Trading and Investing Systems Analysis

An Interactive Qualifying Project report submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

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Abstract

Using tools and information available from the Internet, I performed an in-depth analysis of different platforms for stock market trading and investing. This work was done to understand how different short-term trading and long-term trading strategies can be implemented using the investigated tools. This project builds from previous work done on devising trading systems and attempts to use state of the art tools to find implementations. The experience of this project could lead to a better comprehension of the stock market and will be helpful for actual stock market investment in the future.

Acknowledgements

There are a number of others involved with this project that I would like to thank for making the whole thing possible. First, I would like to thank Professor Craig Wills, for the continual support and help during my project. I would also like to extend my thanks to Professor Gbetonmasse Somasse and Professor Reinhold Ludwig for the guidance in helping me start the project and gain foundation knowledge on the subject.

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1 Introduction

1.1 Statement of the Problem

The motivation of this Interactive Qualifying Project is to understand the financial market and to learn about different existing trading platforms in order to implement trading systems. It covers economics and stock market basics, the process of selecting stocks that have a high performance, the trading platform and resources and their comparisons, and finally how to implement trading systems using the researched trading platforms. The project aids to help stock trading beginners from foundations and background of stock market trading. Further, the project provides an extensive review of trading resources found online. This work is done with the aim of providing guidance on trading platforms to use. Learning the skills needed for smart decision making takes a significant amount of time, especially when an individual takes part in trading regularly.

1.2 Goal

The objectives of this project are to provide the reader with background material to enable them to understand the basics of stock market and economic cycles. Further, it is intended to help the reader develop a trading ideology and guide them on which tools would suitable for their needs. This project extensively covers different state of the art trading resources in the hopes of providing the readers with information of the different stages of trading and the tools required at each phase. This research also implements a previously researched trading system using these resources. Trading systems that supported Machine Learning are discussed with the aim of finding a combination of trading platforms to implement it.This work was done with the goal of helping readers to implement their own trading systems using these tools.The breadth of trading resources covered in this project range from trading platforms that are used by amateurs to ones that are more frequented by larger institutions.

1.3 Summary

This report first introduces the background material required to understand trading and the basics of the stock market. This background gives

the readers an understanding so that when reading about the different trading terminology when discussing the trading platforms, they will understand why certain decisions were made. It then implements previously researched trading systems to aid readers as basis point of launching their trading systems using these trading platforms. Finally, it recommends trading platforms to readers depending on factors like experience level, trading goal, and intended trading frequency. Eventually, the goal is to provide readers trading platforms or connected trading platforms they can deploy to trade better the basis of DOW or the S&P 500 indexes or personally set profit targets.

2 Background

2.1 Basic Macroeconomics

2.1.1 Cycles

The economy as a whole goes through a periodic cycle, as seen in Figure 1. This is known as the business cycle and consists of expansion, contraction, and recovery. Generally, phases of expansion and boom, periods where unemployment regresses and GDP increases, are followed with a recession phase. Recessions are contraction periods where there is an 13 overall downturn in economic activity. They start during the peak of the economic expansion and follow until the start of the recovery phase. Recovery or depression phase is the period where the economy starts to bounce back and regains economic productivity and unemployment start rising again.

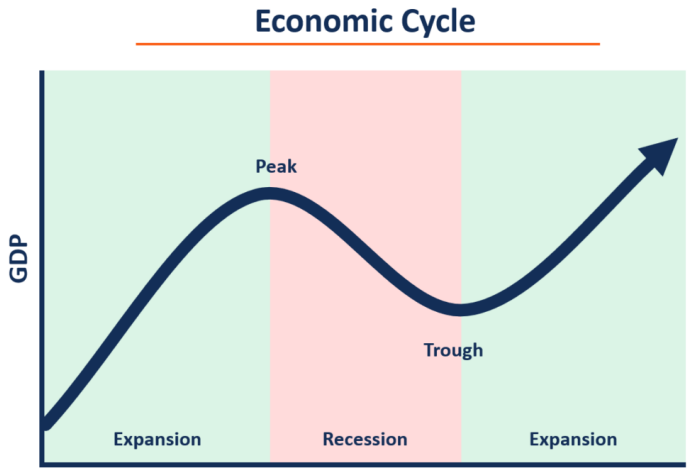

Figure 1: Macroeconomic Cycle

2.1.2 Types of Assets

There are four assets that are traded; equities, bonds, currencies, and commodities.Equities are more commonly known as stocks or shares. Stocks are essentially pieces of a company that are owned by individuals or groups. There are a couple of types of stocks that each have certain attributes, common and preferred. Common stocks are the most populous and represent

ownership of a portion of the company or a claim to the dividends paid by the company. Preferred stocks do not guarantee the same voting or ownership stake in the company as common stocks, however, preferred stocks are guaranteed a fixed dividend in perpetuity and are paid off before common stocks in the case of bankruptcy. Bonds are a fixed income investment that represents a loan made by an investor to a borrower. Bonds are most commonly issued by governments at all levels; local, state, and federal. Bonds can also be sold by companies as an alternative to selling stocks in the company. Currencies are traded in pairs 14 as relative values to each other, as one increase in value the other decreases with respect to the first. The foreign exchange or forex market is the largest market in the world. The last asset, commodities, are tangible real-world products. Commodities include; oil, livestock, wood, metals, and grains among others. The commodity market is generally used to buy futures of these products, which in turn sets the prices of the products when they reach the market.

Depending upon which phase of the cycle the economy is in impacts how financial institutions trade and which asset they base their plan around. During expansions historical data has shown that the stock market experiences the highest annual growth among the asset classes, however, during recessions stocks have the greatest losses. Bonds are the opposite of stocks with lower returns during expansions and higher returns during recessions. The foreign exchange market depends on which pairs of currencies are being traded and how the respective countries' economies are performing. For example, if the US is experiencing a recession and the UK is experiencing an expansion then the value of the dollar with respect to the English pound will decrease. However, if the US and UK are experiencing recessions but the UK has a worse recession then the dollar will increase in value with respect to the English pound. Commodities are similar to stocks in that during an expansion the returns are higher and during a recession the returns are small or losses. This is due to the fact that the commodities market is just that a market for commodities or physical goods. During an expansion people and companies have excess money and are looking to expand which requires goods to do creating higher demands and during a recession the opposite is true, people and companies have less money and are therefore less likely to spend on goods they do not need decreasing demand.

2.2 Trading

2.2.1 Overview

Trading involves more frequent transactions, such as the buying and selling of stocks, commodities, currency pairs, or other instruments. The goal is to generate returns that outperform buy-and-hold investing. While investors may be content with annual returns of 10% to 15%, traders might seek a 10% return each month. Trading profits are generated by buying at a lower price and selling at a higher price within a relatively short period of time. The reverse also is true: trading profits can be made by selling at a higher price and buying to cover at a lower price (known as "selling short") to profit in falling markets.

While buy-and-hold investors wait out less profitable positions, traders seek to make profits within a specified period of time and often use a protective stop-loss order to automatically close out losing positions at a predetermined price level. Traders often employ technical analysis tools, such as moving averages and stochastic oscillators, to find high-probability trading setups.

2.2.2 Day Trading

Day trading usually refers to the practice of purchasing and selling a security within a single trading day. While it can occur in any marketplace, it is most common in the foreign exchange (forex) and stock markets. Day traders are typically well-educated and well-funded. They use high amounts of leverage and short-term trading strategies to capitalize on small price movements that occur in highly liquid stocks or currencies.

2.2.3 Swing Trading

Swing trading requires holding an asset, either long or short, for more than one trading session, but no longer than several weeks or a couple of months. The goal of this technique is to encapsulate a piece of a potential price movement. More or less, swing trading is recognizing where an asset's price is most likely going to move and capitalizing on it.

2.3 Investing

2.3.1 Overview

Investing is to gradually build wealth over an extended period of time through the buying and holding of a portfolio of stocks, baskets of stocks, mutual funds, bonds, and other investment instruments.

Investors often enhance their profits through compounding or reinvesting any profits and dividends into additional shares of stock. Investments often are held for a period of years, or even decades, taking advantage of perks like interest, dividends, and stock splits along the way. While markets inevitably fluctuate, investors will "ride out" the downtrends with the expectation that prices will rebound and any losses eventually will be recovered. Investors typically are more concerned with market fundamentals, such as price-to-earnings ratios and management forecasts.

2.3.2 Value Investing

Value investing is an investment strategy that involves picking stocks that appear to be trading for less than their intrinsic or book value. Value investors actively ferret out stocks they think the stock market is underestimating. They believe the market overreacts to good and bad news, resulting in stock price movements that do not correspond to a company's long-term fundamentals. The overreaction offers an opportunity to profit by buying stocks at discounted prices—on sale.

Warren Buffett is probably the best-known value investor today, but there are many others, including Benjamin Graham (Buffet's professor and mentor), David Dodd, Charlie Munger, Christopher Browne (another Graham student), and billionaire hedge-fund manager, Seth Klarman.

2.3.3 Growth Investing

Growth investing is an investment style and strategy that is focused on increasing an investor's capital. Growth investors typically invest in growth stocks—that is, young or small companies whose earnings are expected to increase at an above-average rate compared to their industry sector or the overall market.

Growth investing is highly attractive to many investors because buying stock in emerging companies can provide impressive returns if the companies are successful. However, such companies are untried, and thus often pose a fairly high risk.

2.4 Fundamental Analysis

2.4.1 Overview

Fundamental analysis is the method of studying factors that affect an asset's value. This can be macroeconomic factors such as the state of the economy and industry conditions to microeconomic factors like the effectiveness of the company's management. This method of stock analysis is considered to be in contrast to technical analysis, which forecasts the direction of prices through an analysis of historical market data such as price and volume.

Fundamental Analysis can cover anything that correlates with the economic well being of a company. These fundamentals can include revenue and profit, while they can also include company's market shares to the quality of its management. As a result, Fundamental Analysis has two principal schools of thought: Quantitative and Qualitative Fundamental Analysis

2.4.2 Quantitative Fundamental Analysis

Quantitative Fundamental Analysis like it name suggests relates to insight that can be derived from numbers and amounts. Quantitative Fundamentals are the measurable characteristics of a business. That's why the biggest source of quantitative data is financial statements. Revenue, profit, assets, and more can be measured with great precision.

In Quantitative Fundamentals, there is heavy emphasis on financial statements. Financial statements are the medium by which a company discloses information concerning its financial performance. There are three main financial statements to consider: income statements, balance sheets and cash flow statements.

Balance sheets represents the record of the company's assets, liabilities, and equity at a particular point in time. Assets represents the cash reserves or

resources the company owns or has under management. Liabilities represent the debt the company owes.

Income statements are statements that give in depth insight into a company's performance over a specific time frame. These are usually reported when - in the case of public ones - companies come out with their earnings which typically are done on the fiscal quarter.

The statement of cash flows represents a record of a business' cash inflows and outflows over a period of time. They document the cash from investing which represents the cash used for investing in assets, as well as the proceeds from sale of assets. In addition, Statement of cash flows also contain the information related to the amount of cash the company paid or received from the issuing and borrowing of funds. Lastly, their is also the Operating Cash Flow which is the cash gained from day-to-day operations.

2.4.3 Qualitative Fundamental Analysis

Qualitative Fundamental Analysis are fundamentals that relate to the information about a company that are not described through numbers. Qualitative Fundamental Analysis capture the company's aspects or risks difficult to measure in numbers- such as management competencies and credibility, competitive strategies, RD capabilities, brand recall, and others.

Qualitative Fundamentals can tell us about a company that is not tangible from financial statements. Qualitative Fundamentals include the quality of a company's key executives, its brand-name recognition, patents, and proprietary technology. heavy emphasis on financial statements. Generally, there are key areas this analysis covers: Business Model, Competitive advantage, Management and Corporate Governance.

The Business Model of company describes the process of how the company aims to make profit. This could be through consumer product sales, ad revenue, licensing, etc.

Competitive Advantage represents the edge a company has in its industry. A company's long-term success is driven largely by its ability to maintain a

competitive advantage and sustain it. Companies with strong competitive advantage can keep their competitors at bay and enjoy growth and sustained profit.

Management of a company is also a significant factor to consider when doing Qualitative Fundamental Analysis. Investors usually consider the leadership of the company when making investments. The track record and resumes of top executives and board members can forecast a company's potential as key decisions they make influence the bottom line.

Corporate governance describes the policies in place within an organization denoting the relationships and responsibilities between management, directors, and stakeholders.These policies are defined and determined in the company charter and its bylaws, along with corporate laws and regulations.

2.5 Technical Analysis

Technical Analysis is a discipline in which investments are evaluated by analyzing statistical trends from price movement and volume. Technical Analysis discipline believe that past trading activity and price changes of a security can be valuable indicators of the security's future price movements.

In Technical Analysis, there are two key areas in this discipline: Chart Patterns and Technical Indicators.

2.5.1 Chart Patterns

Chart Patterns are the distinctive formations created by the movements of security prices on a chart. These patterns are identified by a line that connects common price points, such as closing prices or highs or lows, during a specific period of time.

There are numerous types of chart patterns in technical analysis, including the cup and handle, ascending/descending channels, and the head-and-shoulders pattern. Trend lines are the most basic form of chart patterns and have two main types: support and resistance levels.

A support level represents a level where the price tends to find support as it falls. This means that the price is more likely to "bounce" off this level rather than break through it. However, once the price has breached this level, by an amount exceeding some noise, it is likely to continue falling until meeting another support level.

A resistance level is level where the price tends to find resistance as it rises. Again, this means that the price is more likely to "bounce" off this level rather than break through it. However, once the price has breached this level, by an amount exceeding some noise, it is likely to continue rising until meeting another resistance level.

2.5.2 Technical Indicators

Technical indicators, also known as "technicals," are focused on historical trading data, such as price, volume, and open interest, rather than the fundamentals of a business, like earnings, revenue, or profit margins. Technical indicators are commonly used by active traders, since they're designed to analyze short-term price movements, but long-term investors may also use technical indicators to identify entry and exit points. There are two main types of technical indicators: Overlays and Oscillators.

Overlays are technical indicators that use the same scale as prices are plotted over the top of the prices on the chart. Moving averages - calculations used to analyze data points by creating a series of averages of different subsets of the full data set - are a good example of this category of Technical indicators.

Oscillators are like the name suggests technical indicators that oscillate between a local minimum and maximum are plotted above or below a price chart. Some commonly used oscillators are Relative Strength Index and Moving Average Convergence Divergence. Relative Strength Index is an indicator used in technical analysis that measures the magnitude of recent price changes to evaluate overbought or oversold conditions in the price of a stock or other asset. Moving Average Convergence Divergence is a trading indicator used in technical analysis of stock prices. It is designed to reveal changes in the strength, direction, momentum, and duration of a trend in a stock's price.

2.6 Differences between Investing and Trading

Investing and trading are two very different methods of attempting to profit in the financial markets. Both investors and traders seek profits through market participation. In general, investors seek larger returns over an extended period through buying and holding. Traders, by contrast, take advantage of both rising and falling markets to enter and exit positions over a shorter timeframe, taking smaller, more frequent profits.

The goal of investing is to gradually build wealth over an extended period of time through the buying and holding of a portfolio of stocks, baskets of stocks, mutual funds, bonds, and other investment instruments.

Trading involves more frequent transactions, such as the buying and selling of stocks, commodities, currency pairs, or other instruments. The goal is to generate returns that outperform buy-and-hold investing. While investors may be content with annual returns of 10% to 15%, traders might seek a 10% return each month. Trading profits are generated by buying at a lower price and selling at a higher price within a relatively short period of time. The reverse also is true: trading profits can be made by selling at a higher price and buying to cover at a lower price (known as "selling short") to profit in falling markets.

3 Trading Platforms and Resources

3.1 General Overview

Today, there numerous platforms that aid individuals trade or invest. These platforms can aid individuals in different tasks like visualization of stock price and volume movement, trying out testing ideologies through backtesting, or even directly executing trade orders - support Order Management Systems - in some cases.

One terminology commonly referred to in this research and used in this field is Backtesting. Backtesting is a term used in modeling to refer to testing a predictive model on historical data. Backtesting is a type of retrodiction, and a special type of cross-validation applied to previous time period.

In addition to Bactesting, Order Management System is something commonly used in this research. An order management system (OMS) is an electronic system developed to execute securities orders in an efficient and cost-effective manner. Brokers and dealers use order management systems when filling orders for various types of securities and can track the progress of each order throughout the system.

For this research, I looked into some popular platforms used by investors and traders in the industry. These platforms can be used to enhance each other to provide the user with better guidance in devising their trading strategies or making their trading orders. In the next chapters, I summarize the trading platforms that were reviewed during this research.

3.2 Trading Platforms

3.2.1 AlgoTrader

AlgoTrader is an institutional class data management, backtesting and a strategy executing solution. AlgoTrader is multi asset supporting Stocks, Futures, Options, ETFs, Forex, and more custom derivative spreads. Underneath, AlgoTrader is a Java based trading software that is deployed through Docker.

AlgoTrader is commonly used at an institutional level and with more professional traders. Its platform supports a complete trading lifecycle from programmatically devising the trading strategy and implementation to backtesting, live simulation and automated order management. At an institutional level, they provide financial institutions to manage multiple portfolios with ease.

AlgoTrader uses highly regarded time series database InfluxDB for storing live and historical market data. This results in hassle-free installation with no dependencies, storage of up to one million values each second, sophisticated compression to limit storage footprint, data tagging to allow flexible queries, the possibility of accelerated backtests up to 200%, and real-time aggregation of tick data into straightforward bar data.

Compared to other systems like Ninja, AlgoTrader platform offers several unique features that are not accessible elsewhere. Creating a signal based on several securities and then trading alternative securities. Automatic rolling allows you to continuously trade futures and options. Using time-based strategies that are not able to be programmed with traditional programming languages. There are several time-based window functions. These include, during, between, afterwards, parallel with, along with, finishes and begins. You can benefit from a sleek combination of Java and Esper. The former is used for procedural actions, such as placing an order. The latter can be used for time-based market data analysis and signals. You can automate quantitive strategies that use formal trading rules, based on MATLAB or Excel that previously had to be manually traded because of an inadequate trading platform.

3.2.2 TradeStation

TradeStation is a platform that supports live trading different assets like Stocks (long/short), Bonds, Cryptocurrency, Futures, Options. TradeStation also provides well enhanced Stock screeners. It lets you build a list of up to 2,000 stocks that you can continuously monitor in real-time, based on more than 180 technical and fundamental criteria. Although TradeStation can be used for live trading, it is also a popular backtesting and analysis tool. Its charting software is amongst the most used and is infused with automated technical analysis displaying patterns and signals as they happen in real time.

It supports numerous technical indicators in the charting capability which comes well integrated with its trade order management system. In addition, it provides vast educational content through YouCanTrade (TradeStation's learning page). TradeStation also provides an ability to add on tools found in its marketplace giving room for other 3rd parties to develop products that could further aid the platform's users.

TradeStation tends to cater to active traders and cost-wary investors with its low commissions and a feature-rich trading platform. TradeStation Web Trading: This simple browser-based platform enables investors to quickly log in and check streaming real-time prices for stocks, ETFs, options, and more. Placing a trade is a snap thanks to its "one-click" feature that allows traders to place a trade in a matter of seconds. TradeStation 10: A key feature of the desktop platform is complex charting. It offers 50 years of historical charting data, plus hundreds of technical indicators (e.g., moving averages) that can be overlaid on any chart. Customers can build a watch list, which can show hundreds of data points for individual securities, offering a quick view of key metrics for your favorite stocks. TradeStation's RadarScreen is a cool feature for scanning the market in real time based on customizable indicators. OptionStation Pro, which is built into the TradeStation 10 platform, provides a clean view of options chains, and enables you to see the maximum profit or loss for simple or complex options trades.

TradeStation ranks well for having lower margin rates than many competing brokerages, though it is most competitive for people who carry large balances. Additionally, TradeStation has a unique feature, known as its Fully Paid Stock Lending program, that allows its customers to make their stocks available to lend out to other traders (say, when a short position is opened). TradeStation will give you 30% of the margin interest it earns if you opt in, which could help boost your returns.

3.2.3 QuantConnect

QuantConnect is a free Web-based backtesting centered tool. In addition, Quant Connect also provides LEAN an Algorithmic Trading Engine that is built upon Python and C. This component of Quant Connect enables users to have automated consideration for fundamental news (stock splits,

dividends, corporate events, mergers, etc..), backtest and live trade from almost any time series. LEAN by QuantConnect is also very configurable and can be extended to suit the user's portfolio needs/desires. This is an open-source component that can be incorporated through Python programming language. QuantConnect also provide cloud support integrating computer nodes with customizable resource allocations. QuantConnect also enables traders/investors a platform to exchange trading strategies and scripts. Their pricing varies at different individual, team, trading firm and larger institution standards. QuantConnect also supports live trading through integration with brokers like Interactive Broker, Oanda, GDAX etc...

3.2.4 PyAlgoTrade

PyAlgoTrade is a free open-source software package available in Python programming language. PyAlgoTrade supports backtesting, paper trading and live trading. Compared to other trading tools, PyAlgoTrade requires more adept programming skills providing the user with more in-depth customization for backtesting with support for data from popular platforms like Quandl, Google Finance and Yahoo finance. In addition, it also streams real-time Twitter feeds for incorporating twitter events into trading decisions. This software is event driven and supports functionalities like Market, Limit and Stop Limit orders. A sample snippet of code can be seen in Figure 2.

```
from pyalgotrade import strategy
from pyalgotrade.tools import yahoofinance

instruments = ["AAPL"]
class MyStrategy(strategy.BacktestingStrategy):
    def __init__(self, feed, instrument, useAdjustedClose = False):
        strategy.BacktestingStrategy.__init__(self, feed,cash_or_brk=100000)
        self.__instrument = instrument
        self.setUseAdjustedValues(useAdjustedClose)
        # We will allow buying more shares than cash allows.
        self.getBroker().setAllowNegativeCash(True)

    def onBars(self, bars):
        bar = bars[self.__instrument]
        self.marketOrder(self.__instrument, 10) # buy 10
        self.info("BUY 10 %s, Portfolio value: %s" %(self.__instrument, self.getBroker().getEquity()))

feed = yahoofinance.build_feed(instruments, fromYear=2000, toYear=2012, storage="data")
# Evaluate the strategy with the feed's bars.
myStrategy = MyStrategy(feed, instruments[0])
myStrategy.run()

print "Final portfolio value: $%.2f" % myStrategy.getResult()
```

Figure 2: PyAlgTrade Code Sample

3.2.5 ProfitsPi

Profitspi offers many different tools to analyze the stock market. They have charts with different data shown on each one. For example, the user may choose to view a chart with Bollinger Bands, Relative Strength Index, Historical Volatility, or with other data that this website offers. This platform also provides the user to backtest different markets across the world. For example, the user can back test the New York Stock Exchange to look at the data for the 52-week highs at latest close. This allows the user to view data and aiding them in investing/trading decisions. This website seems to be a little more complex, so the user must know exactly what they are looking for before visiting.

3.2.6 Ninja Trader

NinjaTrader offers software and brokerage services for active traders. With a funded account, the NinjaTrader platform is free to use for charting, market analysis, and live trading. To access the platform's premium features—such as advanced order types, automated trading, and backtesting—you'll need to lease or buy the software (from $60/month to lease; $1,099 one-time payment to buy). The Order Flow+ suite of premium features, which allows you to analyze trade activity using order flow, volume bars, and market depth, is available only with a lifetime license.

The NinjaTrader platform is ideal for active traders who want lots of technical analysis tools. The platform boasts excellent charting, real-time analysis, customizable technical indicators, Chart Trader (a chart-based order entry tool), and thousands of apps and add-ons from 3rd-party developers.As a brokerage, NinjaTrader offers access to the futures and forex markets. The company has partnered with several supporting brokerages, including Interactive Brokers and TD Ameritrade, to give traders access to other markets, including options on futures, CFDs, and equities.

3.2.7 AmiBroker

AmiBroker is a comprehensive technical analysis platform designed with advanced traders in mind. In addition to detailed technical charts, AmiBroker offers some of the most in-depth strategy backtesting options available to traders. Walk-forward testing and Monte Carlo simulations make AmiBroker

an excellent choice for traders working on developing new trading strategies, and a built-in programming language makes the platform incredibly versatile.

The Standard version of the software costs $279 (one-time fee) but is limited to one-minute charting intervals at the finest resolution and only allows you to look at 10 stocks in real-time at once. The Professional version of AmiBroker costs $339 and unlocks unlimited real-time data as well as intraday charting intervals as fine as ticks. The Ultimate Pro Pack costs $499 and includes AmiBroker Professional as well as the AmiQuote and AFL Code Pack softwares. AmiQuote is a program that automatically downloads real-time quote data, while the Code Pack software is designed to write code for you based on plain-English sentences. These software packages can be purchased separately as well.

3.2.8 TradingView

TradingView is a popular financial visualization platform with the ease of use of any modern website. TradingView is widely used for Price Charting, however, it still supports backtesting. It also has social network capabilities connecting different Traders and Investors to share ideas and strategies. Although not commonly used for placing active trades, it can be used for Forex trading with integration with platforms like Oanda. TradingView also enables members to publish scripts that execute their trading strategies, any member of TradingView can use these tools to enhance their trading approach. TradingView is a cloud-based charting software that has free account access, however, the Pro version with full access comes at a cost of $60/month subscription. It is also available through smartphones in addition to the web.

3.2.9 Finviz

Finviz (Financial Visualizations) offers many tools for stock market analysis, though it can look confusing when visiting their website. On their screener tab, it gives a list of almost 7500 stocks with data on all of them. One can narrow down the search to what you prefer to look for in specific data. The map tab will bring you to a chart that shows the biggest contributors in the stock market based on their value in specific areas like consumer goods or technology. They also color code this to show a loss or gain in the market. They also have a section on their website that shows futures and

their data. This gives the user the ability to see how the futures are performing, assess price action, and how relative performance to other futures. They have a similar format for Forex trading and cryptocurrencies. Overall, this website shows data for whatever someone might be interested in investing in.

4 Trading Platforms Analysis

From the previous chapter, we were able to review the trading platforms investigated in this research. These trading platforms can provide us with similar utilities, but they can also be trading platforms used in different stages in a trading process.

In this chapter, I try to analyze these platforms in more details to give users more foundations when making decisions on which trading platforms to use. Since the nature of some of these platforms differ, I classified them into sub categories for better comparisons. These trading platforms fall into either Trade Compatible, Software Library and Charting and Screening trading platforms.

4.1 Trade Compatible Platforms

In this section, I summarize the criteria for classifying these platforms as Trade Compatible. To be more explicit, by Trade Compatible platforms I'm referring to trading platforms that support Order Management Systems for different asset classes. These platforms can be used for more than just executing trade orders. In some cases, they can even be used for the whole trading process: From screening stocks, backtesting trading strategies, charting live price action, paper trading and live trading.

There are key features we need to ask when selecting platforms for trading. First, we need to know whether we can actually afford these trading platforms. Prices such trading platform can range from being $50 a month to $200, in some cases we can use these trading platforms for free. Another key factor to consider would be the target user of these platforms. These trading platforms can be sophisticated and can require technically expertise in the underlying software in order to use them. Some can be easily accessible to the average retail investor and have interactive user interfaces that enable users without high level of technical expertise to use them. Others can require deeper knowledge of programming and scripting languages and this could be a roadblock to some investors. Another key factor in selecting a trading platform is the asset class it supports. Some users might be interested in the Foreign exchange market, or even in cryptocurrencies rather than trading just equity assests: Stocks, Futures, Options and Exchange Traded Funds.

Taking that into consideration, I have organized a comparison table for the Trade Compatible trading platforms in terms of price, expertise required to use, and asset classes supported for trading are shown in Figure 3 and 4 .

Trading System	Price	Level of Expertise to use	Asset Classes Trading
AlgoTrader	Price quote available per institution request	Technical Expertise required as software deals with an extensive number of programmable tools.	Stocks, Futures, Options, ETFs, Forex, and more custom derivative spreads
TradeStation	Traders who do not brokerage clients pay $99/month while professionals pay up to $199/month	Easy to use, supplies customers with good user interface.	Stocks (long/short), Bonds, Cryptocurrency, Futures, Options
QuantConnect	Provide a free version but can cost $8/month - $80/month. Depending on scale. Institutions pay up to $80/month	Easy to use, however can get complicated when integrating their Algorithmic trading platform. As this is a tool that requires extensive coding.	QuantConnect offer Equity, Forex, Futures, Options/Derivatives, Cryptocurrency, and CFD data for backtesting.
DELTIX	Price per request	Good analytics and system UI	Equities, Options, Futures, Forex
AmiBroker	Set onetime fee of $279 standard and $339 for Professional edition	Moderately simple user interface	Equities, Options, Futures, Forex
Quantopian	Free open-source software	Can be challenging to use for the average user. Requires proficiency in some level of programming	Equity/Stocks and ETFs
Ninja Trader	$50/month or $995 lifetime license	Moderately simple user interface	Futures, Options, Forex, CFD's and Stocks.

Figure 3: Trade Compatible Platforms: Price vs Ease of Use vs Supported Asset Classes

Trading System	Paper Trading/Live Trading/Backtesting	Order Management System	Key Notes
AlgoTrader	AlgoTrader can be used from Backtesting to Live Trading.	Provide an automated order management system.	- Used mainly by institutions. - AlgoTrader has very good integration with TradingView library access to many popular indicators. - Market data updates live at real-time automatically. - AlgoTrader uses highly regarded time series database InfluxDB, to store both live and historical market data.
TradeStation	Supports all backtesting, live trading and paper trading	Supplies Order Management system enhanced with state-of-the-art charting software	- Has educational content for newer subscribers and provides a marketplace for 3rd parties to develop. - TradeStation has quite an easy simple coding language called EasyLanguage. This is a crossover between HTML and SQL. - This language supports not only charting, but also buy/sell strategies. - TradeStation's RadarScreen is a cool feature for scanning the market in real-time based on customizable indicators. - OptionStation Pro, which is built into the TradeStation platform, provides clean view of options chains. - TradeStation ultimately caters to short term traders more than to long-term investors.

Figure 4: Trade Compatible Platforms: Price vs Ease of Use vs Supported Asset Classes

In addition to the factors mentioned above, one may also want to consider the order management system provided and support for backtesting, paper trading or live trading. I also cover some key advantages for this systems to better aid users make good choices on selecting trading platforms they would like to use in Figure 5 and 6

Trading System	Paper Trading/Live Trading/Backtesting	Order Management System	Key Notes
QuantConnect	Supports live trading through integration with brokers like Interactive Broker, Oanda, GDAX	They leverage other brokerages for order management	- LEAN an Algorithmic Trading Engine that is built upon Python and C#. - QuantConnect also provide cloud support integrating computer nodes with customizable resource allocations. - QuantConnect supports Interactive Brokers, Alpaca, GDAX, FXM, OANDA and Bitfinex. - Data is usually down to the tick (real-time and automatic). - Users can leverage the cloud integration to live trade more than algorithm at a time. Since each algorithm is running on a live server. One can simply deploy multiple algorithms on different servers.
DELTIX	Supports Backtesting, Live Trading and Paper Trading	Provided	- C# and .Net based strategy backtesting and optimization. Known for processing incoming time series data relatively fast
Ninja Trader	Dedicated software for backtesting and auto-trading. Live trading supported through integration with brokers like Interactive Brokers, TD Ameritrade, and others. However, live trading is available for Futures and Options	Order Management Systems provided	- Known for backtesting price-based signals.

Figure 5: Trade Compatible Platforms: Order Management System vs Trading levels supported

Trading System	Paper Trading/Live Trading/Backtesting	Order Management System	Key Notes	
AmiBroker	Mainly used for backtesting and charting, however live trading possible through integration with other brokerages	Not Provided	-	Supports its own scripting language AmiBroker Formula Language. State-of-the art backtesting software
Quantopian	Web based backtesting tool. However, supports live trading through Interactive brokers	Not provided	-	Software that is provided by a collective group of amateur traders. Unfortunately, support for Quantopian was closed last December and no longer has software-maintained support. All code is open source currently resides on GitHub

Figure 6: Order Management System vs Trading levels supported

4.2 Software Library Platforms

In this section, I summarize the criteria for classifying these platforms as Software Library Platforms. In more simple terms, these are open source software or code that can be used to perform algorithmic trading. The two platforms discussed in this subcategory are PyAlgoTrade and Zipline - both are python based libraries used for algorithmic trading.They can be used for different tasks such as bactesting, live trading and paper trading, however, these systems don't provide order management systems and require integration with brokers to execute trade orders. At the core, they are actually open source code making them quite hard to use for the average investor or trader. These platforms require an adept knowledge of programming in Python programming language to use.

For keeping consistency with previously discussed trading platforms, we compare the Software Library trading platforms on basis of pricing, easy of use, asset classes supported, support for backtesting, paper trading, live trading, and order management systems. In the case of these selected trading platforms, they both share free pricing, and similar order management

system integration. The main difference between these platforms is in the underlying asset they support for orders through brokerages. I have organized a comparison table for the Software Library trading platforms, and distinguished them on other key internal utilities in Figure 7 and 8

Trading System	Price	Level of Expertise to use	Asset Classes Trading
PyAlgoTrade	Free open-source software	Can be challenging to use for the average user. Requires proficiency in some level of programming	Supports what the brokerage provides
Zipline	Free open-source Python library	Can be challenging to use for the average user. Requires proficiency in some level of programming	Harder to use with multiple financial asset classes. US-equity only support.

Figure 7: Software Library Platforms: Price vs Ease of Use vs Supported Asset Classes

Trading System	Paper Trading/Live Trading/Backtesting	Order Management System	Key Notes
PyAlgoTrade	Does support backtesting, paper trading and live trading.	None, must be integrated with another brokerage platform	- PyAlgoTrade streams real-time Twitter feeds for incorporating twitter events into trading decisions. This software is event driven and supports functionalities like Market, Limit and Stop Limit orders - This mainly an event-driven library which is active; It is well supported and supports TA-Lib integration (Technical Analysis library). - Very widely used, however, it has a drawback as it does not support the popular Pandas library.
Zipline	Can be used for backtesting, Trading to extensions with other platforms.	None, must be integrated with another brokerage platform	- Zipline is an event-driven backtesting framework. - Zipline tends to be slower to run on a local machine, running on cloud would be suited for this software. - Unlike its similar sibling, PyAlgoTrade, however, Zipline offers support with Pandas library. Also has cloud integration support. - It is also quite easier to use the PyAlgoTrade.

Figure 8: Software Library Platforms: Order Management System vs Trading levels supported

4.3 Charting and Screening Platforms

In this section, I summarize the criteria for classifying trading platforms as Charting and Screening Platforms. These platforms are trading platforms that are frequented for analysis on different parameters to select stocks we desire to trade. They also provide real time updates to market news and have different blogs/forums for discussing trading ideas and predictions. They are usually used for deciding whether to buy, sell or hold a current position in a given asset. They also can not directly be used for placing market orders and are usually supplemented with other trading platforms that support order management.I have organized the differences and similarities of these trading platforms in Figure 9 and 10.

Stock screening is the process of searching for companies that meet certain financial criteria. A stock screener has three components: A database of companies. A set of variables. A screening engine that finds the companies that satisfy those variables and generates a list of matches.

Trading System	Price	Level of Expertise to use	Asset Classes Trading
FINVIZ	Free limited, full elite version comes at $25/month	Good website design and easy to use	None
PROFITSPI	Price varies depending on the package. $10 – $70/month	Simple website design easy for anyone to use	None
Trading View	Free limited with full version costing $60/month	Good website UI, easy to use with extended functionalities specially for charting	Forex for trading

Figure 9: Charting and Screening Platforms: Price vs Ease of Use vs Supported Asset Classes

Trading System	Paper Trading/Live Trading/Backtesting	Order Management System		Key Notes
FINVIZ	Supports backtesting and used mainly for screening. No live trading supported	No Order Management System as it does not support trading	-	Advanced screeners and charts used by many institutional banks like Wells Fargo, Bank of America
PROFITSPI	Supports Backtesting. No live trading/paper trading	No Order Management System as it does not support trading	-	Has a broad range built-in Screeners and Pattern APIs
Trading View	Supports backtesting mostly, but can also be used for Forex trading with integration with platforms like Oanda	None	-	It has social network capabilities connecting different Traders and Investors to share ideas and strategies. TradingView also enables members to publish scripts that execute their trading strategies,

Figure 10: Charting and Screening Platforms: Order Management System vs Trading levels supported

5 Trading Systems and Implementations

5.1 Previous Works

5.1.1 Overview

This research project on Trading Investing Systems is an extension of a previously investigated Interactive Qualifying Project research project that was completed in 2019. The aforementioned project was a research advised by Professor Reinhold Ludwig and Professor Gbetonmasse Somasse which I had partially contributed towards before its final completion(Albert et al., 2019).

The project objective was centered on understanding the financial market and devising an approach to build a system of trading systems. It covered basics of economics and stock market, and process of devising asset selection systems and a system of systems to use methodology in market.

In the project, we covered enough background material required to understand the basics of the stock market, trading and investing. This was intended to aid readers to develop an understanding and rationale before describing the three trading systems discussed in the report. After explaining each trading system, the research team had combined these three trading systems to build a conjoined system that uses the strength from each individual system. The objective of these systems was to devise a trading or investing approach that would perform better than baseline S&P 500.

5.1.2 Trading Systems

In the scope of the project, we refer to a trading system as a set of sub-tasks that can be combined to trade a given asset. They were generally designed to trade autonomously without constant supervision. However, in some cases, this system can be used to provide an indicator that an active trader can use to make better trading decisions. These systems help traders remove emotion from trading by setting rules to enter and exit positions. The systems are effective as they are fully based on these set rules and do not deviate from them. They also help traders save time. Since the system can be configured to do the trading for the trader. A standard trading system consists of the

following parts: stock selection, market actions(buying, selling and holding), and position sizing/allocations (Albert et al., 2019).

One of the trading system that was devised by the team during this research was a Machine Learning Trader. This algorithmic trading system was heavily leveraged on the book Advances in Financial Machine Learning (de Prado, 2018) . The trading system took concepts from the book and extend them. It was extended using the Heikin Ashi (Albert et al., 2019) transform and used market actions like buying and selling to make profitable trades. This trading system used a defined parameter for stock selection. The stock needed to have a positive trend over the last two months, and a positive over the past half year. A beta of 0.5 and 1.5 is good to reduce volatility and allow for better swing trading. A RSI of less than 60 will make sure the stock is on an uptrend but not overbought. A volume of greater than 1 million per day will allow plenty of liquidity for trading. This trading system heavily relied on Machine Learning models to make optimal decisions when it came to the trading system. The method uses data and optimization algorithms in order to find the optimal result. It works by finding patterns in previous data to predict future events. For this system the machine learning algorithm was trained on the past 5 years of daily data for a given stock not including the section of training data 5 months long. This provided a good sized training set along with a testing set that changed every program run. This trading system implemented the Random forest classification and a bagging classifier. The trading system's algorithm was back tested on 60 consecutive trading days. It performs a walk forward analysis focusing on ROI (Albert et al., 2019).

Machine Learning models: Random forests or random decision forests are an ensemble learning method for classification, that operates by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or of the individual trees. On the other hand, a Bagging classifier is an ensemble meta-estimator that fits base classifiers each on random subsets of the original dataset and then aggregate their individual predictions (either by voting or by averaging) to form a final prediction. Both classifiers differ fundamentally in that in Random forests only a subset of features are selected at random out of the total and the best split feature from the subset is used to split each node in a tree,

unlike in bagging where all features are considered for splitting a node.

Another trading system that was devised in this research was a manual approach for backtesting and stock screening. This trading system allowed more flexibility to react to fundamental news as the trader was responsible for market actions. This system uses a seven criteria for stock screening; Price over $1, a price-to-earnings ratio over 20, a forward price-to-earnings ratio over 15, earnings per share growth this year over 20%, return on investment over 25%, and price-to-sales ratio over 3. Once a stock passed the screener, the trader will further investigate it's fundamentals and anticipated market events. For risk management, this system dictates that if the price of the stock drops 15% below the priced at which it was purchased, the stock will be sold. The risk decreases when the investor distributes their cash over multiple stocks/assets, so this is another way that the risk will be managed (Albert et al., 2019).

Lastly there is a third trading system the team covers. This system is also like the second Trading System mentioned above as it is manually implemented system. It follows an approach whereby the trader/investor would do additional analysis once the screen implemented. This system, however, differs as it gives more emphasis to the fundamental analysis compared to preceding system. The only automated part about this system is that it implements a trailing stop that executes automatically. For selecting the stocks, the system uses a screening platform to select trading or investing opportunities. This system looks for stocks that are undervalued by the general market and thus have a high potential for gains. Also known as value investing. The screener uses five selected parameters: Market cap less than $1 billion, Price greater than $1, An average 10-day volume greater than 10,000, A price-to-sales ratio for the trailing twelve months in the lowest 10% of the market, An estimated EPS growth for the next year in the highest 20% of the industry. For example (Tech stocks, BioTech Stocks, Banks/Financial stocks)

This approach aims to look for small and micro-cap companies filters out companies that have less room for growth while the minimum price of $1 removes any highly volatile penny stocks. The 10-day volume average allows for easy liquidity. The P/S screen finds companies that have had low sales and 52 when combined with the estimated EPS growth looks for companies

looking to grow their sales and thus increase the value of their company. Unlike Trading System 2 mentioned above, this system uses an equally distributed allocation of portfolio capital. In this system, the risk is mitigated by a trailing stop loss of 5% and using the screener itself. The screener rarely selects stocks from the same sector due to the screen requirement being dependent upon the EPS growth in the highest 20% of its industry(Albert et al., 2019).

5.2 Implementation of Trading Systems

5.2.1 Manual Trading Systems Implementation

These trading methods are not the most complicated to automate as they rely on user to make market action moves. The user will be expected to buy/sell and hold an asset at given time without any automated executions. They simply require a platform that provides an order management system. In addition, they need to rely on external screening software to implement their trading guidelines. This can be done using any of the top screeners found. For example, TD Ameritrade, Zacks Nasdaq's Screener, FINVIZ, Profitspi, TradingView are some platforms that come to mind. In this research, we covered FINVIZ and TradingView as the prime candidates for screening software. TradingView is a platform that offers incredibly flexible screening, however, can be slightly overwhelming for new traders and investors. FINVIZ provides a stock screening platform that is free and accessible to the layman. It is well-designed web user interface coupled with the reduced number of configurations make it suitable to most traders. However, advanced investors and traders may not find it is screening filters flexible enough. The trading systems can be implemented through FINVIZ with all needed parameters as FINVIZ would be more suitable to the average user. TradingView would still work for these systems, however, the subscription fees needed to utilize the Pro version of this platform and the countless parameter options can be daunting to most traders. As a result, it would be recommended to use FINVIZ for the screen part. As mentioned since the trading systems discussed did not required any automation, we could combine the FINVIZ screener and combine it with any system that is an order management system and supports the asset class. In the figure below, TradeStation was selected just due to better reviews for UI.

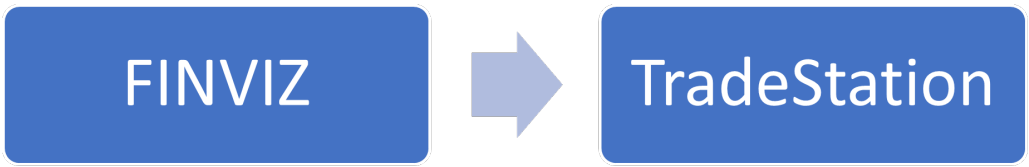

Figure 11: Implementation of Manual Trading Systems

5.2.2 Machine Learning Trader System Implementation

For the Machine Learning Trader System, the stock screen phase can be implemented through FINVIZ as done for other trading methods. Since traders use such a trading system will also need much more technical expertise, they could also use TradingView to enhance their experience with the charting software that TradingView supplies.

This trading system also needs a data pipeline since it will later be trained on the Machine Learning models, however, we also need to be able to preprocess this data to fit models input. This can be done through the yfinance library which is open source in Python language. Since this trading system uses very detailed implementations very processing data, we need more room for configuration. This would require significant technical skills. PyAlgoTrade can be used to integrate Heikin Ashi Transformation Bars into the overall data processing pipeline. Training data selection for the models occur through a cumulative summation algorithm. This algorithm selects time periods after a price movement in the 75% percentile. This would also need to be done programmatically using different tools provided in Python. The algorithm is executed every time the cumulative summation described earlier moves up 1.5% or down 1.5% in a single movement. PyAlgoTrade would be used to implement this approach of when to run algorithm to start trading. This trading system focuses on trading only a single stock or asset class at a time. It also works by trading 100% positions when selling and buying. This can be implemented in TradeStation or Interactive Brokers as most order management system's provide the capability to such adjustments to trades(Albert et al., 2019).

Selling criteria: Stock sold at either 3% above or below purchase price, and Stock sold at either 3% above or below price within last 5 days. The

order execution would eventually be configured to implemented through the order management system that is integrated with PyAlgoTrade. PyAlgoTrade would handle the machine learning training and the decision making in terms of when to buy/sell/hold. This system by far would be most challenging to implement through purely the tools mentioned, there would need to be a buffer code that implements some of the data preprocessing needs. Below are some tools that could be used to achieve the mentioned trading system(Albert et al., 2019).

Figure 12: Implementation of Machine Learning Trader

5.3 System of Systems Implementation

Stock Selection / Screener For the stock selection, the system of systems leverages the screening methodologies of Trading system 2 and Trading system 3 to make selection criteria. The system of systems simply requires a platform that provides a screener for this phase. This stock screen phase can be implemented through FINVIZ as done for other trading methods. Since traders use such a trading system will also need much more technical expertise, they could also use TradingView to enhance their experience with the charting software that TradingView supplies. Thus, it would be recommended to proceed to use TradingView for such an interconnected system.

Asset Allocation System of systems allocates the selected stocks based upon those stocks that exhibit the most desirable traits and values. In this case, the Trading 3 approach to allocate portfolio was selected. This would be an easy feature to configure in most order management systems. To be consistent with previous selection, we could use TradeStation.

Buy/Sell Timing The System of system utilizes the buying system used in system 1's Machine Learning algorithm. The stock price data is fed into the algorithm and if the algorithm returns a -1 it buys and if it returns a 1 it does nothing. This can be implemented with PyAlgoTrade and some buffer code. For selling it uses the methods from all systems combined. It uses the algorithmic trading approach from the Machine Learning based trading system while also integrating the manual nature of selling from the other two trading systems. Thus, it can use TradeStation for executing in general and use PyAlgoTrade source code with user modification to make the selling trigger in the Machine Learning Trader version. For Trading system 2 and Trading system 3, user manually makes trades thus no need for using PyAlgoTrade can directly make orders on TradeStation or any order management system-based platform.

System termination The system is terminated if it loses a specified amount of money in a specified amount of time. The retirement thresholds are -10% in a month, -7% in a week, and -15% since creation. It will run until one of these criteria are met, or it is manually disabled(Albert et al., 2019).

6 Summary and Future Work

6.1 Summary

There are numerous trading platforms for investors and traders today. These trading platforms can come at a cost and be complex to use. Some of these trading platforms also do not fully support utilities a user requires. The trading platforms mentioned in this researched can also be used for pure analysis and leverage external brokers for trade executions. I was able to learn about these state of the art trading platforms and how use them in a trading process.

The Trading platforms investigated are much more effective when combined with other underlying trading platforms and represent a successful aggregation of trading platforms. Through the implementation of Trading systems and System of systems discussed from previous research we can assert that the trading platforms are best when enhanced in an intertwined system of trading platforms. Through out this research I have learned a significant amount investing and trading. At the start, I had little to no experience trading or investing and had knowledge of how to implement an autonomous trading system using these trading platforms I researched.

6.2 Future Work

Some future work that can be done to improve this research would implementing different trading principles using these platforms to see which ones tend to be effective. As mentioned these trading platforms can provide us with implementation of simple or complex trading systems and can even be layered to support system of system of trading mechanisms. One area that can be furthered is investigating the different Machine Learning or Neural Networks available to deploy on the trading platforms discussed. Neural networks are better to learn market trends and are able to create better buying and selling signals that produce more profit. Additionally, a machine learning algorithm could be trained and implemented using these system of trading platforms.

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