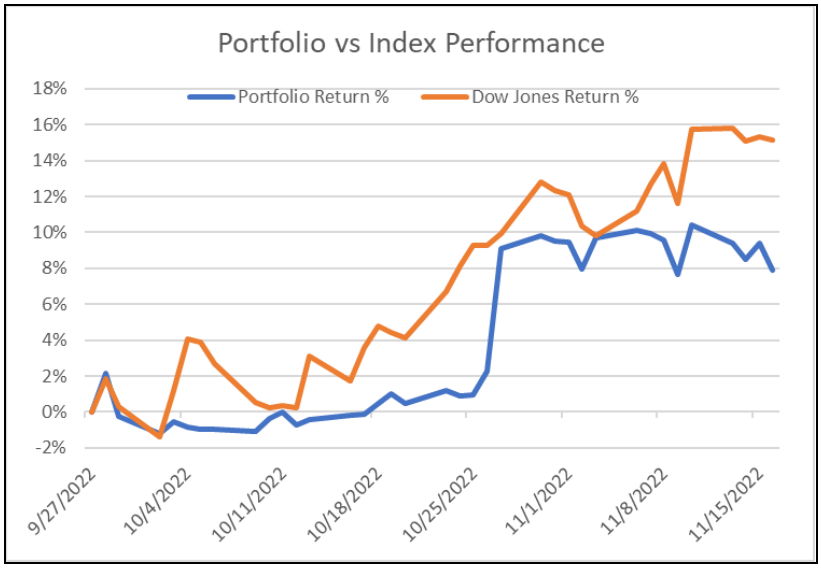

Figure 22: Graph displaying the percent change for the industrial sector stocks vs the Dow Jones Index over the virtual trading period.

8.4. Basic Materials Sector

Of the 15 stocks that were chosen with little volatility from the Basic Materials sectors, only nine of them were selected based on the applied methods discussed throughout the paper to be invested. The stocks were HUN, KALU, SXT, UFPI, CCF, CTVA, FUL, IOSP, and GPRE. Throughout the duration of investment, most of those stocks were eventually sold, with only four of the initial nine stocks remaining, being CTVA, FUL, HUN, KALU, and UFPI which continue to show good returns.

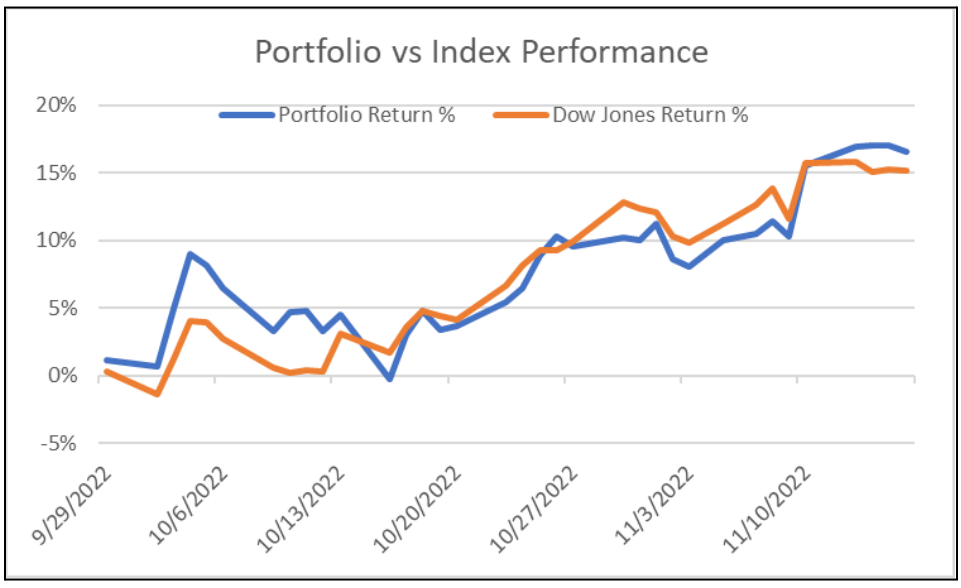

Figure 23: Graph displaying percent change for the basic materials sector stocks vs the Dow Jones Index over the virtual trading period.

8.5. Agricultural Sector

The stocks chosen to invest in the agricultural sector include AGRO, CALM, DAR, DOLE, IBA, POST. These were chosen because they showed the least volatility and had positive trend lines and Fourier models. For the experiment the stocks were bought and held on for the duration of the experiment. As shown below, in this short term investment model, provided a profit based on the functions and models used.

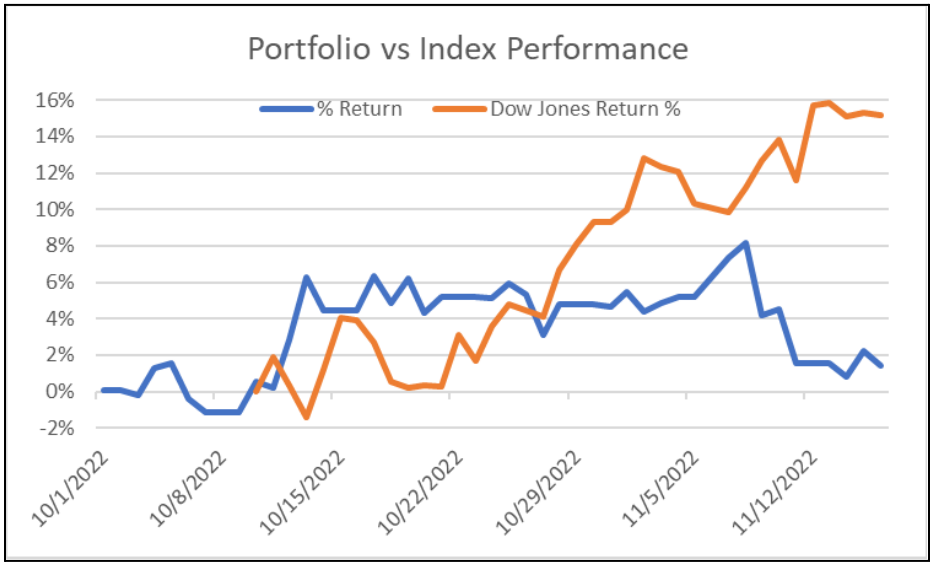

Figure 24: Graph displaying the percent change for the agricultural sector stocks vs the Dow Jones Index over the virtual trading period.

9. Conclusion

9.1. Summary

After having used several different models to try to predict the movement of a stock price, the final verdict is that with the very volatile state the stock market is currently in, it is hard to determine the direction of the stock price. None of the models gave outstanding predictions. However, the best model in our study by far was the combination of the fourier model with the

market influence. The Fourier gave a good idea of where the stock was heading and the indexes like Dow Jones and Nasdaq included market trends we weren't able to see before, thus giving better predictions. The other model worth mentioning is the combination of the Bollinger bands and Relative Strength Index. These two combined gave a very good idea when a stock has been overbought or oversold, giving us the advantage of knowing when to buy in or sell out. However, no model is full proof and will not be completely accurate every time. Even with models which aren't one hundred percent accurate every time, the predictions they make are better than going in blind when purchasing a stock.

Despite the market's volatility, the project was able to predict stock trends for a short period of time. Various types of trend lines and models were tested and the fourier series with market influence turned out to be the best mdoel. Most of the group was able to use these models to assist profitable decisions in the virtual trading game. All members were able to make a profit at some point during the game.

9.2. Recommendations

As all studies entail, there is a limited amount of time available to research and develop, and not all proposals were able to be observed and tested. The following are some possible areas of research that could be taken into further consideration.

For conducting further research, one may look at the relationship between all sectors, opposed to applying the process individually from beginning to end. Different sectors are more volatile than others. Thus some growths are more steady while others produce larger margins. It would be interesting to see which sector can yield the most accurate models.

Another area that can be studied is PCA (Principal Component Analysis). This technique is used to increase interpretability while keeping information loss to a minimum. Results would be more promising compared to the moving averages, as information is kept to a minimum and maximizes successful variance.

Lastly, the RSI (Relative Strength Index) should be considered as a more dynamic factor in our models, as well as in the virtual trading process. Since we introduced this model later in this study, we were not able to experiment enough with it due to time constraints. However, this buy/sell signal proved to be favorable in the minimal experimentation we conducted with it, and further probing may be fruitful.

The USD is the world's dominant reserve currency, making it an excellent choice of market to be analyzed for this study. However, in addition to the US economy, the European economy follows similar trends to that of the US, making it a favorable comparison to study if time permits.

As opposed to executing different areas of research, improvements to the model itself can be made with the addition of automation. Having the system automatically adjust the prediction algorithm with new data as it comes in, would decrease inaccuracies due to changes in data. This would make the current prediction more accurate with the resources accessible. The possibilities of further research are endless as the market continues to have many factors of influence. These are just some insights that were thought of while approaching the end of the study.

9.3. Future Projection

With the considerations of current events happening in the world, the stock market will continue to be volatile within the near future and will be difficult to predict. World events such as the war in Ukraine and Afriganistan contributed to the market's volatility. As this paper is being written, more pressing events are on the verge of taking place, one of which is China preparing to invade Taiwan. With the pending news of conflict, it is possible to look further into Defense stocks as well as others to apply our study on. The recession as a result of the Covid-19 pandemic has limited the circulation of money. Thus, the prediction should only be used for short term modeling. After conducting this research, future projections were made for each sector studied using the data compiled from findings.

For the technology sector, technology is constantly progressing. It is favorable for investment with its high margin for potential growth. This sector is where there will be the largest profit making it a promising investment to have in everyone's portfolio.

The consumer cyclical sector should not be invested in. The sector is overall unstable and volatile, making it difficult to predict. Based on the invested stocks, the stocks often lost money even when it was shown to grow using our predictions. It is risky, and makes it unpromising for investing. Leaving the pandemic, more people are traveling causing the stock to go up. The sector is full of stocks relating to wants such as vacation and luxury goods, but we are in recession so growth does not seem promising. As a result this sector is unstable and overall losing money.

The industrial sector is highly dependent on other markets with its sub sectors focusing mainly on providing services to other businesses. This sector can be safely invested in if one does the necessary market analysis beforehand. The industrial sector just came out of a recent recession during our virtual trading session and if one can predict that, some major profit can be made.

The basic materials sector over the course of this study and simulation has shown steady increase in profits. Drops in closing price would often lead to a more sufficient increase afterwards. Overall return has yet to reach the negatives with several instances in which selling short would be the most beneficial option. For the sake of the study, nearly half of the original chosen stocks remained and were not sold in order to observe a long term investment. The remaining stocks continued to increase in price before beginning to level out. Stocks within the basic materials sector have been shown to be relatively promising with strong incentives to buy and sell short.

The agricultural sector growth is steady but yields minimal profit. It makes it a good long term investment when there is a long term, but for the sake of this project, the goal was to create a short term model for the closing prices. Thus, a long term prediction was not in line with this study. While this study takes into account six sectors of the stock market, it is important to look at those that weren’t covered such as health care, utilities, consumer staples, and telecommunication.

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Appendix A: Matlab Code

Import Stock Prices

```
import datetime
import time
import pandas as pd
from openpyxl import Workbook

tickers =
["AOS","ABM","AIMC","ASTE","BXC","BWXT","FBHS","GFF","GGG","HLIO","IEP","KE","KEX","M
RCY","MTZ","NPO","OC","PRLB","RHI","ROCK"]
interval = '1d'
period1 = int(time.mktime(datetime.datetime(2020, 10, 4, 23, 59).timetuple()))
period2 = int(time.mktime(datetime.datetime(2022, 10, 5, 23, 59).timetuple()))

for ticker in tickers:
   query_string =
f'https://query1.finance.yahoo.com/v7/finance/download/{ticker}?period1={period1}&per
iod2={period2}&interval={interval}&events=history&includeAdjustedClose=true'
   df = pd.read_csv(query_string)
   df.to_csv('C:/Users/Dang Tran/OneDrive - Worcester Polytechnic Institute
(wpi.edu)/Documents/MATLAB/IQP Stock Prediction/Assignment 1/Stocks/' + ticker +
'.csv', index = False)
```

Auto-Correlation

```
% “file” refers to the .csv with the stock closing prices

% acf finds autocorrelation factors
[acf, lags] = autocorr(file.Close, size(file.Close, 1) - 1);

% Looping through acf's to find relevant time period
for i = 1:length(acf)
      if(acf(i) < 0)
            time = i - 2;
```

```
        break
        end
end
```

Linear Trendline

```
% Creating a vector with time period with 1 interval between each point
yy = linspace(1, time, time);

% Relevant period
RV = file.Close(end-time+1:end,:);

% Find ax+b polynomial function factors
p = polyfit(yy, transpose(RV),1);

% Extending the time period 2 days into the future
yynew = linspace(1, time+2, time+2);

% Calculating the linear trend line values
for k = 1:time
    y(k) = p(1)*k +p(2);
end
```

Fourier Expansion

```
% Difference between the trend and the actual closing price
diff = transpose(RV) - trend;

% Calculating the fourier values
if time < 50
   f = fit(yy', diff', 'fourier2');
else
   f = fit(yy', diff', 'fourier3');
end

% Calculating the fourier trend line values
for i = 1:(time + 2)
    yf(i) = y(i) + f(i);
end
```

Error Bounds

```
% Difference between the fourier model trend and the actual closing price
```

```
fdiff = transpose(RV) - yh(1:time);

% Finding the error by taking the mean of the absolute value of fdiff
error = mean(abs(fdiff));

% Calculating the upper and lower error bounds
upperErrorLine = yf + err;
lowerErrorLine = yf - err;
```

Moving Averages

```
% Finding Moving Averages
movingAverages = (movmean(file.Close, [10 0]));
```

Normalization

```
% Finding the stock price on Sep 2nd (our “present day” value)
stockPrice = file.Close(end);

% Normalising for relevant values
normStock = file.Close(end-time+1:end,:) / stockPrice;

% Finding the Dow jJnes price on Sep 2nd
DJprice = dowjones.DJIA(end);

% Normalising for dow jones relevant values
normDJ = dowjones.DJIA(end-time+1:end,:) / DJprice;
```

Relative Strength Index (RSI)

```
% Calculating RSI values
index = rsindex(file);
```

Bollinger Bands

```
% Calculating Bollinger Bands
[middle,upper,lower] = bollinger(file.Close);
CloseBolling = [middle, upper, lower];
```

Appendix B: Virtual Trading

Technology Sector

Date	Cash	Net Worth	% Return
27-Sep-2022	$100,000.00	$100,000.00	0.00%
28-Sep-2022	$0.00	$102,140.78	2.14%
29-Sep-2022	$0.00	$100,511.78	0.51%
1-Oct-2022	$0.00	$99,958.84	-0.04%
2-Oct-2022	$0.00	$99,958.84	-0.04%
3-Oct-2022	$0.00	$102,696.59	2.70%
4-Oct-2022	$0.00	$104,480.23	4.48%
5-Oct-2022	$46,755.68	$104,233.52	4.23%
6-Oct-2022	$46,755.68	$105,635.68	5.64%
7-Oct-2022	$95,186.21	$104,075.06	4.08%
8-Oct-2022	$95,186.21	$104,075.06	4.08%
9-Oct-2022	$95,186.21	$104,075.06	4.08%
10-Oct-2022	$95,186.21	$104,055.98	4.06%
11-Oct-2022	$95,186.21	$104,402.85	4.40%
12-Oct-2022	$95,186.21	$103,376.23	3.38%
13-Oct-2022	$95,186.21	$103,469.49	3.47%
14-Oct-2022	$95,186.21	$106,350.75	6.35%
15-Oct-2022	$95,186.21	$106,350.75	6.35%
16-Oct-2022	$95,186.21	$106,350.75	6.35%
17-Oct-2022	$95,186.21	$101,887.70	1.89%

18-Oct-2022	$95,186.21	$100,760.85	0.76%
19-Oct-2022	$95,186.21	$101,645.56	1.65%
20-Oct-2022	$95,186.21	$101,309.49	1.31%
21-Oct-2022	$95,186.21	$99,733.02	-0.27%
22-Oct-2022	$95,186.21	$99,733.02	-0.27%
23-Oct-2022	$95,186.21	$99,733.02	-0.27%
24-Oct-2022	$95,186.21	$99,936.91	-0.06%
25-Oct-2022	$95,186.21	$98,415.43	-1.58%
26-Oct-2022	$95,186.21	$100,337.04	0.34%
27-Oct-2022	$30,486.68	$102,007.85	2.01%
28-Oct-2022	$30,486.68	$103,601.49	3.60%
29-Oct-2022	$30,486.68	$103,601.49	3.60%
30-Oct-2022	$30,486.68	$103,601.49	3.60%
31-Oct-2022	$30,486.68	$103,452.31	3.45%
1-Nov-2022	$0.00	$107,291.17	7.29%
2-Nov-2022	$0.00	$104,780.25	4.78%
3-Nov-2022	$0.00	$103,264.74	3.26%
4-Nov-2022	$0.00	$110,571.19	10.57%
5-Nov-2022	$0.00	$110,571.19	10.57%
6-Nov-2022	$0.00	$110,571.19	10.57%
7-Nov-2022	$0.00	$110,770.04	10.77%
8-Nov-2022	$30,155.09	$112,354.00	12.35%
9-Nov-2022	$30,155.09	$112,350.54	12.35%

10-Nov-2022	$0.00	$119,067.28	19.07%
11-Nov-2022	$0.00	$121,819.49	21.82%

Cyclical Consumer

Date	Cash	Net Worth	% Return
10/1/2022	$64,532.50	$100,118.08	0.12%
10/2/2022	$64,532.50	$100,118.08	0.12%
10/3/2022	$64,532.50	$99,893.29	-0.11%
10/4/2022	$58,660.87	$100,263.82	0.26%
10/5/2022	$58,660.87	$99,390.44	-0.61%
10/6/2022	$58,660.87	$98,701.80	-1.30%
10/7/2022	$1,589.79	$96,739.99	-3.26%
10/8/2022	$1,589.79	$96,739.99	-3.26%
10/9/2022	$1,589.79	$96,739.99	-3.26%
10/10/2022	$1,589.79	$95,882.49	-4.12%
10/11/2022	$1,589.79	$94,591.79	-5.41%
10/12/2022	$1,589.79	$95,138.74	-4.86%
10/13/2022	$1,589.79	$95,168.09	-4.83%
10/14/2022	$50,400.04	$92,065.29	-7.93%
10/15/2022	$50,400.04	$92,065.29	-7.93%
10/16/2022	$50,400.04	$92,065.29	-7.93%
10/17/2022	$50,400.04	$94,606.39	-5.39%
10/18/2022	$50,400.04	$95,557.64	-4.44%
10/19/2022	$50,400.04	$95,129.09	-4.87%

10/20/2022	$50,400.04	$95,174.09	-4.83%
10/21/2022	$50,400.04	$96,753.84	-3.25%
10/22/2022	$50,400.04	$96,753.84	-3.25%
10/23/2022	$50,400.04	$96,753.84	-3.25%
10/24/2022	$50,400.04	$96,914.44	-3.09%
10/25/2022	$50,400.04	$97,306.24	-2.69%
10/26/2022	$50,400.04	$95,589.39	-4.41%
10/27/2022	$50,400.04	$93,935.84	-6.06%
10/28/2022	$50,400.04	$91,361.29	-8.64%
10/29/2022	$50,400.04	$91,361.29	-8.64%
10/30/2022	$50,400.04	$91,361.29	-8.64%
10/31/2022	$50,622.80	$91,644.68	-8.36%
11/1/2022	$27,204.80	$90,539.09	-9.46%
11/2/2022	$27,204.80	$87,612.44	-12.39%
11/3/2022	$27,204.80	$86,638.10	-13.36%
11/4/2022	$27,204.80	$86,050.66	-13.95%
11/5/2022	$27,204.80	$86,050.66	-13.95%
11/7/2022	$0.00	$86,676.12	-13.32%
11/8/2022	$0.00	$87,393.10	-12.61%
11/9/2022	$10,104.24	$80,778.00	-19.22%
11/10/2022	$10,379.84	$82,992.40	-17.01%
11/11/2022	$11,284.61	$85,854.83	-14.15%

Industrial Sector

Date	Cash	Net Worth	% Return

9/27/2022	$100,000.00	$100,000.00	0.00%
9/28/2022	$0.00	$102,160.36	2.16%
9/29/2022	$0.00	$99,752.59	-0.25%
10/1/2022	$0.00	$98,806.30	-1.19%
10/2/2022	$0.00	$98,806.30	-1.19%
10/3/2022	$58,801.01	$99,445.83	-0.55%
10/4/2022	$58,801.01	$99,160.53	-0.84%
10/5/2022	$49,270.32	$99,055.38	-0.94%
10/6/2022	$49,270.32	$99,038.30	-0.96%
10/7/2022	$49,270.32	$98,936.79	-1.06%
10/8/2022	$49,270.32	$98,936.79	-1.06%
10/9/2022	$49,270.32	$98,936.79	-1.06%
10/10/2022	$49,270.32	$99,650.91	-0.35%
10/11/2022	$49,270.32	$100,003.07	0.00%
10/12/2022	$49,270.32	$99,261.83	-0.74%
10/13/2022	$49,270.32	$99,609.62	-0.39%
10/14/2022	$49,270.32	$99,821.20	-0.18%
10/15/2022	$49,270.32	$99,821.20	-0.18%
10/16/2022	$49,270.32	$99,821.20	-0.18%
10/17/2022	$49,270.32	$99,877.42	-0.12%
10/18/2022	$49,270.32	$100,466.71	0.47%
10/19/2022	$49,270.32	$101,042.86	1.04%
10/20/2022	$49,270.32	$100,494.02	0.49%
10/21/2022	$49,270.32	$101,220.78	1.22%
10/22/2022	$49,270.32	$101,220.78	1.22%
10/23/2022	$49,270.32	$101,220.78	1.22%

10/24/2022	$49,270.32	$100,920.92	0.92%
10/25/2022	$49,270.32	$100,944.81	0.94%
10/26/2022	$49,270.32	$102,245.72	2.25%
10/27/2022	$49,270.32	$109,111.99	9.11%
10/28/2022	$49,270.32	$109,819.21	9.82%
10/29/2022	$49,270.32	$109,819.21	9.82%
10/30/2022	$49,270.32	$109,819.21	9.82%
10/31/2022	$49,270.32	$109,497.94	9.50%
11/1/2022	$23,217.74	$109,484.32	9.48%
11/2/2022	$23,217.74	$107,983.12	7.98%
11/3/2022	$7,192.64	$109,721.82	9.72%
11/4/2022	$107.54	$110,107.42	10.11%
11/5/2022	$107.54	$110,107.42	10.11%
11/6/2022	$107.54	$110,107.42	10.11%
11/7/2022	$107.54	$109,935.69	9.94%
11/8/2022	$107.54	$109,564.34	9.56%
11/9/2022	$107.54	$107,635.27	7.64%
11/10/2022	$107.54	$110,405.59	10.41%
11/11/2022	$0.00	$109,394.55	9.39%

Basic Materials Sector

Date	Cash	Net Worth	% Return
9/29/2022	$0.00	$101,113.33	1.11%
10/1/2022	$0.00	$100,626.74	0.63%
10/2/2022	$0.00	$100,626.74	0.63%

10/3/2022	$0.00	$104,940.59	4.94%
10/4/2022	$0.00	$109,020.09	9.02%
10/5/2022	$0.00	$108,151.29	8.15%
10/6/2022	$0.00	$106,447.67	6.45%
10/7/2022	$25,221.48	$103,294.02	3.29%
10/8/2022	$25,221.48	$103,294.02	3.29%
10/9/2022	$25,221.48	$103,294.02	3.29%
10/10/2022	$0.00	$104,688.93	4.69%
10/11/2022	$0.00	$104,803.14	4.80%
10/12/2022	$0.00	$103,235.13	3.24%
10/13/2022	$0.00	$104,520.13	4.52%
10/14/2022	$0.00	$99,731.70	-0.27%
10/15/2022	$0.00	$99,731.70	-0.27%
10/16/2022	$0.00	$99,731.70	-0.27%
10/17/2022	$0.00	$103,018.86	3.02%
10/18/2022	$0.00	$104,788.66	4.79%
10/19/2022	$0.00	$103,367.12	3.37%
10/20/2022	$0.00	$103,650.56	3.65%
10/21/2022	$0.00	$105,414.80	5.41%
10/22/2022	$0.00	$105,414.80	5.41%
10/23/2022	$0.00	$105,414.80	5.41%
10/24/2022	$0.00	$106,475.40	6.48%

10/25/2022	$0.00	$108,860.18	8.86%
10/26/2022	$0.00	$110,258.87	10.26%
10/27/2022	$0.00	$109,507.46	9.51%
10/28/2022	$26,951.13	$110,247.23	10.25%
10/29/2022	$26,951.13	$110,247.23	10.25%
10/30/2022	$26,951.13	$110,247.23	10.25%
10/31/2022	$26,951.13	$110,059.61	10.06%
11/1/2022	$26,951.13	$111,215.09	11.22%
11/2/2022	$26,951.13	$108,661.07	8.66%
11/3/2022	$26,951.13	$108,076.11	8.08%
11/4/2022	$26,951.13	$110,051.12	10.05%
11/5/2022	$26,951.13	$110,051.12	10.05%
11/7/2022	$26,951.13	$110,457.17	10.46%
11/8/2022	$26,951.13	$111,396.56	11.40%
11/9/2022	$26,951.13	$110,266.09	10.27%
11/10/2022	$26,951.13	$115,592.96	15.59%
11/11/2022	$26,951.13	$116,975.93	16.98%

Agricultural Sector

Date	Cash	Net Worth	% Return
10/1/2022	$35,285.60	$100,037.74	0.04%
10/2/2022	$35,285.60	$100,037.74	0.04%
10/3/2022	$15,607.12	$99,775.04	-0.22%

10/4/2022	$15,607.12	$101,308.69	1.31%
10/5/2022	$8,369.97	$101,552.24	1.55%
10/6/2022	$8,369.97	$99,589.03	-0.41%
10/7/2022	$8,369.97	$98,858.89	-1.14%
10/8/2022	$8,369.97	$98,858.89	-1.14%
10/9/2022	$8,369.97	$98,858.89	-1.14%
10/10/2022	$8,369.97	$100,558.32	0.56%
10/11/2022	$8,369.97	$100,237.04	0.24%
10/12/2022	$8,369.97	$102,807.63	2.81%
10/13/2022	$8,369.97	$106,257.85	6.26%
10/14/2022	$8,369.97	$104,477.51	4.48%
10/15/2022	$8,369.97	$104,477.51	4.48%
10/16/2022	$8,369.97	$104,477.51	4.48%
10/17/2022	$8,369.97	$106,308.22	6.31%
10/18/2022	$8,369.97	$104,876.86	4.88%
10/19/2022	$8,369.97	$106,180.22	6.18%
10/20/2022	$8,369.97	$104,341.39	4.34%
10/21/2022	$8,369.97	$105,189.91	5.19%
10/22/2022	$8,369.97	$105,189.91	5.19%
10/23/2022	$8,369.97	$105,189.91	5.19%
10/24/2022	$8,369.97	$105,096.89	5.10%
10/25/2022	$8,369.97	$105,939.29	5.94%
10/26/2022	$8,369.97	$105,320.58	5.32%
10/27/2022	$8,369.97	$103,124.86	3.12%
10/28/2022	$8,369.97	$104,782.12	4.78%
10/29/2022	$8,369.97	$104,782.12	4.78%
10/30/2022	$8,369.97	$104,782.12	4.78%
10/31/2022	$8,369.97	$104,656.87	4.66%

11/1/2022	$8,369.97	$105,446.60	5.45%
11/2/2022	$8,369.97	$104,376.67	4.38%
11/3/2022	$8,369.97	$104,840.47	4.84%
11/4/2022	$8,369.97	$105,218.31	5.22%
11/5/2022	$8,369.97	$105,218.31	5.22%
11/7/2022	$8,369.97	$107,378.71	7.38%
11/8/2022	$8,369.97	$108,128.02	8.13%
11/9/2022	$8,369.97	$104,203.95	4.20%
11/10/2022	$8,369.97	$104,552.90	4.55%
11/11/2022	$1,846.32	$101,565.96	1.57%