

Algo-Trading Project Report



NUS SGUS Batch 1

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Executive Summary

With the objective of designing and developing an intelligent systematic trading system leveraging the fundamentals of investing, data visualisation and automation, we have developed the prototype of our trading system in 3 phases: Design, Development & Test and Deployment.

Phase 1: Design

To design portfolio visualisation and configure customised dashboards for our users, we adopted a design thinking process to better understand our users' journey in using some online financial platforms in the markets. Some of the challenges faced by our users in using these online platforms include:

- Current interface of some financial platforms is not user-friendly
- Payment required for subscription of premium services
- Trading process is manual and require human intervention to make predictions
- Data analysis is limited in terms of types of analyses
- Too many instruments in financial markets, so users find it difficult to decide what strategy to use for which equities.
- Lack of knowledge in risk management

Phase 2: Development & Test with QuantConnect

To develop smart trading algorithms to leverage several strategies of output and trade, 11 strategies — using sentiment, technical and fundamental analysis — were developed for decision making and predictions for investing in different equities in financial markets.

A period of 20 years (1 January 2001 to 31 December 2020) of historical data together with different parameters were used for backtesting in QuantConnect. The Modern Portfolio Theory (MPT) framework was also adopted to achieve optimal performance in our strategies and to maximise returns for our traders or investors.

Phase 3: Deployment

To address the issues raised by our users, we have successfully deployed the prototype of our trading system by integrating the smart trading algorithms (developed using QuantConnect) with the portfolio visualisation, dashboards, and reports (designed using PowerBI).

Our prototype offers the flexibility to connect to many sources such as APIs, brokers, news or data to provide timely information; including the ability to manage and proportion individual equities and strategies to form a balanced and comprehensive portfolio of low & high risk, long & short-term trades/investments. Our customised dashboard also provides weightage recommendations.

Overall, our prototype is accessible and convenient to use anytime anywhere, provides timely information and offers flexibility in its design at an affordable rate.

Introduction

In recent decades, there have been way too many negative sentiments and disruptions in the market that it makes conventional trading almost less certain of a stable gain. In nature, an investment is supposed to be an asset which is purchased, in hope that in time, the value will appreciate in the future.

There has been constant information overload which can be aggravated by both forces of globalization and digitalization. Agnew and Szykman have exemplified that there are three main causes of information overload. One is pure quantity. The second is having too many options, and the third factor is option similarity (Brian J. Bloch, 2021)¹. In addition, the unknown risks will be ever present, especially in a bearish and volatile market. It has never been a much better time to be able to come up with a solution to reduce or mitigate the impact of these underlying problems.

Diversification and taking a prudent approach remain paramount in coming up with good investment strategies in an ever-changing climate. Rapid advancement in technology especially in a pandemic has enabled both financial and digital literacies to remain key agendas among the masses. People have proven to take the leap of faith by exploring cutting edge methods such as algorithmic trading to increase speed, accuracy, and reduced cost (Shift Markets, 2019)². In addition, the ability to interpret back-test results into making logical decisions based on multiple market cycles can potentially define a competitive strategy. This would help investors stay relevant and practical.

As with every smart decision we make, failing to plan is planning to fail. Smart investors take a calibrated approach in investing by introducing key concepts such as the Modern Portfolio Theory to help construct their portfolio in which expected returns can be maximized for a given level of risk.

Our project aims to look at the various risks and returns through key indicators by implementing well-defined algorithmic trading strategies into one. This can potentially result in the ideal holistic portfolio solution, as we establish the benefits of each investment. We aim to make it both enterprising and intuitive for end users through the dashboard visualizations.

¹ From the Article - [Information Overload: How It Hurts Investors](#). Investopedia.

² From the Article - [Advantages of Algorithmic Trading](#). Nasdaq.

Industry Analysis

Since the break of the Covid19 pandemic that has led to international border closures and market downturn in March 2020, the interest in trading and investing within Singapore has soared with SGX seeing a 250% increase in CDP account openings from Feb to July 2020 as compared to the previous year³. Banks including DBS have also reported a rise in self-directed investing activities involving equities and foreign exchange trading.

With increased activity in financial markets during the period, SGX has also noted in an April report that the Straits Times Index's 30-day volatility increased to 51.7% on March 31, the highest it has been since December 2008. It comes as no surprise as well when we take a look at the average daily trading volume in the US market that has grown exponentially from 7 billion in 2019, to 10.9 billion in 2020, and 14.7 billion so far in 2021⁴.

As multiple macro-environmental factors continue to spur the growth of the technology landscape in Singapore, the number of robo-advisors has also grown tremendously in recent years with the majority launched just in the past 5 years to ride on the rising interest within retail investors. Investors are spoiled with choices as the number of players grows with each trying to capture market share aggressively to grow its AUM. Most robo-advisory platforms are algorithm-driven in the execution of their investment approach and have somewhat become a crowd-favourite among those who prefer passive investing, those who are learning to invest and those who would like to tap on the algorithmic capability of the platform.

In Singapore, the assets under management (AUM) by robo-advisors are projected to hit US\$1,591 million in 2021 based on Statista's data and market research. With an expected annual growth rate of 17.47% (CAGR 2021-2025), the amount is projected to hit US\$3,031million by 2025⁵. The research also projected an average AUM of US\$11,430 per user in 2021, with the number of users projected to reach 206,100 by 2025. With the industry outlook for the asset management business showing great promise, Singapore seems to be on track to make these projections come true - especially with the country's digital transformation sped up by Covid-19 and the rising awareness and interest on trading and investing during this time period.

³ From the Article: [More people trading and investing during Covid-19 pandemic. The Straits Times.](#)

⁴ From the Article: [Trading volume is up from 2020's breakneck pace as retail investors jump in. CNBC.](#)

⁵ From the Article: [Robo-Advisors - Singapore.](#)

POLITICAL

Launch of Tech.Pass visa for established tech entrepreneurs, leaders or technical experts to Singapore to perform frontier and disruptive innovations.⁶

Heavy investment and strong initiative to develop FinTech landscape by central bank, MAS.⁷

Well-enforced IP protection law encourages innovation and R&D effort.⁸

ECONOMIC

Increase in net inflow of funds to Singapore for asset management, with its economic position as a strategic financial hub in Asia.⁹

Relatively low interest rate prompts savers to invest money elsewhere for better return to keep up with long term inflation.¹⁰

High income growth population. Wealth per adult has grown at an average annual rate of 5.3% since 2000, more than double the average growth rate in the Asia-Pacific region and exceeding the 4.5% average growth rate of world wealth per adult.¹¹

SOCIAL

Only second to China, Singapore is among the countries with the highest saving rate - a habit ingrained in the social upbringing.¹²

In Asia, 46% of financial wealth is held in bank deposits, compared to 14% in North America.¹³

Ultra-connected population with 90% smartphone penetration and 5.2 mil active users of internet in 2020 - in which 92% access the internet with a smartphone.¹⁴

Rise of interest in investing and trading within younger generation, resulting in a generation of young, active investors diving into markets.¹⁵

TECHNOLOGICAL

Rate of innovation and progress in deep tech and AI rapidly spurred by government initiatives.¹⁶

Increased technological awareness and knowledge in the society during Covid19.¹⁷

Influx of global tech firms setting up base in Singapore brings about transfer of knowledge and encourages a conducive ecosystem for incubation of ideas and innovation.¹⁸

⁶ From the Article: [Singapore offers tech visas to talent that earns \\$15,000 monthly.](#)

⁷ From the Article: [How the Singapore government supports the country's tech scene. CIO.](#)

⁸ From the Article: [Singapore flexes its standing as Asia's technology capital.](#)

⁹ From the Report: [2019 Singapore Asset Management Survey.](#)

¹⁰ From the Article: [Commentary: Low interest rates could tempt more to borrow beyond their means.](#)

¹¹ From the Report: [Global Wealth Report 2019 \(Publication\).](#)

¹² From the Report: [Global Wealth Report 2019 \(Publication\).](#)

¹³ From the Article: [StashAway crosses US\\$1b in assets under management.](#)

¹⁴ From the Report: [Singapore Fintech Report 2021.](#)

¹⁵ From the Article: [Plan Gen Z: A new generation of young, active investors is diving into markets.](#)

¹⁶ From the Article : [Deep tech to drive digital economy in Singapore post-Covid-19 world.](#)

¹⁷ From the Article: [How digital tech can help Singapore tackle crises and build a better society.](#)

¹⁸ From the Article: [The Big Read: As tech titans converge in Singapore, can it truly become Asia's Silicon Valley?](#)

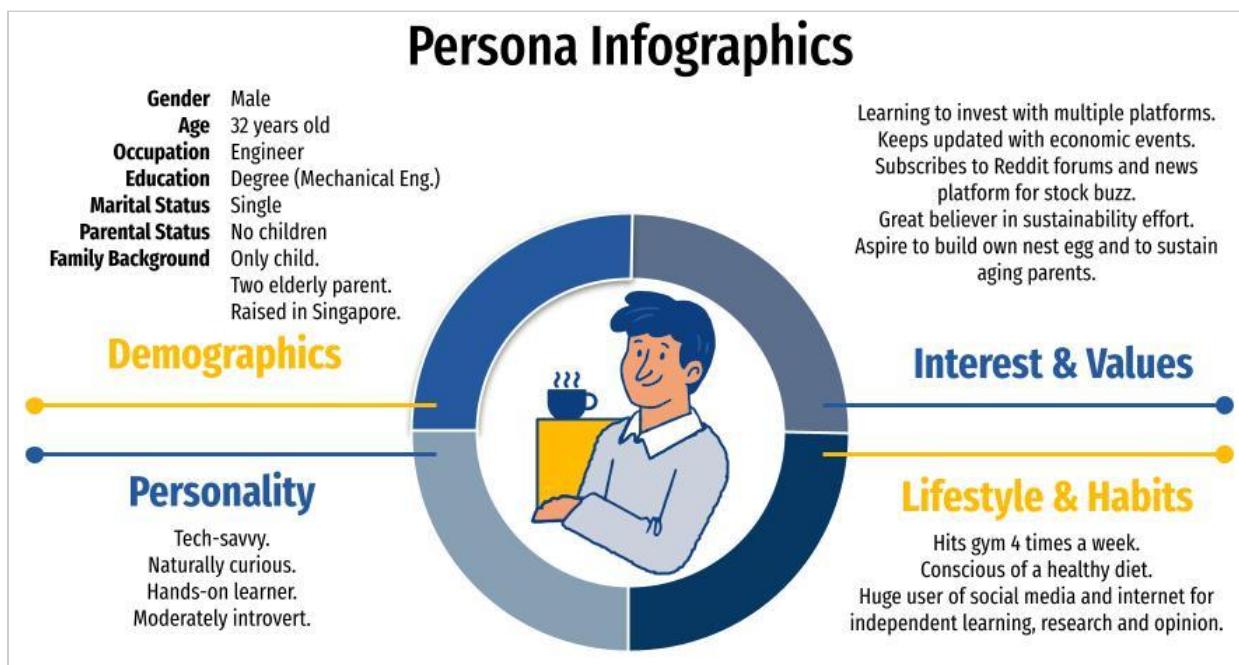
	Fees	Screeners	Portfolio vs Benchmark Comparison	Fund Fees Analysis	Portfolio Analysis (Diversity and Risk)	Unique Value Proposition	Drawback
Morningstar Instant X-Ray	\$199/year	√	√	√	√	Morningstar is the source for information and analysis in the investment industry. You'll have access to the kinds of investment tools typically available only to insiders.	Heavily oriented toward analysis and tools than it is for portfolio tracking.
Portfolio Visualizer	Free to use	√	√	√	√	You can pick and choose what you want to use. Backtest up to 3 different portfolios at once. Optimize portfolio allocations with 7 optimization strategies.	Limited explanation on analytical tools available. Hence, the platform is only useful to very technically experienced users.
Sharesight	<u>Free Tier</u> >> 10 holdings >> 1 portfolio <u>Starter</u> \$15/month \$135/year >> 20 holdings >> 1 portfolio <u>Investor</u> \$24/month \$216/year >> Unlimited holdings >> 2 portfolios <u>Expert</u> \$31/month \$279/year >> Unlimited holdings >>5 portfolios	X	√ Only for Investor and Expert plan subscribers.	X	X	Partners with leading brokers, accountants, and data providers. Support 150+ brokers, with easy import of trades from 36 international brokers. Advanced reporting options including for tax purposes.	Primarily for tracking. Hence, the lack of analytical information, news and tools for optimising or backtesting of portfolios and strategies.
Yahoo Finance	<u>Free Tier</u> >> Basic tracking of stock holding <u>Yahoo Finance Plus</u> \$34.99/month \$349.99/year >> Advanced technical analysis features for the chart, advanced portfolio analytics, fair value analysis for stocks, third party stock researches	√	√ Only for Yahoo Finance Plus users	X	√ For Yahoo Finance Plus users	Brokerage linking feature is available, with ability to make trades within Yahoo Finance including cryptocurrencies. Access to research reports for advanced traders doing their due diligence and investment ideas. Fair value analysis for stock, calculated according to the Peter Lynch valuation method. Best suited for retail traders whose strategy blends fundamental and technical trading, or prefer simple easy-to-understand platforms.	None of the features are ground-breaking, and many are available for free elsewhere. Brokerage linking feature available in the US only.

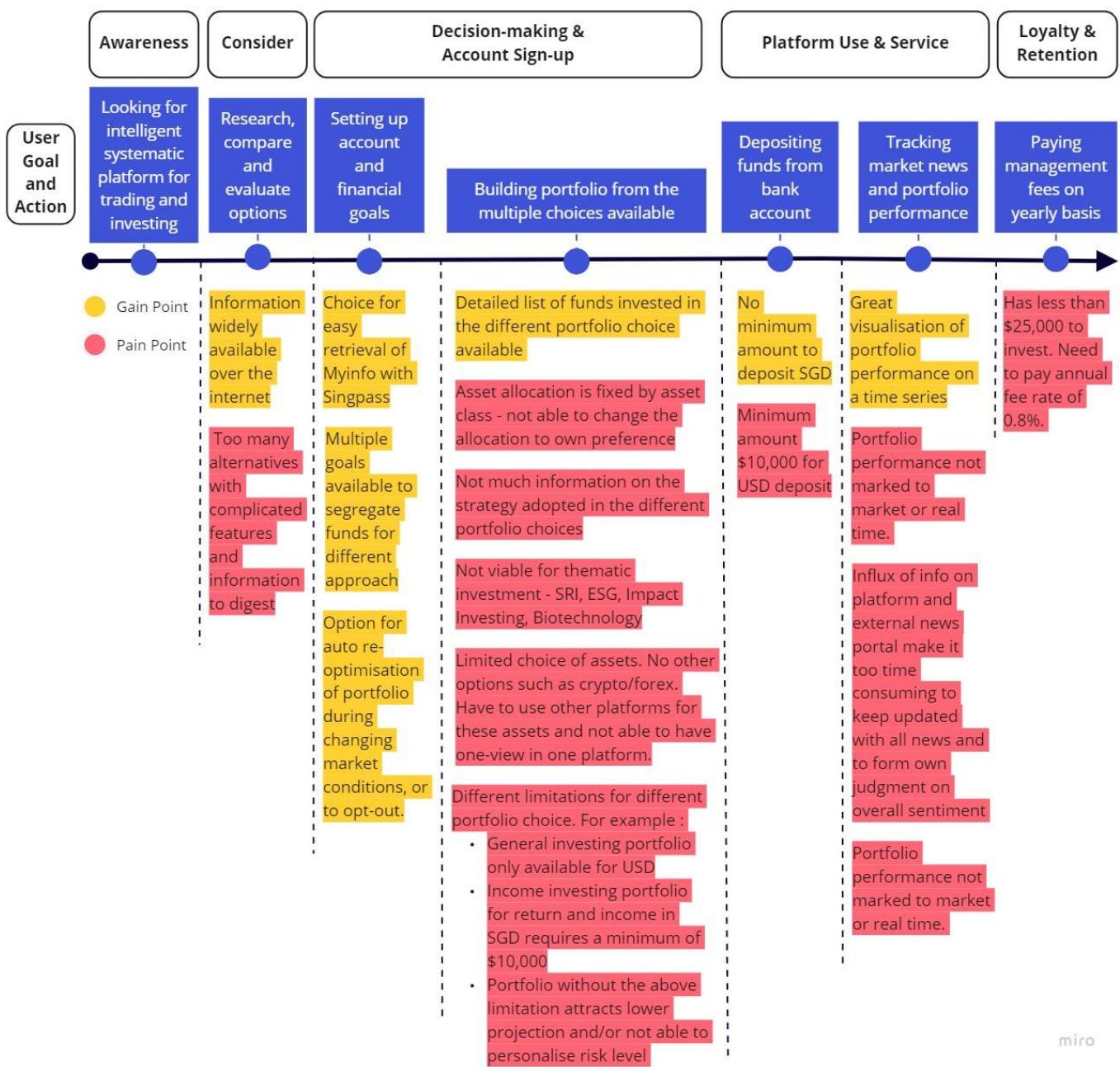
Understanding User Persona and the Journey

With trading and investment being a personal journey for most retail investors, there is no one-size-fits-all solution as every investor has varying financial knowledge and preference. In order to understand the different target groups better, a customer journey is detailed out for people who are looking for an intelligent system for trading and investing, as well as for people who are looking for a robust analytic platform for portfolio monitoring and management purposes.

I. Insightful and intelligent system for trading and investing

With robo-advisors often being the go-to choice for their systematic and algorithmic approach in investment, the customer journey below is based on a user who is experimenting with the platform capability of an established robo-advisor in Singapore that has a relatively more active investment approach compared to other players in the market.





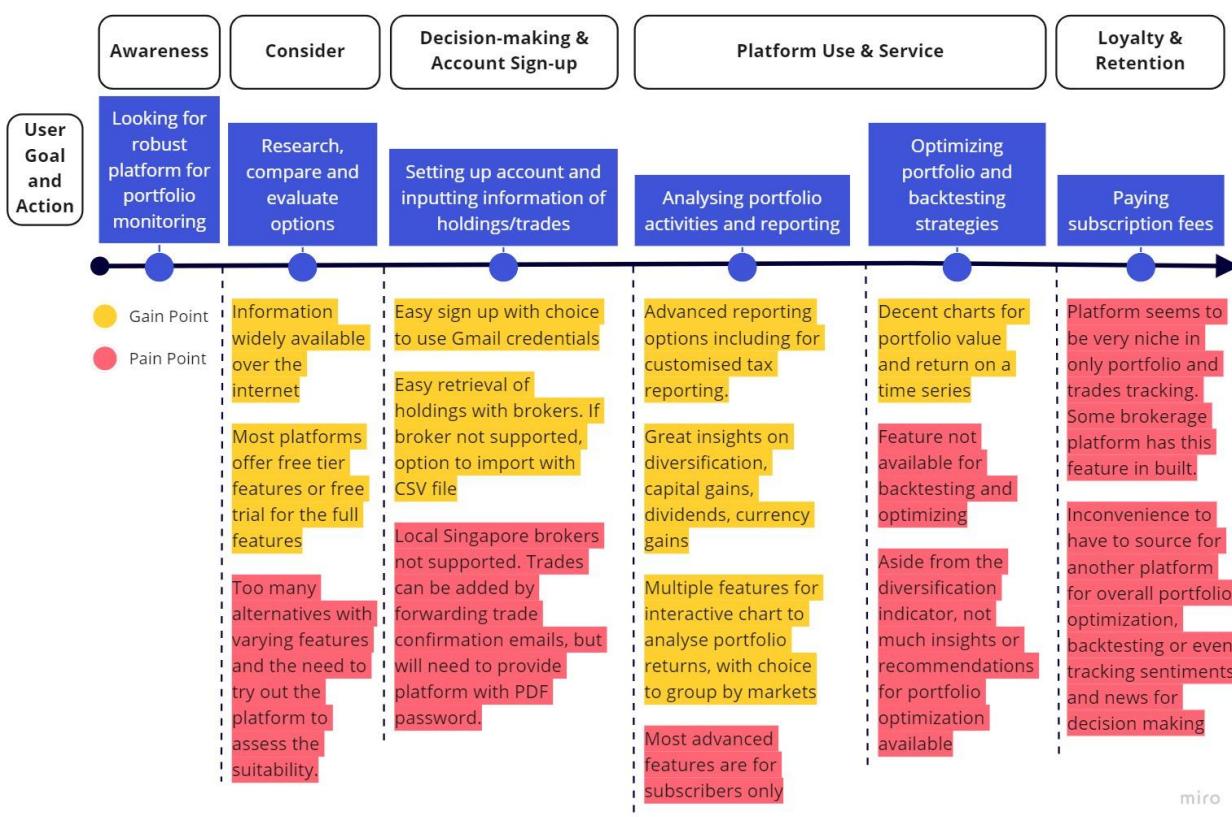
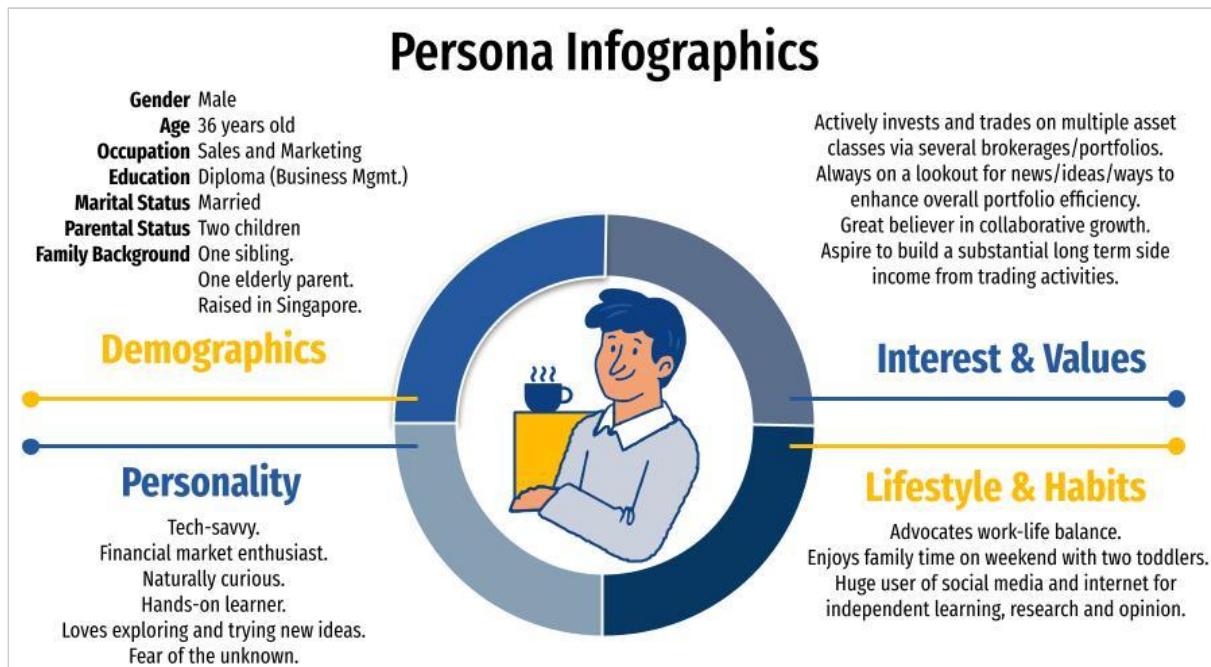
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II. Aggregated portfolio monitoring and analytics for optimization

Our survey revealed that 50% of the respondents find it tedious or inconvenient to manage their portfolio with multiple brokers and platforms that they use concurrently for different reasons and platform features - with 81% currently not using any portfolio or strategy planning tools or services.

There are many great options available for traders and investors to aggregate, manage and assess their financial portfolios. However not many provide robust algorithms, data and tools to empower users to analyze all their portfolios in a single platform and to engineer informed decisions with insights. The

customer journey below is based on a user who is experimenting with the platform capability of an online portfolio tracker prized for its award-winning performance and tax reporting.



Design and Prototype : Proposed Solution

Phase 1 – Design

I. Lean Canvas

Using the Design Thinking methodology, our team brainstormed and came up with the lean canvas to identify the product specification and requirements.

Problem	Solution	Unique Value Proposition	Unfair Advantage	Customer Segments
Lack of knowledge. Cost. Time needed due to complication.	Provide recommendation on the strategy and % equity allocation based on the risk tolerance (Low, High, Mix) using MPT and visualised through efficient frontier	Focus on family offices who have wealth management requirements - as a tool for them to use.	Proprietary algo-trading which can be tailored to risk profile	Anyone who is eligible to invest in Singapore
Not building a diversified portfolio	Backtest results on individual strategies with details on performance by time/instruments type/country benchmarked against index return	User-friendly interface to infuse another way of trading through smart Algorithms to help users in making better investment decisions that suit needs.	Multi products - equity, ETF, forex, bond which allow better diversification of risk and reward unlike others which focus on etf and fixed income from reputable financial institutions.	Customers with sufficient investment knowledge/experience and wish to actively manage their strategies and portfolios and to explore algorithms to aid in their trading/investment activities
Investing in areas where the investor has some knowledge of, and are looking for platforms to support their trading choices. (too many instruments/unfamiliar with different instruments)	Main page showcasing the 'actual results' based on the selected recommendation	Provides recommendation for strategies and portfolio weightages for all users but also allows better-informed/educated users more flexibility in trading choices not only in trading instruments but also strategies.	Multi channel broker you can select broker to use from our side (something to plan in future to plug in broker and test)	Family offices - algo-strategies, trading and reporting in one package
How to put money to work, especially in the current environment of low interest rates	Key Metrics		Channels	
Difficulty in aggregating, monitoring and managing investment portfolios in asset classes such as stocks and FX independently, without having to rely on "external" fund managers such as through brokerages/ unit trusts.	> Revenue per client > Client retention rate > New account sign-ups > Alpha > Sharpe Ratio > Average monthly/yearly profit % of top trading strategies > % deviation of future projection against current performance ? > Daily Active Users > Monthly Active Users	Forward looking solutions-taking into consideration alternative indicators using reddit/news sentiment using NLP. Able to compare across multiple strategies and see the advantages & disadvantages of each relative to one another.	> Advertisement through social media or influencers > SG fintech associations > Workshops/talks > Govt approved for CPFIS/SRS > Introduce free trials (e.g. one month) to graduating students of universities, poly.	Customers who are interested in a more actively managed portfolio compared to passive investing.
People want personalised investment based on their risk and return appetite with ability to see future projection profit				miro
Complicated features and hard to understand information for users when it comes to investing their money				

Cost Structure	Data Requirement	Skillsets Needed	Revenue Streams
<ul style="list-style-type: none"> > Customer acquisition cost onto new platform > Cost of hosting the platform on cloud > Staffing cost > Fees for data feed > Compliance and security > VPN cost to run the algo-program > Backtest platform 	<p><u>Data provider</u></p> <ul style="list-style-type: none"> > Live data with low latency to ensure best pricing can be booked > Provide historical adjusted and non-adjusted price with a long time horizon of 10 years backtest > Data for the records can be from end of day to minute - Transparent exchange data fees (cost) <p><u>Data</u></p> <ul style="list-style-type: none"> > Projected return vs current return sentiment vs current return > To see how accurate is the sentiment indicators scripts 	<ul style="list-style-type: none"> > Technical [programmer, API, UI/ UX, Python, ML/AI, NLP, PowerBI, QuantConnect, software update(security?)] > Programmer (Javascript, NodeJS) (optional but required for custom visuals in PowerBI) > Technical Writer (Documentation) > Finance and investment knowledged people (explain the type of instruments and how it works) > Technical Analysis (with indicators) > Legal & compliance - knowledge on the each country's regulation and understanding on KYC/ AML requirements (lower priority) > Marketing Manager 	<ul style="list-style-type: none"> > Subscription/ management fees > Trading Capital Gains = profit sharing > Advertisement (from financial education providers such as Udemy) > Data mining (monetisation of customer data) > Cash back from liquid provider brokers > Dividends > Arbitrage > Marketing targeted financial products and services to customers through strategic partnerships (eg. mortgages, credit cards, or insurance policies) > Interest earned on cash balances ("cash management"). Since many robo-advised accounts only have a small allocation to cash in their portfolios, this can only become a significant source of income if there are many users.

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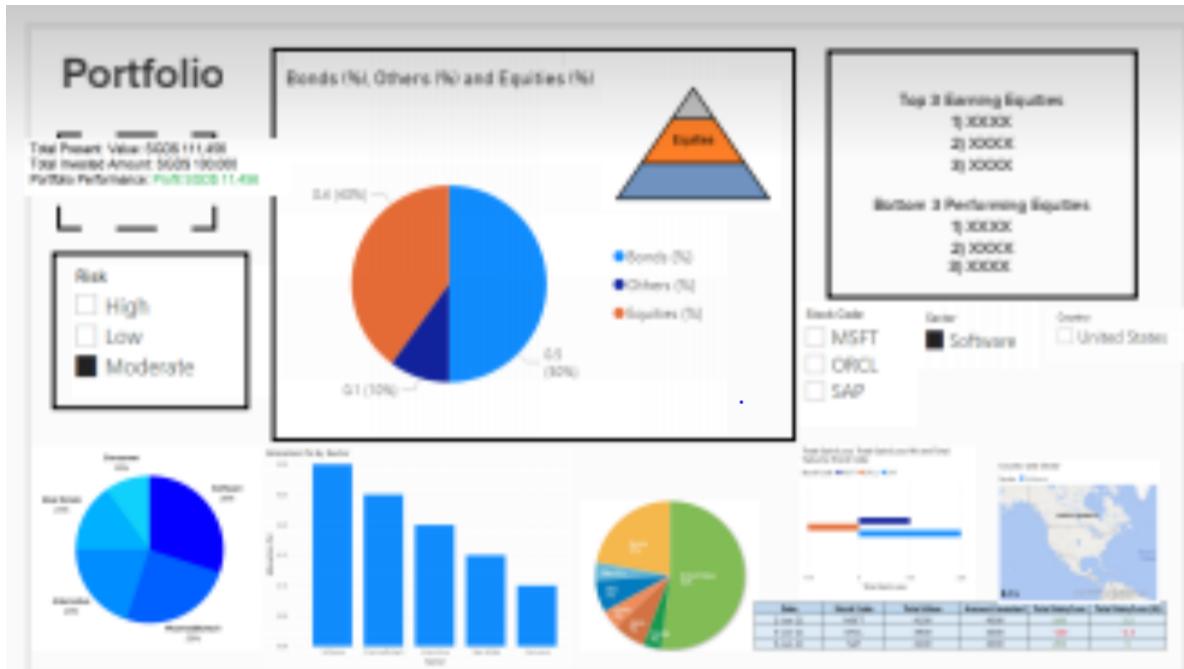
II. Mural

After obtaining the dashboard specification and requirement, we prepared a mock up Power BI dashboard with Mural to get a sense of the initial dashboard with the following main tabs.

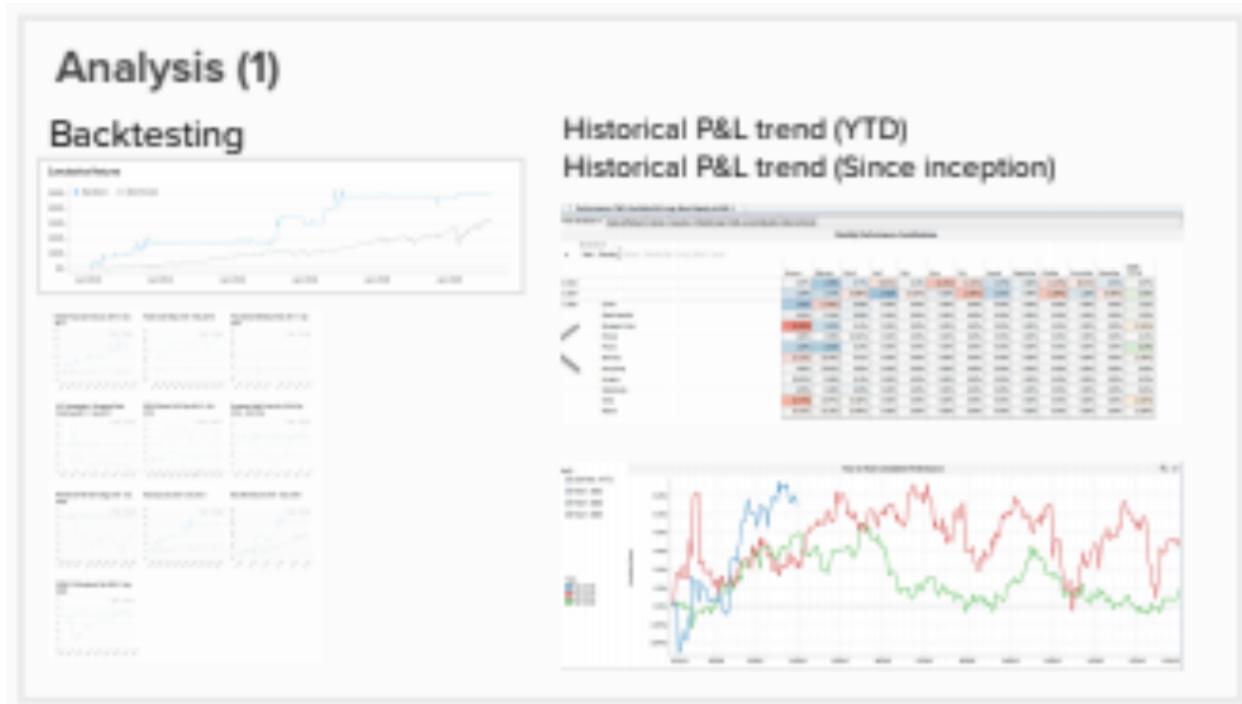
→ Portfolio - to show the current portfolio managed with detailed breakdown on realized and unrealized positions as well as latest news.



- Strategy - portfolio recommendation based on risk appetite and also the portfolio mixture by instrument type and country

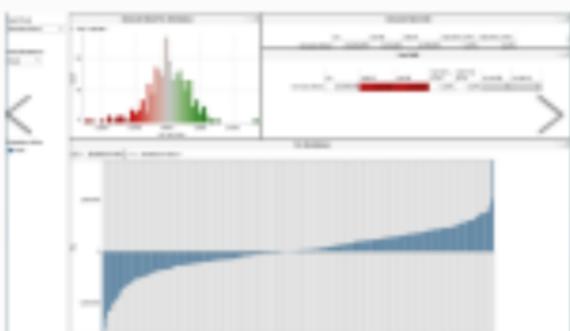


- Analysis - Analysis of the backtesting strategies as a portfolio



Analysis (2)

Value at Risk (VaR)

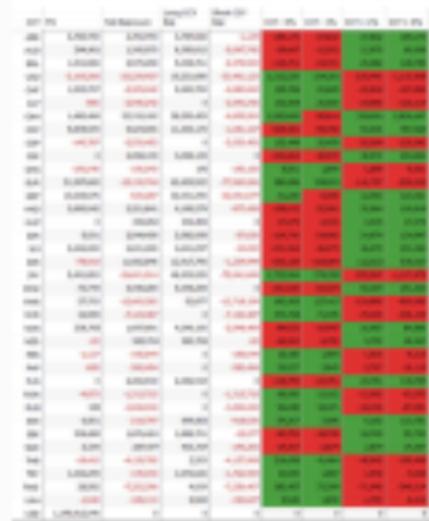


Concentration Risk

Top Concentrations			
Top Instruments		Top Allocated Exposure	
Security	Type	Value	% Alloc
SGX USD/JPY	Future	\$1,000	1.00%
SGX USD/CNY	Future	\$1,000	1.00%
SGX USD/EUR	Future	\$1,000	1.00%
SGX USD/CHF	Future	\$1,000	1.00%
SGX USD/GBP	Future	\$1,000	1.00%
SGX USD/AUD	Future	\$1,000	1.00%
SGX USD/CAD	Future	\$1,000	1.00%
SGX USD/NZD	Future	\$1,000	1.00%
SGX USD/HKD	Future	\$1,000	1.00%
SGX USD/VND	Future	\$1,000	1.00%
SGX USD/SGD	Future	\$1,000	1.00%
SGX USD/INR	Future	\$1,000	1.00%
SGX USD/IDR	Future	\$1,000	1.00%
SGX USD/RUB	Future	\$1,000	1.00%
SGX USD/CNY	Future	\$1,000	1.00%
Top Portfolio Concentrations			
Asset Type	Market	Value	% Alloc
Credit Derivatives	SGX	\$1,000	1.00%
Stocks (Equities)	SGX	\$1,000	1.00%
Corporate Bonds	SGX	\$1,000	1.00%
Government Bonds	SGX	\$1,000	1.00%
Commodities	SGX	\$1,000	1.00%
Currency Exposure			
Currency	Long	Short	
USD/CNY	\$1,000	\$1,000	
Geographic Exposure			
Region	Market	Value	% Alloc
North America	SGX	\$1,000	1.00%
Asia Pacific (Excl. Japan)	SGX	\$1,000	1.00%
Europe (Excl. UK)	SGX	\$1,000	1.00%
UK	SGX	\$1,000	1.00%
Emerging Markets	SGX	\$1,000	1.00%
Latin America	SGX	\$1,000	1.00%
Other	SGX	\$1,000	1.00%
Sector Exposure			
Sector	Market	Value	% Alloc
Financials	SGX	\$1,000	1.00%
Consumer Staples	SGX	\$1,000	1.00%
Consumer Discretionary	SGX	\$1,000	1.00%
Healthcare	SGX	\$1,000	1.00%
Technology	SGX	\$1,000	1.00%
Energy	SGX	\$1,000	1.00%
Utilities	SGX	\$1,000	1.00%
Telecommunications	SGX	\$1,000	1.00%
Industrial Goods	SGX	\$1,000	1.00%
Real Estate	SGX	\$1,000	1.00%
Materials	SGX	\$1,000	1.00%

Analysis (3)

FX Net Open Position



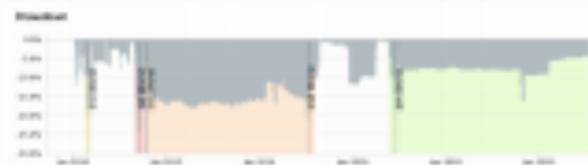
Beta = 1.1

Alpha = 0.10

Standard Deviation = 0.12

Sharpe Ratio = 0.9

Drawdown



→ Analyst - Analyst recommendation on selected stocks

Analyst

Historical price chart of instrument

Related news

Analyst recommendations

Recommendation Trends >

Month	Strong Buy	Buy	Hold	Underperform	Sell
Mar	10	20	20	10	5
Feb	10	20	20	10	5
Jan	10	20	20	10	5
Dec	10	20	20	10	5

→ Macro-Sentiment - Overview on the sentiments

Macro-Sentiment

VIX Chart

Bond Yield Curves

BTC Chart

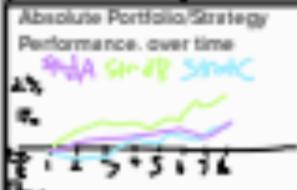
Euro\$ Chart

COT Futures/
Options Data

Key Interest
Rate Trends

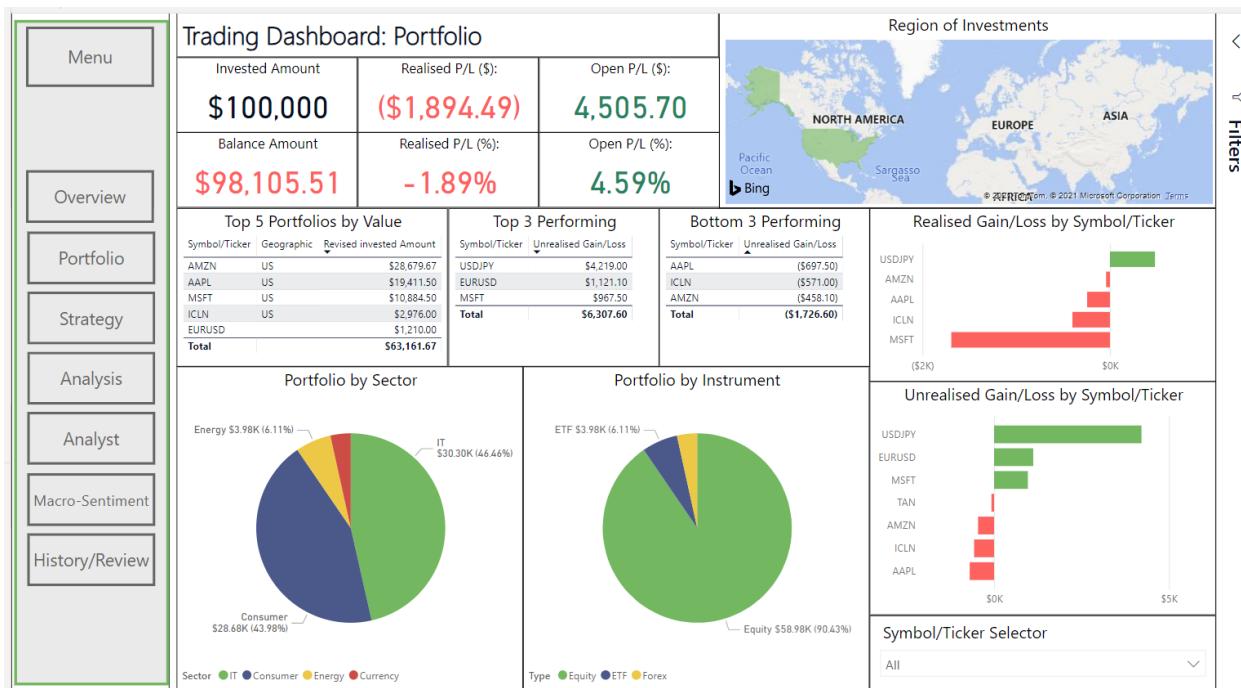
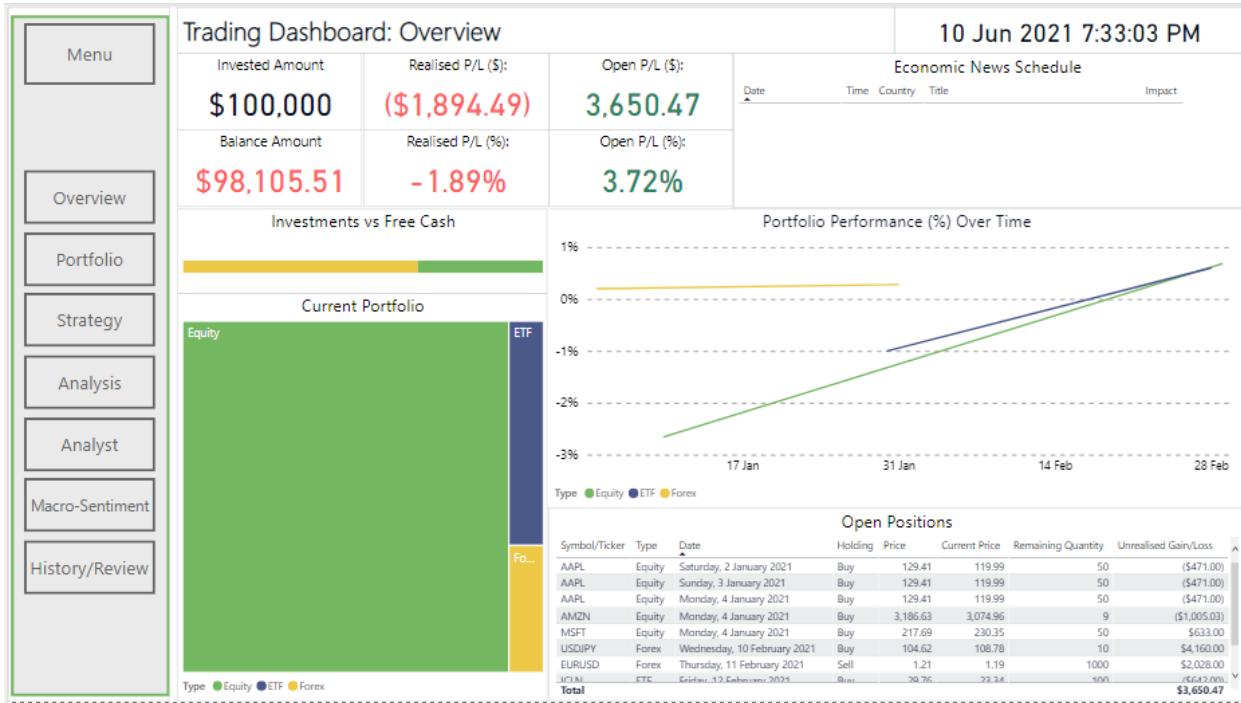
→ History/Review - Review on the back tested strategies

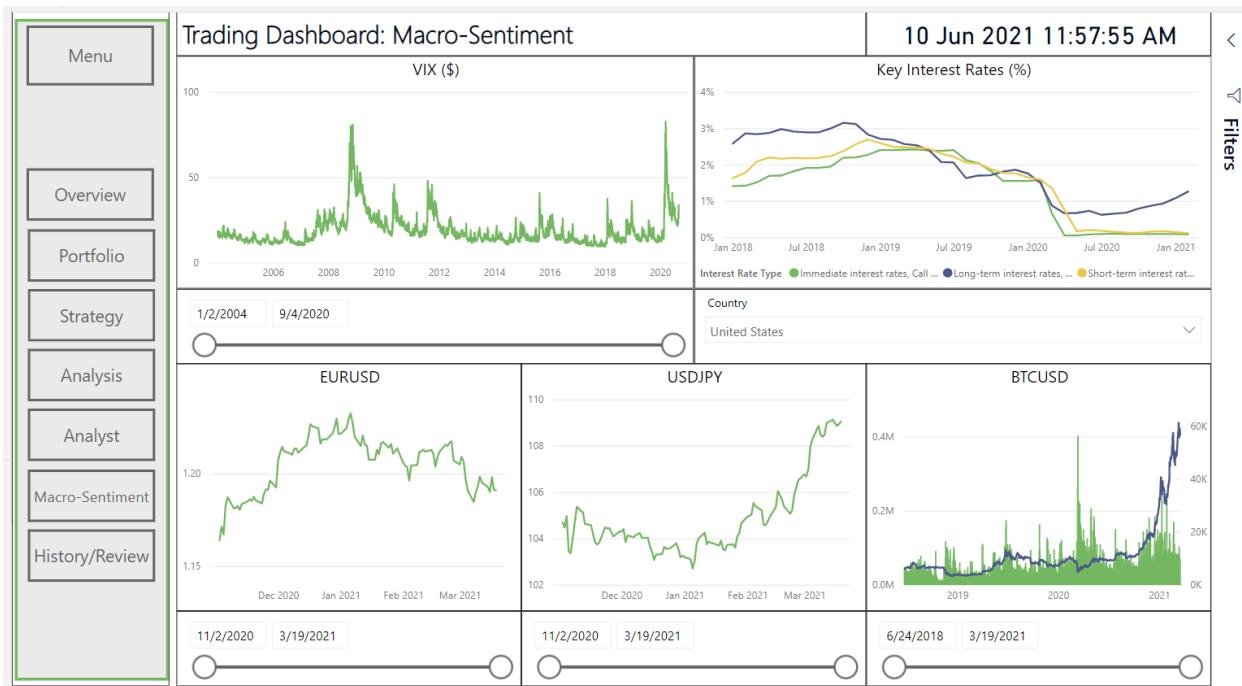
History/ Review

Strategy Review	Strategy A Performance & Review						
	Invested Amount:	Realized P/L (abs):	Open P/L (abs):	Beta = 11 Alpha = 0.10 Standard Deviation = 0.12 Sharpe Ratio = 0.9			
Strat. A	\$20,000	\$1,000	\$100				
Strat. B.	\$21,000	5.0%	0.5%				
Strat. C.	Absolute Portfolio/Strategy Performance over time  						
etc..							
	Close	Current Market Entry/Exit	Open/Long/Short				
	EUR USD	Long	Fxex: xxx				
	EUR USD	Short	Fxex: yy				
	EUR USD	Short	Fxex: zz				
	EUR USD	Long	Fxex: vv				

III. Power BI

Using the Mural's dashboard, we have built the first mockup dashboard in Power BI as a start for the following tabs except for Strategy, Analysis, Analyst and History/Review tabs.





Documentation on the data source, dictionary and dashboard building are fully documented in the [Phase 1 Documentation](#).

Phase 2 – Develop/Test with QuantConnect

Multiple strategies using sentiment analysis, technical analysis, and fundamental analysis, were developed for decision making and predictions for investing in multiple equities in financial markets (see Table 2). To develop smart trading algorithms, various parameters were optimised and a period of 20 years of historical data (see Table 1) were used for backtesting in QuantConnect. The Modern Portfolio Theory (MPT) framework was also adopted to achieve optimal performance in our strategies and to maximise returns for our traders or investors.

Timeframe	Start Date	End Date
Frame 1	2016, 1, 1	2020, 12, 31
Frame 2	2011, 1, 1	2015, 12, 31
Frame 3	2006, 1, 1	2010, 12, 31
Frame 4	2001, 1, 1	2005, 12, 31

Table 1: Time frame for backtesting

Strategies	Asset Class	Predictions for Investing	Indicators
Pre-Holiday Effect		Fundamental analysis	Calendar - holiday
Fama French 5 Factors	Equities	Fundamental analysis, Weighted fundamental ratio	FA weighted ratio
Carry Trade		Fundamental analysis	High & low interest rates
Moving Average Crossover		Technical analysis	Simple Moving Average (MA5/MA40)
Risk Premia	Forex	Technical analysis	Signals from skewness indicator (mean reversion)
Momentum Strategy		Technical analysis	Momentum based on low frequency component of Forex market and Moving Average
MPT ETF Allocation (SPY, QQQ, TLT, GLD)		MPT based on daily return to determine % allocation against 4 securities	MPT based on daily return
Asset Class Momentum with ETFs Strategy		Technical analysis	Momentum - absolute change for past 6 months
Market/Bond Rotation Strategy (Macro conditions)	Multi Asset (equities, bonds, commodities)	Fundamental analysis	Macro finance indicator
Subreddit Sentiment		Sentiment analysis (social)	Vader Sentiment Score
News Sentiment with NLP & VADER via Tiingo API		Sentiment analysis (news)	Vader Sentiment Score

Table 2: List of strategies and types of indicators used as predictions for investing in financial markets

I. Pre-Holiday Effect Strategy

The Pre-Holiday Effect strategy considers the calendar or specifically the holiday effect anomaly in the equities market. It would seem that there is a possibility for stock markets to rise on the days prior to a holiday. Market returns before holidays are often more than the average returns during normal trading days, by up to more than 10 times.

Fundamentally, it is sensible to comprehend that there are higher chances for market participants to have a ‘feel good’ effect prior to a holiday, resulting in positive market movement. This positive sentiment could form a strategy for profitable trades.

Fundamental Reason

The basis for this strategy is behavioural. Perhaps short-sellers close their short positions prior to holidays (short sellers are vulnerable to higher losses, ie: unlimited downside as prices can go up on an unlimited basis, compared to going long where downside risk is deemed to be limited to the bought price of the security). On a behavioural basis, the feel good factor around holidays may perhaps result in optimism which corresponds to positive movements in prices.

Investigation on the impact of number of entry days prior to holiday

The SPDR S&P 500 exchange traded fund (ETF) was chosen for this strategy as it is the largest ETF in the world. The value of one share of the ETF is worth approximately 1/10 of the cash S&P 500's current level.

To understand what a good number of days would be to enter the transaction prior to a holiday, an investigation was done where different days were compared. For this investigation, a period of 1, 2, 3 and 4 days prior to the holiday was chosen. It was deemed that any period longer than that would dilute the impact of the pre-holiday factor with other influences coming into effect such as earning results, macro factors, technical indicators, etc.

Observations and Results

The tables below summarise the results obtained using QuantConnect by varying the days prior to the holidays between one to four days:

Time Frame	Sharpe Ratio	Average Win	Average Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	0.32	0.63%	-0.61%	67%	1.14%	4.60%	5.82%	0.011	-0.009	0.031
Frame 2	0.187	0.70%	-0.69%	58%	0.46%	3.10%	2.32%	0.004	0.002	0.021
Frame 3	0.282	1.13%	-1.08%	60%	1.19%	4.30%	6.07%	0.011	-0.008	0.037
Frame 4	0.993	1.26%	-0.64%	73%	3.88%	3.20%	20.97%	0.032	-0.001	0.033
Average	0.4455	0.93%	-0.76%	64.50%	1.66%	3.80%	8.79%	0.0145	-0.004	0.0305

Table 1: Pre-Holiday Effect - 1 day

Time Frame	Sharpe Ratio	Average Win	Average Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	0.514	0.69%	-0.75%	66%	2.32%	6.00%	12.15%	0.021	-0.01	0.038
Frame 2	0.143	0.77%	-0.55%	47%	0.48%	5.00%	2.40%	0.004	0.002	0.031
Frame 3	0.27	1.30%	-0.99%	52%	1.88%	7.50%	9.75%	0.019	-0.037	0.065
Frame 4	0.583	1.15%	-1.03%	61%	3.25%	7.10%	17.33%	0.028	-0.007	0.048
Average	0.3775	0.98%	-0.83%	56.50%	1.98%	6.40%	10.41%	0.018	-0.013	0.0455

Table 2: Pre-Holiday Effect - 2 days ¹⁹

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	0.283	0.85%	-0.83%	56%	1.52%	11.70%	7.86%	0.015	-0.013	0.048
Frame 2	0.739	0.96%	-0.78%	65%	3.85%	4.70%	20.79%	0.034	-0.01	0.044
Frame 3	0.129	1.96%	-1.45%	46%	0.86%	11.60%	4.39%	0.012	-0.037	0.079
Frame 4	0.357	1.33%	-1.44%	60%	2.23%	13.70%	11.66%	0.02	-0.01	0.056
Average	0.377	1.28%	-1.13%	56.75%	2.12%	10.43%	11.18%	0.02025	-0.0175	0.0568

Table 3: Pre-Holiday Effect - 3 days

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	0.218	0.98%	-1.42%	64%	1.30%	15.00%	6.66%	0.014	-0.01	0.056
Frame 2	0.695	1.17%	-1.00%	63%	4.04%	7.90%	21.89%	0.035	-0.008	0.049
Frame 3	0.068	1.75%	-1.32%	44%	0.26%	19.20%	1.31%	0.008	-0.036	0.088
Frame 4	0.192	1.65%	-1.77%	56%	1.22%	18.40%	6.24%	0.012	-0.002	0.062
Average	0.29325	1.39%	-1.38%	56.75%	1.70%	15.13%	9.03%	0.01725	-0.014	0.0638

Table 4: Pre-Holiday Effect - 4 days

¹⁹ Detail of backtest result for 2 Days Pre-Holiday : [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 4](#)

It is observed that:

- Over the four periods investigated, on an overall average basis, all four scenarios of varying days showed a higher absolute magnitude of Average Win % compared to Average Loss %. Further, the Win Rate % is higher than the Loss Rate % across all four scenarios (ie: Average Win Rate > 50%, while Average Loss Rate < 50%).
- In terms of compounded annual returns, using a strategy of initiating the transaction 2 and 3 days prior to a holiday is superior compared to 1 and 4 days. Compounding annual returns ranged from 0.48% to 3.25% for 2 days and 0.86% to 3.85% for 3 days. Meanwhile, the simple average over the four distinct periods were at 1.98% and 2.12% respectively for 2 and 3 days, higher compared to 1.66% and 1.70% for 1 and 4 days respectively.
- In terms of drawdowns, initiating the transaction 1 and 2 days prior to a holiday is superior compared to 3 and 4 days. Drawdown ranged between 3.10% and 4.60% for 1 day and 5.00% and 7.50% for 2 days. Meanwhile, the simple average over the four distinct periods were at 3.80% and 6.40% respectively for 1 and 2 days, lower compared to 10.43% and 15.13% for 3 and 4 days respectively.
- In terms of measuring risk, and using Annual Standard Deviation to represent this, it was found that initiating the transaction 1 and 2 days prior to a holiday is superior compared to 3 and 4 days. Annual Standard Deviation ranged between 2.1% and 3.7% for 1 day and 3.1% and 6.5% for 2 days. Meanwhile, the simple average over the four distinct periods were at 3.05% and 4.55% respectively for 1 and 2 days, lower compared to 5.68% and 6.38% for 3 and 4 days respectively.

Recommendation, Conclusion and Future Work

Based on the results that Average Win % is higher compared to Average Loss % and that the Win Rate % is higher than the Loss Rate % across all four scenarios, this affirms that the pre-holiday effect results in positive outcomes. Thus, is it viable for this strategy to be considered in the portfolio.

In terms of determining the number of entry days prior to holiday, using 2 days showed a better upper half result for both returns (ie: compounded annual returns) and risk (ie: lower Annual Standard Deviation and also Drawdowns). Thus, for this strategy of pre-holiday effect, 2 days prior to the holiday is chosen.

It is envisaged that the effect of the pre-holiday market would be applicable to other equity markets as well. This is a possible future work consideration to investigate its performance to other stock market indices starting with deep and liquid markets such as Japan, Germany, United Kingdom and Hong Kong.

II. Fama French 5 Factors for Equity

Introduction & Method

The Fama French five-factor model²⁰, improved from the Fama French three-factor model, is one of the most classic models (Fama and French, 2015).

The Fama French five-factor model was proposed in 2014 and is adapted from the Fama French three-factor model (Fama and French, 2015). It builds upon the dividend discount model which states that the value of stocks today is dependent upon future dividends. Fama and French add two factors; investment and profitability, to the dividend discount model to better capture the relationship between risk and return. The model is as follows:

$$R = \alpha + \beta_m MKT + \beta_s SMB + \beta_h HML + \beta_r RMW + \beta_c CMA$$

Where:

- o MKT is the excess return of the market. It is the return on the value-weighted market portfolio.
- o SMB is the return on a diversified portfolio of small-cap stocks minus the return on a diversified portfolio of big-cap stocks.
- o HML is the difference between the returns on diversified portfolios of stocks with high and low Book-to-Market ratios.
- o RMW is the difference between the returns on diversified portfolios of stocks with robust (high and steady) and weak (low) profitability.
- o CMA is the difference between the returns on diversified portfolios of the stocks of low and high investment firms, which we call conservative and aggressive. Here, low/high investment means reinvestment ratio is low/high.

QuantConnect Strategy Thought Process²¹

- 1) List stocks which have fundamental data and share price above certain prices.
- 2) Rank the list of stocks based on the following fundamental data which has been weighted:
 - a. Book Value
 - b. Total Equity,
 - c. Operating profit margin
 - d. Return on total asset growth

²⁰ From the Article: [A five-factor asset pricing model](#)

²¹ From QuantConnect's strategy library : [Fama French Five Factors](#)

- e. Total asset growth
- 3) Buy those stocks which are the highest rank while sell the stocks with the lowest rank based on the number of predetermined quantities for buy and sell.
- 4) Liquidate stocks which hit stop loss before the monthly rebalancing.
- 5) During monthly rebalancing:
- a. Liquidate those shares which hit the profit target of % of share price
 - b. Liquidate those shares which are not in the buy/sell rank
 - c. Buy or sell new stocks which are in the highest and lowest rank
 - d. Keep holding existing stocks which are in the latest buy/sell rank that has yet to hit profit/loss

Optimization of Main Parameters

To avoid overfitting, only Frame 1 is used for optimization via individual parameter optimization and thereafter optimized all the selected parameters.

Parameters	Default	Individually Optimized	Optimized as a Whole
Data Normalization²²	None (factoring splits and dividends)	Raw (No modifications to the asset price at all. Dividends are paid in cash; splits are applied directly to your portfolio quantity)	TotalReturn (Return of the investment adding the dividend sum to the initial asset price)
Coarse Selection	200 and share price > \$5	>\$20	>\$25
Weight of Fundamental Data	BookValuePerShare – 1 TotalEquity – 1 OperationMargin – 1 ROE – 1 Total Asset Growth – 1	BookValuePerShare – 1 TotalEquity – 1 OperationMargin – 1 ROE – 1 Total Asset Growth – 2	BookValuePerShare – 2 TotalEquity – 1 OperationMargin – 1 ROE – 1 Total Asset Growth – 2
Position	Buy – 5 Sell – 5 (100/10 = 10% total equity)	Buy – 4 Sell – 3 (100/7 = 14% of total equity per-trade)	Buy – 4 Sell – 2 (100/6 = 16% of total equity per-trade)
Stop Loss	10% (10*10% = 1, 1% risk per trade)	15% (14*15% = 2.1, 2.1% risk per trade)	16% (16*16% = 2.56% risk per trade)

²² More information on [data normalization](#) in QuantConnect

Take Profit	None (profit is made when its not part of the monthly selection)	25%	25%
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Results

A. Default Parameters

PSR	0.232%
Unrealized	-\$3,880.37
Fees	-\$1,252.15
Net Profit	-\$7,719.92
Return	-12.85%
Equity	\$87,152.57
Holdings	\$48,258.06
Volume	\$8,001,113.56
Capacity	\$1.1M

B. Optimized Parameters

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1²³	0.886	1.85%	-1.12%	48%	17.56%	19.30%	124.71%	0.167	-0.039	0.182
Frame 2²⁴	0.467	1.40%	-1.16%	51%	7.58%	25.90%	44.14%	0.08	-0.037	0.163
Frame 3²⁵	0.581	1.55%	-1.08%	48%	9.26%	35.50%	55.74%	0.089	-0.033	0.152
Frame 4²⁶	0.269	1.37%	-1.24%	50.00%	3.90%	39.90%	21.07%	0.049	0.047	0.185
11 years²⁷	1.025	1.65%	-1.14%	53.00%	19.38%	28.70%	602.61%	0.176	-0.019	0.169

²³ Details of backtest result for [Frame 1](#)

²⁴ Details of backtest result for [Frame 2](#)

²⁵ Details of backtest result for [Frame 3](#)

²⁶ Details of backtest result for [Frame 4](#)

²⁷ Details of backtest result for [11 years](#)

C. Comparison against SPY Results

Time Frame	Start Date	End Date	Fully Optimised Returns	SPY Benchmark
Frame 1	2016, 1, 1	2020, 12, 31	124.71%	99%
Frame 2	2011, 1, 1	2015, 12, 31	44.14%	74.2%
Frame 3	2006, 1, 1	2010, 12, 31	55.74%	10.26%
Frame 4	2001, 1, 1	2005, 12, 31	21.07%	1.1%
11 years	2010, 1, 1	2020, 12, 31	602.61%	271.99%

Conclusion

Based on all the results from the backtest, this strategy return is higher than SPY benchmark. Note of caution as this is based on the historical results which may not be representative of the future performance.

References for Individual Parameter Optimization

A. Data Normalization

* Using Raw (price as raw, dividends paid as cash and quantity adjusted on splits)

PSR	0.219%
Unrealized	-\$3,881.12
Fees	-\$1,247.12
Net Profit	-\$6,123.20
Return	-13.27%
Equity	\$86,725.14
Holdings	\$48,279.52
Volume	\$7,961,061.36
Capacity	\$1.1M

B. Coarse Selection – optimal results is using share price > \$20

* Using top 200 which has the following share prices

Share Price	Returns
\$10 (default)	-7.25%
\$15	1.23%
\$20	12.23%

\$25	9.34%
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C. 5 Factor Weightage – optimal results is using scenario 5

Fundamentals	Return	BookValue	TotalEquity	OpMargin	ROE	TAgrowth
Default	-12.85%	1	1	1	1	1
Scenario 1	-19.10%	2	1	1	1	1
Scenario 2	-18.77%	1	2	1	1	1
Scenario 3	-17.60%	1	1	2	1	1
Scenario 4	-25.89%	1	1	1	2	1
Scenario 5	-0.31%	1	1	1	1	2
Scenario 6	-3.43%	1	1	2	1	2
Scenario 7	-21.87%	2	1	2	1	1

D. Positioning – optimal results is using scenario 3

No. of Holdings	Buy	Sell	Return
Default	5	5	-12.85%
Scenario 1	6	4	-15.50%
Scenario 2	5	4	-21.41%
Scenario 3	4	3	-15.28%
Scenario 4	4	4	-25.78%

E. Stop Loss – optimal results is using 15%

Stop Loss	Return
Default – 10%	-12.85%
5%	-11.34%
8%	4.64%
12%	-2.62%
14%	6.8%

15%	7.24%
20%	-9.96%

F. Take Profit – optimal results is using 25%

Take Profit	Return
Default – none	-12.85%
15%	-12.85%
20%	-12.85%
25%	-12.82%
30%	-12.85%
23%	-12.85%

III. Carry Trade Strategy with Currencies (Forex)

Introduction

Carry trade is a common strategy in forex which aims to sell low-interest rate currencies and buy into high-interest rate currencies rather. It seeks to capture the spread between the currency rates. It is as if you borrow money from a country with a low interest rate, in order to invest in another country that offers a higher interest rate.

Concept

Nine currency pairs (available on Quandl) are selected and the custom data are imported using AddData(type, symbol, resolution, timeZone, fillDataForward).

```
from QuantConnect.Python import PythonQuandl

class QuandlRate(PythonQuandl):

    def __init__(self):
        self.ValueColumnName = 'Value'
```

The nine currency pairs are as follow:

- USD/EUR
- USD/ZAR

- USD/AUD
- USD/JPY
- USD/TRY
- USD/INR
- USD/CNY
- USD/MXN
- USD/CAD

The forex symbols are then sorted by the value of interest rate. The algorithm goes *long* on currency pairs with *high interest rate* and *short* on currency pairs with *low interest rate*. This strategy is rebalanced on a monthly basis.

Results and Observations

The backtest results reflected promising win rates for the majority of the four time frames, even with one financial crisis that occurred in one of the years.

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std Dev
Frame 1 ²⁸	0.908	0.12%	-0.01%	84%	7.27%	8.90%	42.08%	-0.052	-0.005	0.057
Frame 2 ²⁹	0.234	-0.09%	-0.08%	52%	1.68%	14.60%	8.53%	0.013	0.006	0.056
Frame 3 ³⁰	0.206	0.13%	-0.10%	69%	2.12%	12.30%	11.09%	0.019	-0.011	0.092
Frame 4 ³¹	0.111	0.05%	0.00%	100.00%	0.47%	9.10%	2.37%	0.004	0.002	0.035

Key observations with regards to the performance of the strategy:

²⁸ Details of backtest result for [Frame 1](#)

²⁹ Details of backtest result for [Frame 2](#)

³⁰ Details of backtest result for [Frame 3](#)

³¹ Details of backtest result for [Frame 4](#)

- In Frame 1, the win rate has improved tremendously from previous 5 years hitting 84% of total 117 trades put through. The average loss is very minimal at 0.01% negative while the win rate has increased to 12% from previous.
- In Frame 2, the win rate is lower but above the 50% cut off percentage. The average win is still higher than the average loss.
- In Frame 3, the average win is still higher than the average loss, and with an above average win rate of 69% in total 105 trades is good by standards.
- In Frame 4, there is a 100% win rate reflected in all the 44 trades in that time frame. Although the average win is minimal, the effectiveness is 100%.

Conclusion

The returns of this carry trade strategy has been consistently good over the years. It is believed that there is a low correlation between the returns of a carry trade strategy with forex and the returns of traditional asset classes such as equities and bonds. In modern portfolio theory, a carry trade strategy is a proven profitable way of diversifying a portfolio. However, investors must pay attention to the correlation of the carry trade strategy with the global financial environment and the exchange rate stability.

IV. Moving Average Crossover, Risk Premia & Momentum Strategy for Forex

Sourcing for correlated currency pairs is a strong tool that you can use to help you understand the markets better and develop high-probability trading strategies. You can also manage risk and diversify trading instruments effectively, especially if you monitor correlation coefficients regularly and always be alerted to news or information on market changes and the shifting of currency relationships.

In QuantConnect, it offers forex trading through two popular brokerages: FXCM and OANDA. QuantConnect hosts 13 currency pairs from April 2007 to present (provided by FXCM³²), and 71 currency pairs from April 2004 to present (provided by OANDA³³). However, it was noted that there may be slightly different prices depending on your choice on brokerages that you are trading on.

Identify Currency Pairs That Are Highly Correlated

The below tables show the correlation of currency pairs that were calculated over a period of one month and one year³⁴.

Currency Pairs	EUR/USD	GBP/USD	USD/CHF	USD/JPY	EUR/JPY	USD/CAD	AUD/USD	EUR/CHF	AUD/NZD	USD/SGD
EUR/USD	1	0.69	-0.95	-0.74	0.36	-0.54	0.89	-0.08	-0.66	-0.61
GBP/USD	0.69	1	-0.56	-0.36	0.46	-0.58	0.88	0.23	-0.75	-0.41

³² List of currency pairs provided by FXCM:

<https://www.quantconnect.com/docs/data-library/forex#Forex-FXCM-Brokerage-Forex-Data>

³³ List of currency pairs provided by OANDA:

<https://www.quantconnect.com/docs/data-library/forex#Forex-OANDA-Brokerage-Forex-Data>

³⁴ Correlation of currency pairs (one month and one year period) retrieved as of 11 April 2021:

<https://za.investing.com/tools/correlation-calculator>

USD/CHF	-0.95	-0.56	1	0.71	-0.33	0.53	-0.83	0.4	0.59	0.64
USD/JPY	-0.74	-0.36	0.71	1	0.36	0.14	-0.6	0.1	0.47	0.16
EUR/JPY	0.36	0.46	-0.33	0.36	1	-0.56	0.4	0.01	-0.27	-0.62
USD/CAD	-0.54	-0.58	0.53	0.14	-0.56	1	-0.68	0.11	0.27	0.43
AUD/USD	0.89	0.88	-0.83	-0.6	0.4	-0.68	1	-0.02	-0.72	-0.47
EUR/CHF	-0.08	0.23	0.4	0.1	0.01	0.11	-0.02	1	-0.07	0.24
AUD/NZD	-0.66	-0.75	0.59	0.47	-0.27	0.27	-0.72	-0.07	1	0.19
USD/SGD	-0.61	-0.41	0.64	0.16	-0.62	0.43	-0.47	0.24	0.19	1

Table 1: Correlation of currency pairs (one-month period)

Examples of strong positive correlations	Examples of strong negative correlations		
EUR/USD and AUD/USD	+0.93	EUR/USD and USD/CHF	-0.96
GBP/USD and AUD/USD	+0.92	GBP/USD and USD/CAD	-0.96
EUR/JPY and AUD/USD	+0.91	EUR/JPY and USD/CAD	-0.92
EUR/JPY and EUR/CHF	+0.92	USD/CAD and AUD/USD	-0.96
USD/CAD and USD/SGD	+0.95	EUR/USD and USD/SGD	-0.96

Table 2: Examples of highly correlated currency pairs (one-year period)

Decide on Currency Pairs

Based on the observation of the correlation coefficients on a monthly and yearly time frames and the popularity of the currency pairs traded in OANDA³⁵, the following six currency pairs had been identified to make a trade.

- EUR/USD
- GBP/USD
- USD/CHF
- AUD/USD
- USD/CAD
- USD/JPY

Manage Risk

³⁵ Popular forex pairs traded in OANDA retrieved as of 11 April 2021: <https://www.oanda.com/sg-en/trading/cfds/forex/>

For currency pairs (with strong positive correlations), separating lengthy and high positions within separate pairs may increase your profits. However, if a wrong forecast had been made, it could also maximise losses.

For currency pairs (with strong negative correlations), possessing lengthy and high positions on both the pairs will cancel each other out since these pairs proceed in opposite directions.

Therefore, most traders usually hold positions on correlated pairs for expansion, while preserving the same general direction (either upwards or downwards) to protect themselves from risk even if a pair proceeds against them. Yet, they benefit from the other pair if it ever happens.

Confirmation of Strategy

There are many indicators in the markets that can be applied to test and confirm your trading strategy. Some of the popular forex trading strategies³⁶ include: Moving Average (MA), Relative Strength Index (RSI), Bollinger Bands, etc. However, indicators are subjective and adding indicators do not necessarily guarantee higher returns. You may test different indicators in QuantConnect to develop your own strategy that works best for you.

The following strategies were explored in this report for forex trading.

A. Moving Average Crossover³⁷

Moving Average Crossover strategy uses 2 Moving Averages: fast MA and slow MA. In this report, MA was applied to some currency pairs that were identified earlier (see section on “Decide on Currency Pairs”) by using a 5 period Simple Moving Average, SMA(5) for the fast MA and a 40 period Simple Moving Average, SMA(40) for the slow MA.

A *bullish* crossover occurs when the fast MA (SMA(5)) crosses *above* the slow MA(SMA(40)), while a *bearish* crossover occurs when the fast MA (SMA(5)) crosses *below* the slow MA(SMA(40)).

The performance of this strategy is sensitive to the choice of currency pairs and other parameters such as the period used for the fast and slow MA, length of historical data used for backtesting, change of resolution (daily, hour, minute, second or tick).

B. Risk Premia³⁸

This strategy enters long-short positions in the forex market based on signals from a skewness indicator. It was suggested that there is a positive linear relationship between the Sharpe ratio of risk premia strategies and their negative skewness.

The implementation of the strategy goes *long* for a forex pair when the skewness indicator is *lower* than a minimum threshold (-0.6) and *short* the pair when the indicator *exceeds* a maximum threshold (0.6).

³⁶ Examples of some recommended forex indicators: <https://www.fxcm.com/markets/insights/c/forex/forex-indicators/>

³⁷ More information on the strategy, Moving Average Crossover: <https://www1.oanda.com/forex-trading/learn/trading-tools-strategies/moving-averages>

³⁸ More information on the strategy, Risk Premia in Forex Markets: <https://www.quantconnect.com/tutorials/strategy-library/risk-premia-in-forex-markets>

The performance of this strategy is sensitive to the choice of currency pairs and other parameters such as adjustment of the thresholds for entering long and short positions (0.6, -0.6), length of historical data used for backtesting.

C. Momentum Strategy³⁹

This trend following strategy exploits short-term momentum in the non-linear trend (low frequency) component of the forex market and uses the MA rule to measure this momentum.

The performance of this strategy is sensitive to the choice of currency pairs and other parameters such as choice of lag parameters in MA rules and length of historical data used for backtesting.

Results and Observations

When using QuantConnect to perform backtesting of historical data, it is recommended to use past 5 years or more for better confirmation of your strategy. However, it was observed that there are some gaps in the results when we run some backtest period in QuantConnect. This was because some of the years/periods were not available⁴⁰ in QuantConnect (i.e. date started for AUDNZD: 02 May 2004, EURUSD: 05 May 2002).

QuantConnect supports Python coding. Therefore, paying attention to the indentation and spacing in the block of codes is important to avoid any indentation error in Python. In one scenario that we had encountered, it only retrieved the result of the last currency pair, despite that there are more currency pairs used for backtesting (due to indentation error).

It was also observed that depending on the choice of currency pairs, having more currency pairs retrieved better results (i.e. higher Sharpe ratio, higher win rate) and returns. Moreover, having more currency pairs also helps to diversify and minimise risk. However, there could be more issues to resolve (i.e. coding error) if many currency pairs were used for backtesting in QuantConnect. Therefore, in this report, six currency pairs were used as an example.

The performances of the strategies are very sensitive to many factors such as the choice of currency pairs, change of parameters, etc. It can be quite time-consuming to conduct many rounds of trials to test different parameters, so as to optimise the performances of these strategies.

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	0.173	0.24%	-0.13%	0%	0.39%	3.80%	2.00%	0.003	0.006	0.019
Frame 2	-0.049	0.30%	-0.20%	38%	-0.16%	4.90%	-1.00%	0	-0.007	0.021
Frame 3	0.516	0.40%	-0.24%	45%	1.85%	4.80%	10.00%	0.015	-0.002	0.03

³⁹ More information on the strategy, Momentum Strategy Based on the Low Frequency Component of Forex Market: <https://www.quantconnect.com/tutorials/strategy-library/the-momentum-strategy-based-on-the-low-frequency-component-of-forex-market>

⁴⁰ Refer to QuantConnect Data Explorer for available Forex and its display range: <https://www.quantconnect.com/data/tree/forex>

Frame 4	-0.113	0.34%	-0.22%	39%	-0.29%	5.10%	-1.00%	-0.002	0.003	0.02
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Table 5: Performance of selected currency pairs (2001 to 2020) using MA Crossover⁴¹

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	-0.135	0.44%	-0.57%	0%	-1.15%	19.10%	-6.00%	-0.01	0.017	0.057
Frame 2	-0.117	0.54%	-0.51%	47%	-1.06%	15.40%	-5.00%	-0.014	0.061	0.058
Frame 3	-0.657	0.70%	-0.86%	50%	-7.39%	31.90%	-32.00%	-0.058	0.04	0.086
Frame 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 6: Performance of selected currency pairs (2001 to 2020) using Risk Premia⁴²

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1	0.121	4.02%	-4.39%	58%	0.78%	20.70%	4.00%	0.007	0.026	0.059
Frame 2	-0.214	0.00%	-3.54%	0%	-2.72%	23.70%	-13.00%	-0.016	0.022	0.075
Frame 3	-0.288	5.41%	-4.30%	29%	-4.13%	28.90%	-19.00%	-0.025	-0.008	0.087
Frame 4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 7: Performance of selected currency pairs (2001 - 2020) using Momentum Strategy (EURUSD)⁴³

Recommendation and Conclusion

Currency correlations is a powerful tool that you can consider developing high-probability trading strategies. You will also be guided in risk management, if you diversify currency pairs effectively and monitor their correlation coefficients regularly (i.e., daily, weekly, monthly, or yearly timeframes).

Moreover, you must be aware that currency correlations are shifting continuously over time mainly due to economic and political factors.

Therefore, it is imperative to stay updated on news or information on market changes that affect the shifting of currency relationships. It is also recommended to check for currency correlations that are long-term to obtain deeper insights; and apply some indicators to test which trading strategy works best for you.

The methods of trading forex that are outlined within this report are just ideas. You should trade forex in a way that suits your own individual style, needs, goals and risk appetite.

⁴¹ Details of backtest results for MA Crossover: [Frame 1](#), [Frame 2](#), [Frame 3](#) and [Frame 4](#)

⁴² Details of backtest results for Risk Premia [Frame 1](#), [Frame 2](#) and [Frame 3](#)

⁴³ Details of backtest results for Momentum Strategy [Frame 1](#), [Frame 2](#) and [Frame 3](#)

V. MPT ETF Allocation Strategy (SPY, QQQ, TLT, GLD)

Introduction & Methodology

This is a Classical Asset Allocation (CAA) with mean-variance optimization (MVO) obtained from QuantConnect⁴⁴. It is based on the work of Keller et al. (2015) in Momentum and Markowitz: A Golden Combination⁴⁵.

Using broad range of asset compositions as proposed by Keller and Butler (2014)⁴⁶ with a short lookback period (maximum of 12 months), compute the optimal allocation on the Efficient Frontier (EF) with a given target volatility (TV) of 10% for offensive model and 5% for defensive model. We imposed limits (max weights) on all risky assets to enforce greater ex-post diversification. E.g. with a universal cap of 25% or 50% for all assets, the portfolio should contain at least resp. four or two assets (i.e. with non-zero weights). No short-sale constraint (long-only) positions and portfolio is rebalanced on a monthly basis.

QuantConnect Strategy Thought Process

- 1) List ETFs by type and highest capitalization (to ensure liquidity and have diversification)
- 2) Each month we estimate the optimal mix of asset weights based on the prior 252 trading days (computed based on optimization of either returns given target volatility or Sharpe Ratio) and use that mix for next month (monthly rebalancing). To enforce greater diversification, we impose limits with maximum weights of 25% for each security.
- 3) As this is a long hold strategy with monthly rebalancing, stop loss and take profit are not required.

⁴⁴ QuantConnect's strategy library :[Classical Asset Allocation](#)

⁴⁵ From the Article: [Momentum and Markowitz: A Golden Combination](#).

⁴⁶ From the Article: [A Century of Generalized Momentum; From Flexible Asset Allocations \(FAA\) to Elastic Asset Allocation \(EAA\)](#).

Optimization of Main Parameters

Backtest for individual parameter optimization is only done on Frame 1 to avoid overfitting of strategy. It is thereafter optimized for all time frames with the selected parameters. No changes are made to the rolling period and to the security limit to ensure consistency with the model and diversification.

Parameters	Default	Individually Optimized	Optimized as a Whole
Data Normalization ⁴⁷	None (factoring splits and dividends)	TotalReturn (Return of the investment adding the dividend sum to the initial asset price)	TotalReturn (Return of the investment adding the dividend sum to the initial asset price)
ETF Universe	8 selected securities	Those + SPY with > % returns	4 securities including SPY
Rolling Period	252	252	252
Volatility	5%	5%	5%
Security Cap	25%	25%	25%
Stop Loss	None	None	None

Results

A. Default Parameters

PSR	23.997%
Unrealized	\$20,692.65
Fees	-\$228.67
Net Profit	\$54,205.01
Return	74.68%
Equity	\$174,681.11
Holdings	\$174,403.83
Volume	\$2,075,929.16
Capacity	\$69K

B. Optimized Parameters

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.

⁴⁷ More information on [data normalization](#) in QuantConnect

					Return					
Frame 1 ⁴⁸	1.345	1.82%	0.00%	98%	22.75%	27.70%	179.02%	0.213	-0.118	0.146
Frame 2 ⁴⁹	0.707	1.24%	-0.47%	70%	8.88%	11.20%	53.08%	0.084	-0.38	0.112
Frame 3 ⁵⁰	0.216	1.48%	-7.52%	84%	2.76%	50.00%	14.59%	0.046	-0.067	0.2
Frame 4 ⁵¹	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11 years ⁵²	1.208	1.85%	-0.63%	74.00%	17.77%	28.00%	505.19%	0.163	-0.092	0.127

C. Comparison against SPY Results

Time Frame	Start Date	End Date	Fully Optimised Returns	SPY Benchmark
Frame 1	2016, 1, 1	2020, 12, 31	179.02%	99%
Frame 2	2011, 1, 1	2015, 12, 31	53%	74.20%
Frame 3	2006, 1, 1	2010, 12, 31	15%	10.26%
Frame 4	2001, 1, 1	2005, 12 ,31	NA	1.10%
11 years	2010, 1, 1	2020, 12 ,31	505.19%	271.99%

Conclusion

Based on the overall optimized backtest results, this strategy outperforms SPY on Frame 1, 3 and 11 years but underperforms against SPY in Frame 2. Since there is a limit on the holdings with max of 25% per security at only 5% volatility, both returns and risks have been capped.

Note of caution that this is based on historical results and may not be representative of future performances.

⁴⁸ Details of backtest result for [Frame 1](#)

⁴⁹ Details of backtest result for [Frame 2](#)

⁵⁰ Details of backtest result for [Frame 3](#)

⁵¹ Backtest result for Frame 4 returns error and not possible for GLD and TLT as both instruments are only available in 2004/2005.

⁵² Details for backtest result for [11 years](#)

References for Individual Parameter Optimization

A. Data Normalization

* Using Raw (price as raw, dividends paid as cash and quantity adjusted on splits)

PSR	26.968%
Unrealized	\$18,925.98
Fees	-\$229.10
Net Profit	\$56,943.23
Return	75.65%
Equity	\$175,652.92
Holdings	\$216,972.21
Volume	\$2,487,355.63
Capacity	\$4.5K

B. ETF Universe

* Building a portfolio of SPY and combination of other ETFs based on the market capitalization and the compounding annual returns of Time Frame 1 for each ETFs

❖ Equity ETF – Selecting ETFs with compounding annual returns above 130%

Symbol	ETF Name	Index	Inception Date (M/D/YYYY)	Market Cap (\$)	Returns / SPY (%)
SPY	SPDR S&P 500 ETF	S&P 500 Index	01/22/1993	361,860,096,000	99
IVV	iShares Core S&P 500 Index Fund ETF	S&P 500 Index	05/15/2000	279,363,590,000	103.75
VTI	Vanguard Total Stock Market ETF	CRSP US Total Market Index	05/24/2001	236,066,197,032	139.96
VOO	Vanguard S&P 500 ETF	S&P 500 Index	09/07/2010	217,653,670,032	125.95
QQQ	Invesco QQQ ETF	NASDAQ-100 Index	03/10/1999	161,001,391,000	131.27
MLPY	Morgan Stanley Cushing MLP High Income Index ETN	Cushing MLP High Income Index	03/16/2011	154,244,599,680	-1.4
VEA	Vanguard FTSE Developed Markets ETF	FTSE Developed All Cap ex US Index	07/20/2007	97,192,786,058	50.79
IEFA	iShares Core MSCI EAFE ETF	MSCI EAFE Investable Market Index	10/18/2012	92,340,072,000	47.95
VWO	Vanguard FTSE Emerging Markets ETF	FTSE Emerging Markets All Cap China A Inclusion Index	03/04/2005	80,206,883,520	105.34
IEMG	iShares Core MSCI Emerging Markets ETF	MSCI Emerging Markets Investable Market Index	10/18/2012	80,056,716,000	86.49
VTV	Vanguard Value ETF	CRSP US Large Cap Value Index	01/26/2004	76,075,924,580	61.29
VUG	Vanguard Growth ETF	CRSP US Large Cap Growth Index	01/26/2004	73,569,994,501	100.23
IJR	iShares Core S&P Small-Cap ETF	S&P Smallcap 600 Index	05/22/2000	69,924,645,000	105.19
IWM	iShares Russell 2000 ETF	Russell 2000 Index	05/22/2000	68,339,376,000	105.26
IWF	iShares Russell 1000 Growth ETF	Russell 1000 Growth Index	05/22/2000	66,992,964,000	105.09
IJH	iShares Core S&P Mid-Cap ETF	S&P MidCap 400 Index	05/22/2000	65,025,811,500	85.16

VIG	Vanguard Dividend Appreciation ETF	NASDAQ US Dividend Achievers Select Index	04/21/2006	58,502,232,973	119.13
ITOT	iShares Core S&P Total U.S. Stock Market ETF	S&P Total Market Index	01/20/2004	38,613,020,000	104.45
USMV	iShares MSCI USA Minimum Volatility ETF	MSCI USA Minimum Volatility (USD) Index	10/18/2011	28,941,522,000	132.84
IXUS	iShares Core MSCI Total International Stock ETF	MSCI ACWI ex USA IMI Index	10/18/2012	28,223,604,000	55.54
SDY	SPDR S&P Dividend ETF	S&P High Yield Dividend Aristocrats Index	11/8/2005	21,104,978,000	82.85
SCHP	Schwab U.S. TIPS ETF	Bloomberg Barclays U.S. Treasury Inflation Protected Securities (TIPS) Index	08/05/2010	17,215,016,000	103.11

❖ Bond ETF - Selecting ETFs with compounding annual returns above 130%

Symbol	ETF Name	Index	Inception Date (M/D/YYYY)	Market Cap (\$)	Returns / SPY (%)
AGG	iShares Core U.S. Aggregate Bond ETF	Bloomberg Barclays US Aggregate Bond Index	09/22/2003	86,879,205,000	111.01
BND	Vanguard Total Bond Market ETF	Bloomberg Barclays U.S. Aggregate Float Adjusted Index	4/3/2007	71,459,839,983	108.17
VCIT	Vanguard Intermediate-Term Corporate Bond ETF	Bloomberg Barclays U.S. 5-10 Year Corporate Bond Index	11/19/2009	43,034,655,694	99.57
LQD	iShares iBoxx \$ Investment Grade Corporate Bond ETF	Markit iBoxx \$ Liquid Investment Grade Index	07/22/2002	41,239,303,000	130.17
BNDX	Vanguard Total International Bond ETF	Bloomberg Barclays Global Aggregate ex-USD Float Adjusted RIC Capped Index Hedged	05/31/2013	39,770,642,029	92.88
VCSH	Vanguard Short-Term Corporate Bond ETF	Bloomberg Barclays U.S. 1-5 Year Corporate Bond Index	11/19/2009	38,059,861,688	92.71
VYM	Vanguard High Dividend Yield ETF	FTSE High Dividend Yield Index	11/10/2006	36,742,440,963	52.98
BSV	Vanguard Short-Term Bond ETF	Barclays Capital U.S. 1-5 Year Government/Credit Float Adjusted Index	4/3/2007	32,071,877,483	110.92
TIP	iShares TIPS Bond Fund ETF	Barclays U.S. Treasury Inflation Protected Securities (TIPS) Index (Series-L)	12/04/2003	26,993,591,000	124.19
MBB	iShares MBS Bonds ETF	Bloomberg Barclays US Mortgage Backed Securities Index	03/13/2007	25,781,268,000	82.1
IGSB	iShares Short-Term Corporate Bond ETF	ICE BofAML 1-5 Year US Corporate Index	1/5/2007	25,333,672,000	93.12
HYG	iShares iBoxx High Yield Corporate Bond ETF	Markit iBoxx \$ Liquid High Yield Index	4/4/2007	21,542,178,000	80.12
SHY	Barclays 1-3 Year Treasury Bond ETF	ICE U.S. Treasury 1-3 Year Index	07/22/2002	19,468,882,000	92.29
SHV	iShares Short Treasury Bond ETF	ICE U.S. Treasury Short Bond Index	1/5/2007	14,940,952,000	64.06

IEF	Ishares 7-10 Year Treasury Bond ETF	ICE U.S. Treasury 7-10 Year Index	07/22/2002	13,784,488,000	113.28
TLT	iShares 20+ Year Treasury Bond ETF	ICE U.S. Treasury 20+ Year Index	07/22/2002	12,259,020,000	131.87

❖ Commodity ETFs - Selecting ETFs with compounding annual returns above 100%

Symbol	ETF Name	Index	Inception Date (M/D/YYYY)	Market Cap (\$)	Returns / SPY (%)
GLD	SPDR Gold Shares ETF	NA - Physically owns a precious metal	11/18/2004	58,565,690,000	124.93
IAU	iShares COMEX Gold Trust ETF	NA - Physically owns a precious metal	01/21/2005	28,556,403,000	119.86
SLV	iShares Silver Trust ETF	NA - Physically owns a precious metal	04/21/2006	15,259,296,000	90.7

❖ Portfolio Mix (Default Volatility at 5%).

It is noted that portfolios with *more* than 2 asset classes of ETFs (Equity, Bonds and/or Commodity) tend to give higher returns compared to portfolios with only 2 asset classes of ETFs. The top three portfolios with highest returns are further tested against different volatility levels.

Portfolio Mix	Equity ETFs	Bond ETFs	Commodity ETFs	Returns
Original	SPY, EFA, EEM, JPXN, VGT	TLT, IEF	-	75.65%
1	SPY, VTI, QQQ, USMV	LQD, TLT,	GLD, IAU	136.57%
2	SPY, VTI, QQQ	LQD, TLT	GLD, IAU	206.90%
3	SPY, VTI, USMV, QQQ	LQD, TLT	-	112.67%
4	SPY, QQQ	LQD, TLT	GLD	145.33%
5	SPY, QQQ	LQD	GLD, IAU	129.11%
6	SPY, VTI	TLT	GLD	134.61%
7	SPY, USMV	TLT	GLD	92.98%
8	SPY, QQQ	TLT	GLD	179.02%
9	SPY, QQQ	LQD	GLD	177.81%
10	SPY, QQQ	TLT	IAU	137.47%

❖ Volatility Level

It is noted that higher volatility does not result in higher return. Based on the selected portfolio mixes, the top 3 highest returns are from the ones with the lowest volatility (5%).

Portfolio Mix	Equity ETFs	Bond ETFs	Commodity ETFs	Returns for 5% volatility	Returns for 7% volatility	Returns for 10% volatility	Returns for 15% volatility
2	SPY, VTI, QQQ	LQD, TLT	GLD, IAU	206.90%	122.53%	154.36%	188.23%

8	SPY, QQQ	TLT	GLD	179.02%	139.84%	165.46%	176.20%
9	SPY, QQQ	LQD	GLD	177.81%	160.86%	159.09%	144.35%

❖ Comparison at Multiple Time Frames (Default Volatility at 5%).

It is noted that portfolio mix 8 is the most suitable over the long term with 505% return.

Time Frame	Portfolio Mix 2 Returns ⁵³	Portfolio Mix 8 Returns ⁵⁴	Portfolio Mix 9 Returns ⁵⁵
Frame 1	206.9%	179.02%	177.81%
Frame 2	13.36%	53.08%	50.88%
Frame 3	21.74%	14.59%	19.61%
Frame 4	NA	NA	NA
11 years	330.07%	505.19%	435.19%

⁵³ Details for backtest result for Portfolio Mix 2 - [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 11 years](#)

⁵⁴ Details for backtest result for Portfolio Mix 8 - [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 11 years](#)

⁵⁵ Details for backtest result for Portfolio Mix 9 - [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 11 years](#)

VI. Asset Class Momentum with ETFs Strategy

Introduction and Methodology

The strategy is adapted from Mebane Faber's work⁵⁶. It is based on a rotational momentum system that compares the performance of different asset classes and picks only the best-performing assets from the investment universe into the portfolio. It finds its entry points using the momentum effect⁵⁷.

The investment universe consists of 15 ETFs from 5 different asset classes. The invested portfolio consists of n ETFs that have the strongest n-month momentum. Momentum is defined as the rate of change in price movements on a daily basis and measured using the momentum indicator MOM(symbol, period) from QuantConnect's LEAN. Each ETF is weighted equally with the portfolio being held for one month period and then rebalanced every month.

The strategy is backtested for the below parameters.

1) Momentum Period

This initial strategy looks back on the 12-month momentum to determine an entry. With the rise of technology in recent years, trading has become easily accessible with even lower brokerage fees. News and information that influences the market movement are easily disseminated with speed compared to years back. Hence, the strategy will be tested on shorter lookback periods of 3-month momentum and 6-month momentum to explore the possibility or effect of capturing an impending momentum earlier.

2) Portfolio Allocation

This initial strategy constructs a portfolio of only 3 ETFs. To explore the benefit of diversifying with lesser weightage in each ETFs, the strategy will be subsequently tested on a portfolio allocation with more ETFs (i.e., 5 ETFs) after establishing the optimum momentum period.

Identifying Asset Classes

- Equities
 - Bonds
 - REITS
 - Foreign Stocks
 - Commodities
-

⁵⁶ From the Article : [A Quantitative Approach to Tactical Asset Allocation](#). The Journal of Wealth Management, Spring 2007.

⁵⁷ More information on Asset Class Momentum strategy in [Quantpedia](#) and [QuantConnect](#)

Deciding on Representative ETFs

The below 15 ETFs are chosen based on the market capitalization of the ETFs.

- Equities (US S&P 500) : SPY, VOO, IVV
- Bonds (Total Bond Market): AGG, BND, BNDX
- REITS : VNQ (North America), VNQI (Global excluding US), REET (Global)
- Foreign Stocks (Foreign Large Cap) : VEA IEFA EFA
- Commodities (Broad Diversified) : DBC, PDBC, GSG

Backtest Periods

Time Frame	Start Date	End Date
Frame 1	2016, 1, 1	2020, 12, 31
Frame 2	2011, 1, 1	2015, 12, 31
Frame 3	2006, 1, 1	2010, 12, 31
Frame 4	2001, 1, 1	2005, 12 ,31
20 years	2001, 1, 1	2020, 12 ,31

Results

A. Momentum Period Parameter (Based on portfolio of 3 ETFs)

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding Annual Return	Drawdown	Alpha	Beta	Annual Std. Dev.	Compounding Annual Return (SPY Benchmark)
Frame 1	0.583	2.52%	-2.29%	62%	12.60%	43.3%	0.162	-0.222	0.225	14.74%
Frame 2	0.715	5.94%	-1.87%	71%	11.54%	20.2%	0.111	-0.046	0.148	11.74%
Frame 3	0.159	4.61%	-8.19%	58%	1.31%	52.7%	0.034	-0.032	0.209	1.97%
Frame 4	0.991	47.08%	-1.73%	25%	12.47%	12.2%	0.108	-0.009	0.109	0.22%
20 years	0.534	6.94%	-3.38%	63%	10.00%	52.5%	0.108	-0.081	0.190	N/A

Table 1: Portfolio of 3 ETFs for 12-month momentum period - Default ⁵⁸

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compounding	Drawdo wn	Alpha	Beta	Annual Std. Dev.	Compou nding

⁵⁸ Details of backtest result for portfolio of 3 ETFs 12-month momentum: [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 4](#), [20 years](#)

					Annual Return					Annual Return (SPY Benchmark)
Frame 1	0.667	1.37%	-1.94%	83%	9.27%	23.6%	0.086	-0.014	0.126	14.74%
Frame 2	0.639	2.44%	-1.86%	67%	9.27%	26.2%	0.086	-0.003	0.134	11.74%
Frame 3	0.791	4.65%	-3.28%	60%	14.58%	29.7%	0.136	-0.033	0.171	1.97%
Frame 4	0.576	4.35%	-1.48%	40%	6.37%	17.1%	0.058	-0.023	0.100	0.22%
20 years	0.683	3.12%	-2.23%	66%	10.46%	31.0%	0.098	-0.021	0.141	N/A

Table 2: Portfolio of 3 ETFs for 3-month momentum period ⁵⁹

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compoun ding Annual Return	Drawdow n	Alpha	Beta	Annual Std. Dev.	Compoun ding Annual Return (SPY Benchmark)
Frame 1	0.639	3.88%	-2.45%	73%	12.32%	37.7%	0.141	-0.153	0.188	14.74%
Frame 2	0.854	4.29%	-1.72%	80%	12.61%	18.5%	0.113	-0.005	0.131	11.74%
Frame 3	0.873	30.95%	-1.34%	74%	20.86%	40.7%	0.203	-0.068	0.229	1.97%
Frame 4	0.847	8.04%	-1.81%	62%	11.40%	15.8%	0.101	-0.017	0.119	0.22%
20 years	0.769	5.21%	-1.97%	74%	14.48%	40.7%	0.140	-0.067	0.176	N/A

Table 3: Portfolio of 3 ETFs with 6-month momentum period ⁶⁰

B. Portfolio Allocation Parameter (Based on 6-month momentum period)

Time Frame	Sharpe Ratio	Avg Win	Avg Loss	Win Rate	Compoun ding Annual Return	Drawdow n	Alpha	Beta	Annual Std. Dev.	Compoun ding Annual Return (SPY Benchmark)
Frame 1	0.741	2.74%	-1.73%	64%	14.20%	38.2%	0.	-0.114	0.181	14.74%
Frame 2	0.704	5.99%	-1.91%	50%	12.61%	22.0%	0.12	-0.011	0.168	11.74%
Frame 3	0.66	4.13%	-1.98%	55%	12.93%	34.1%	0.128	-0.054	0.19	1.97%
Frame 4	0.821	4.40%	-1.17%	58%	5.68%	7.5%	0.049	-0.008	0.059	0.22%
20 years	0.627	3.84%	-1.81%	58%	10.13%	38.30%	0.099	-0.049	0.152	10.13%

Table 4: Portfolio of 5 ETFs for 6-month momentum period ⁶¹

⁵⁹ Details of backtest result for portfolio of 3 ETFs 3-month momentum: [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 4](#), [20 years](#)

⁶⁰ Details of backtest result for portfolio of 3 ETFs 6-month momentum : [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 4](#), [20 years](#)

⁶¹ Details of backtest result for portfolio of 6 ETFs 6-month momentum : [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 4](#), [20 years](#)

Observations and Conclusion

Based on the backtest results, it is observed that the initial strategy to construct a 3 ETFs portfolio with 12-month momentum period performs at a wide varying degree for the different time frames with significant drawdowns. While the portfolio with 3-month momentum period has a lower volatility and drawdown consistently over the 4 time frames, it is compensated with mediocre win-loss rate and a lacklustre average wins compared to the average losses. The portfolio with 6-month momentum period appears to be more well-rounded particularly with a decent average wins compared to its average losses and has a slightly more consistent win-loss rate over the different time frames.

Time Frame 3 is of a particular interest considering the 2008 market crash happened during that period and it would be a great test on the performance of the strategy during market crashes. Among all the different momentum periods backtested, it is well observed that a shorter momentum period allows a better capture of the movements in the market and to act on it at a better speed compared to a 12-month momentum period. The 6-month momentum period returns the most favourable result despite the increase in volatility at Time Frame 3.

The backtest result of diversifying and increasing the portfolio allocation from 3 ETFs to 5 ETFs with the momentum period held constant at 6-month does not seem to yield a significantly better result. Hence, the parameter is not further explored.

It should also be noted that all the ETFs have different inception dates and might not be present at the earlier time frames. For better understanding and objectivity, the details of the ETFs that are present at the different time frames are as follows.

Time Frame	Symbol	ETF Name	Asset Class	Inception Year
Frame 1	SPY	SPDR S&P 500 ETF	S&P 500 Index	1993
	IVV	iShares Core S&P 500 Index Fund ETF	S&P 500 Index	2000
	EFA	iShares MSCI EAFE ETF	Foreign Large Cap	2001
	BND	Vanguard Total Bond Market Index Fund ETF	Total Bond Market	2003
	VNQ	Vanguard Real Estate Index Fund ETF	REIT - North America	2004
Frame 2	GSG	iShares S&P Commodity-Indexed GSCI	Commodity - Broad Diversified	2006

	AGG	iShares Core US Aggregate Bond ETF	Total Bond Market	2007
	VEA	Vanguard Developed Markets Index Fund ETF	Foreign Large Cap	2007
	DBC	PowerShares DB Com Indx Trckng Fund	Commodity - Broad Diversified	2007
	VOO	Vanguard 500 Index Fund ETF	S&P 500 Index	2010
	VNQI	Vanguard Global ex-US Real Estate Index Fd ETF	REIT - Excl. America	2010
Frame 3	IEFA	iShares Core MSCI EAFE ETF	Foreign Large Cap	2012
	BNDX	Vanguard Total International Bond Index Fund ETF	Total Bond Market	2013
	REET	iShares Global REIT ETF	REIT - Global	2014
	PDBC	Invesco Optimum Yld Dvsfd Cmd Str No K-1 ETF	Commodity - Broad Diversified	2014

Generally, an ETF is a great instrument for a portfolio to gain exposure in different asset classes with great liquidity while limiting the unsystematic risk that is industry-specific or company-specific. The rotational momentum system has shown a decent compounding annual return in comparison to the SPY benchmark in a consistent manner over the different time frames.

Nevertheless, since the backtests are performed on historical data, more forward-looking factors are recommended to be taken into consideration. This is especially so at the current time with the rise of multiple alternative investments that are gaining momentum and have great growth potential in the future. Depending on factors such as individual trading and investing preference, risk appetite, time horizon, etc., the suitability of this strategy varies and the strategy should be tweaked accordingly.

VII. Market/Bond Rotation Strategy (Macro Conditions)

Intuitively, it might be possible to generate excess returns via cleverly timed entries and exits in and out of the equity market. This algo may be a first step toward developing a strategy that derives optimal moves in and out of the market on the basis of early indicators of equity market downturns.

Introduction & Thesis

Resources and industrial products are early in the value chain and market value drops in corresponding firms are early indicators of growth worries that ultimately affect other sectors and the broader market.

Equity market value growth benefits substantially from cheap debt, such that increases in bond yields (i.e., drops in bond prices) should be an early indicator of a slowdown in growth. The general benchmark for the board market to be SPY ETF (SPDR S&P 500 trust), thus, the selected alternative investments should have low/ negative correlation coefficient to SPY in order to benefit from the slowdown in growth.

Based on the theory of business cycle (Yield Curve and Credit/Debt Cycle)^{[62][63]}, it will be prudent to get out of the equity market and rotate capital into the bonds, commodities and inverse etf to capitalise and hedge during bear market conditions.

Tracking Market Environment : Sources

- **Metals:** The DBB ETF (Invesco DB Base Metals Fund) provides the signal. DBB tracks the prices of three key industrial metals:aluminum, copper and zinc.
- **Natural Resources:** The IGE ETF (iShares North American Natural Resources) seeks to track the investment results of an index composed of North American equities in the natural resources sector.
- **Cost of Debt:**
 1. The SHY ETF (iShares 1-3 Year Treasury Bond) provides the signal. SHY tracks short-term US Treasury debt (1-3 years).
 2. The TLT ETF (iShares 20+ Year Treasury Bond ETF) seeks to track the investment results of an index composed of U.S. Treasury bonds with remaining maturities greater than twenty years.
- **USD:** The UUP ETF (Invesco DB US Dollar Index Bullish Fund) seeks to track changes, whether positive or negative, in the level of the Deutsche Bank Long USD Currency Portfolio Index - Excess ReturnTM (DB Long USD Currency Portfolio Index ER or Index) plus the interest income from the Fund's holdings of primarily US Treasury securities and money market income less the Fund's expenses.

⁶² From the Report: "[Predicting U.S. Recessions: Financial Variables as Leading Indicators](#)"

⁶³ From the Article: Why Are Recessions So Hard to Predict? Random Shocks and Business Cycles. Economic Insights 4, no. 1 (2019): 1-8.

- **Silver:** The SLV ETF (iShares Silver Trust) seeks to reflect generally the performance of the price of silver.
- **Gold:** The GLD ETF (SPDR Gold Trust) tracks the gold spot price, less expenses and liabilities, using gold bars held in London vaults.
- **Disambiguate GPLD/SLVA pair via inflation expectations:** The RINF ETF (ProShares Inflation Expectations) tracks an index with long exposure to US TIPS and short exposure to US Treasurys of equal maturity, gaining when yields on Treasuries increase relative to those on TIPS.
- **Utilities:** The XLU ETF (Industrial Select Sector SPDR Fund) provides the signal. XLI tracks the broad US utilities sector.
- **Industrials:** The XLI ETF (Industrial Select Sector SPDR Fund) provides the signal. XLI tracks the broad US industrial sector.
- **Safe haven currency (CHF):** The FXF ETF (Invesco CurrencyShares Swiss Franc Trust) offers exposure to the Swiss franc relative to the U.S. dollar, increasing in value when the franc strengthens and declining when the dollar appreciates. This fund could be appropriate for investors seeking to hedge exchange rate exposure or bet against the greenback.
- **Risk currency (AUD):** The FXA ETF (Invesco CurrencyShares Australian Dollar Trust) offers exposure to the Australian dollar relative to the U.S. dollar, increasing in value when the Aussie dollar strengthens and declining when the American dollar appreciates. This fund could be appropriate for investors seeking to hedge exchange rate exposure or bet against the greenback. For investors seeking exposure to the AUD/USD exchange rate
- **Inverse ETF:** DOF ETF (ProShares Short Dow30) provides inverse exposure to the price-weighted Dow Jones Industrial Average, which includes 30 of the largest US companies.

	DBB	SHY	TLT	UUP	GLD	SLV	RINF	XLU	XLI	FXF	FXA	DOG
SPY	0.88	-0.26	-0.18	-0.28	0.55	0.11	0.58	0.94	0.90	0.20	0.00	0.93

Table 1: Correlation coefficient

Universe

The parameters to screen for quality companies based on fundamental values:

- EVToEBITDA >0
- BasicAverageShares (3-Month) >0
- BasicAverageShares (3-Month) x Price > 2B

- EPS >0
- Price > 5

This allows the algorithm to set its universe to filter out unprofitable companies and small cap and penny stocks. Furthermore, the algorithm will seek stocks with the highest momentum by ranking via dollar-volume.

“In the Market”

The resolution chosen in the algorithm is hourly. This is to allow quicker reaction to the market condition. The parameters are paired as such:

- GLD-SLV
- XLI-XLU
- FXF-FXA

These pairing offers a ratio to signal whether the market condition is favourable to stay invested in the equity market or bond/inverse ETF. The confluence factors:

- DDB
- IGE
- SHY
- UUP
- RINF

The algorithm will seek to find a significance of 1% out of an observation rolling period of 252-day. If the extreme condition is true, it will increase the likelihood of the algorithm to produce an “out the market” signal. This is to re-assess/disambiguate double-edged signals provided by the paired signals.

When the signal provides a positive indication to stay “in the market”, the algorithm will look to invest in the top 50 stocks set in the filtered universe. The weight distribution of each stock weighted in favour of the stock with the highest momentum.

The rebalancing portfolio will take place once a month to monitor the performance of the stocks. This is to remove noise in the market and reduce fees due to frequent transactions.

“Out the Market”

Conversely, when the signal provides a positive indication to stay “out the market”, the algorithm will liquidate all stocks holding and rotate capital to bonds, gold and inverse ETF. In order to prevent the algorithm from switching in and out the market frequently due to false signals, a wait out period is introduced to reduce the market noise. The wait out period will allow the portfolio to stay out of the

equity market with a minimum of 15-day once “out the market” signal is triggered. The algorithm will only check after the wait out period whether the market conditions allow the portfolio to invest in the equity market.

The bonds, gold and inverse ETF are as follows:

- TLT
- SHY
- GLD
- UUP
- DOG

The weight distributions are equal to provide a balanced exposure during bear market conditions.

Parameter Optimisation

To avoid overfitting, a base of 15-day wait out is chosen because the fastest correction is in 2018 when S&P500 found rebounded after 15 days⁶⁴. An improvement to the algorithm performance will be an introduction of a dynamic wait out period based on the volatility of the market. Higher standard deviation will increase the wait out period to protect the portfolio from getting in the equity market too soon; the converse is held true.

Results & Improvement Opportunities

Time Frame	Sharpe Ratio	Avg. Win	Avg. Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1 ⁶⁵	1.221	1.08%	-0.54%	52%	22.73%	19.30%	178.78%	0.179	0.143	0.163
Frame 2 ⁶⁶	1.197	0.76%	0.49%	56%	15.90%	15.30%	109.25%	0.128	0.076	0.114
11 years ⁶⁷	1.250	0.91%	0.51%	56%	20.66%	18.40%	690.22%	0.161	0.141	0.143

Time Frame	Market/ Bond Rotation	SPY Benchmark
Frame 1	178.78%	99%
Frame 2	109.25 %	74.2%
11 years	690.22 %	271.99%

Table 1: Net Profit of Market/Bond Rotation Strategy against SPY benchmark

⁶⁴ From the Article:[How Long Do Stock Market Corrections Last?](#).

⁶⁵ Details of backtest result for [Frame 1](#)

⁶⁶ Details of backtest result for [Frame 2](#)

⁶⁷ Details of backtest result for [11 years](#)

Based on all the results from the backtest, this strategy return is higher than SPY benchmark. However, there are some pitfall to this algorithm:

- From 2017-2019, the algorithm mostly stayed out of the equity market in preparation of a correction that only came in 2020. During that period, the equity market continued to grind higher and the bond market underperformed. Hence, the algorithm underperformed the SPY benchmark during that period.
- The algorithm was unable to backtest further in the past as some ETF was not available.

Here are some proposed improvement to enhance the performance of the algorithm:

- Different ETFs/ways to measure prices of resources (e.g., additional key resources such as oil), industrial goods (e.g., a stronger focus on industrial capital goods), and bonds (e.g., corporate bonds instead of government bonds)
- Additional aspects—other than resources, industrial goods, and bond yields—that could provide early indicators of equity downturns
- Improvement of settings (e.g., waiting period, %-points indicating ‘substantial’ drops)
- Code improvements (errors/unintended outcomes, efficiency)

VIII. Subreddit Sentiment

Many have heard of the subreddit "wallstreetbets." It is one of Reddit's most popular hubs for retail traders to share their ideas or positions. Its popularity skyrocketed and hit mainstream media due the short squeeze of GME in early 2021.

This algorithm scrapes the subreddits looking for posts related to the stocks: SPCE, LULU, TLRY, and CLOV (these stocks tend to be a popular conversation in the retail investor space). Then it conducts a sentiment analysis of the comments in the identified post and stores the values in a data frame.

The algorithm may contradict Odd Lot Theory⁶⁸, which states that the small investor is usually wrong. But today, retail investor participation in the market is at an all-time high, and there are plenty of simple stock analysis tools to help small investors make informed decisions. If the general sentiment from retail investors is up, then they could be purchasing the underlying equity.

The Reddit Sentiment trading indicator uses Natural language processing (NLP) and VADER (Valence Aware Dictionary and sEntiment Reasoner)⁶⁹ to set up a rule-based sentiment analysis tool that is specifically attuned to sentiments expressed in news articles and social media. This allows the algorithm to build a collection of most talked about stocks in the subreddit forum.

Universe

There is no integration between Reddit API and QuantConnect, hence a python script is required to obtain the most talked about stocks in the subreddit forum⁷⁰. The python script will need to run regularly to update the list of stocks the algorithm will be tracking.

The algorithm also takes a collection of the top 10 mentioned stocks, titles, texts and timestamp. These data were exported into a csv and imported into dropbox. This is because the URL does not change when a new file is overwritten with the same name. This allows the algorithm to work without changing the code.

Strategy

The algorithm will collect words indicating the sentiment, and score the positive or negative side of the news for each stock. The sum of the sentiment score is calculated for each stock and then used as a proxy for the direction and weight of the insights.

The algorithm will take a long position in the when the sentiment is generally positive and short position when the sentiment is generally negative

⁶⁸ From the Article: [Odd Lot Theory Definition](#). Investopedia.

⁶⁹ From the Article: [VADER: A Parsimonious Rule-based Model for Sentiment Analysis of Social Media Text](#).

⁷⁰ More details of the Python script [here](#).

Results & Improvement Opportunities

Time Frame	Sharpe Ratio	Avg. Win	Avg. Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1 ⁷¹	0.31	0.70%	-0.57%	53%	3.92%	20.80%	21.25%	0.046	-0.034	0.133

Time Frame	News Sentiment	SPY Benchmark
Frame 1	21.25%	99%

Table 1: Net Profit of Subreddit Sentiment Strategy against SPY benchmark

Based on all the results from the backtest, this strategy return is significantly lower than SPY benchmark. Here are the possible reason:

- As the list of popular stocks are dynamically changing, the backtest of the fixed set of stocks is not an accurate representation of the historical performance.
- There is no filter for predatory wallstreetbets submissions⁷².
- Only searches for mentions of ticker names but not company names.

Here are some proposed improvement to enhance the performance of the algorithm:

- An automated list that dynamically changes the universe.
- An idea to prime the algorithm for live trading is to use a neural network. It will create a prediction for the next set of sentiment scores and use those predictions to manage risk.

⁷¹ Details of backtest result for [Frame 1](#)

⁷² More details at [Reddit](#)

IX. News Sentiment with NLP & VADER via Tiingo API

The news sentiment trading indicator uses natural language processing (NLP) and VADER (Valence Aware Dictionary and sEntiment Reasoner)⁷³ to set up a rule-based sentiment analysis tool that is specifically attuned to sentiments expressed in news articles and social media.

The objective is to measure the market participants' sentiment towards the market and trade in the direction of the overall market trend.

QuantConnect provides a 3rd party API integration (Tiingo) to obtain news and events.

Universe

The algorithm takes a collection of the highest volume stocks from cyclical sectors such as Technology, Consumer Cyclical, Financial Services and Basic Materials. These sectors are chosen due to the nature of strong reaction to external factors such as news and events.

The algorithm will then seek stocks with the highest momentum by ranking via dollar-volume.

Strategy

The resolution chosen in the algorithm is hourly. This is to allow quicker reaction to the news and events.

The algorithm will collect words indicating the sentiment, and score the positive or negative side of the news for each stock. The sum of the sentiment score is calculated for each stock and then used as a proxy for the direction and weight of the insights. The algorithm will take a long position in the top 10 assets by sentiment ranking. The algorithm emits 10 insights per day.

Results & Improvement Opportunities

Time Frame	Sharpe Ratio	Avg. Win	Avg. Loss	Win Rate	Compounding Annual Return	Drawdown	Net Profit	Alpha	Beta	Annual Std. Dev.
Frame 1 ⁷⁴	1.144	0.79%	-0.68%	60%	25.95%	20.60%	217.38%	0.123	0.571	0.166

Time Frame	News Sentiment	SPY Benchmark
Frame 1	217.38%	99%

Table 1: Net Profit of News Sentiment Strategy against SPY benchmark

Based on all the results from the backtest, this strategy return is higher than SPY benchmark. However, there are some pitfall to this algorithm:

⁷³ From the Article: [VADER: A Parsimonious Rule-based Model for Sentiment Analysis of Social Media Text](#).

⁷⁴ Backtest results link not available for free account as the total orders exceeds 10,000

- One of the limitations with this model is that the words used are not exhaustive and more could be added to better categorize positive and negative sentiment. The sample size, accuracy of describing a trend of an asset, and the scoring scale determine the trade signal and algorithm's performance. Generally speaking, the larger the sample size, the more precise the scoring scale is, and the more accurately the signal. If we polish the description words sample pool, the result should reflect this more refined.
- The algorithm was unable to backtest further in the past because there is insufficient data provided by Tiingo API. A possible solution is to seek another source to supplement the data required.

Here are some proposed improvement to enhance the performance of the algorithm:

- Currently, the scoring system is based on a predefined dictionary provided by VADER. NLP machine learning can improve the ability to adapt and learn to improve the scoring system.

Portfolio Management using Modern Portfolio Theory (MPT)

Evaluation of Strategies

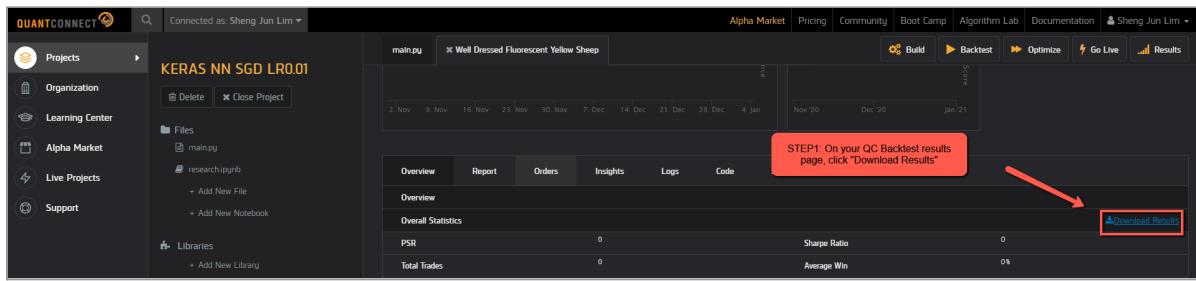
Following the backtest of the various strategies, the results of the strategies will need to be analysed and compared to be able to arrive at a decision on which strategies should be used, and the resource amount to be allocated to each strategy within the trader/investor's portfolio. For this purpose, the Modern Portfolio Theory (MPT) framework is utilised.

A. Extraction of Strategy Backtest Data

Prior to any analysis, the strategy backtest data (equity) must be extracted from the backtest data generated in QuantConnect. The data extraction is repeated for all strategies under consideration. The following steps outline the method of data extraction utilized.

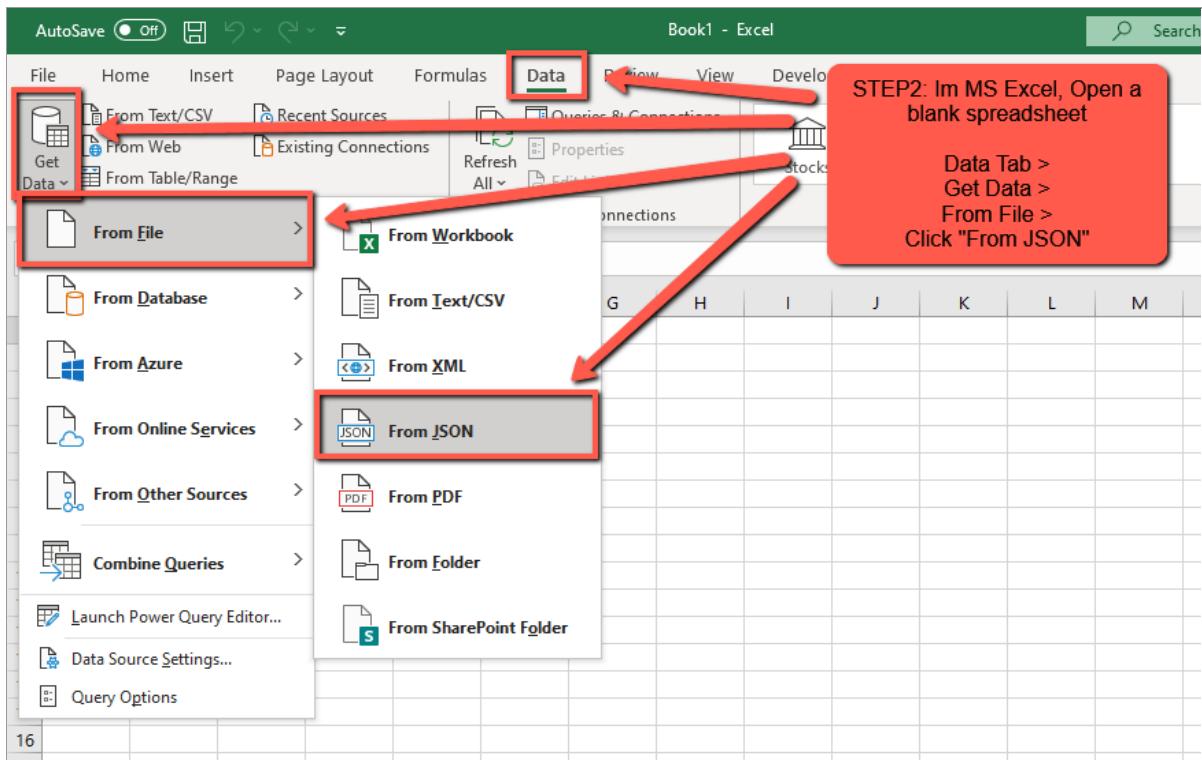
Step 1: Downloading the QuantConnect backtest results JSON file

From within the relevant QuantConnect backtest results page, click "Download Results" to download the backtest results JSON file to the computer.



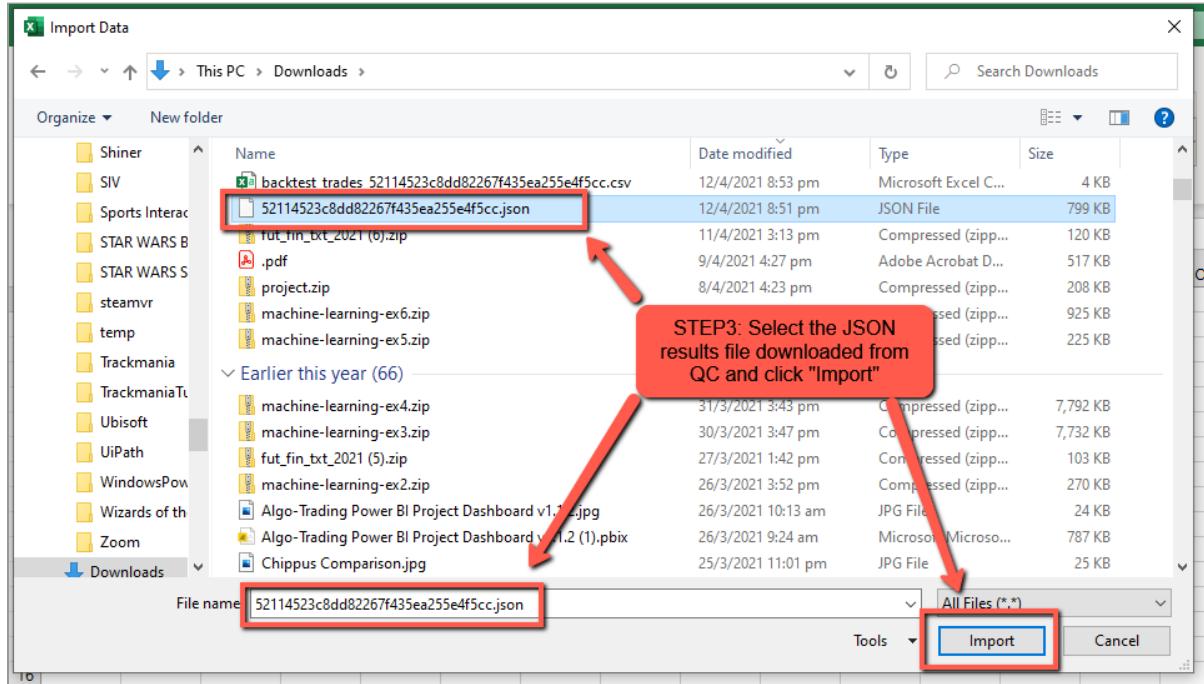
Step 2: Opening the backtest JSON file with Microsoft Excel

Open a new Microsoft Excel spreadsheet, within the "Data" tab, click "Get Data" > "From File" > "from JSON".



Step 3: Importing the downloaded backtest results JSON file

Select the JSON file to be processed and click "Import".



Step 4: Expanding the JSON records to access the strategy's equity data

Following import of the JSON file, the records will now be accessible within Excel's Power Query Editor. The diagrams below detail the order of expansion of the relevant records.

STEP4a: Power Query Editor should now be open.
Click "Record" under "Chart"

The screenshot shows the Power Query Editor interface. The ribbon at the top has 'Record Tools' selected. On the left, there's a 'Convert' ribbon tab. The main area is titled 'Carts' and contains a table with several columns. One column is labeled 'Chart' and its 'Record' button is highlighted with a red box. A red arrow points from the text 'Click "Record" under "Chart"' to this button.

STEP4b: Click "Record" under Strategy Equity

STEP4c: Click "Record" under Series

The image contains two side-by-side screenshots of the Power Query Editor. Both have red callout boxes with arrows pointing to specific 'Record' buttons. The left screenshot shows the 'Strategy Equity' section of the 'Carts' query, where the 'Record' button next to 'Strategy Equity' is highlighted. The right screenshot shows the 'Series' section of the same query, where the 'Record' button next to 'Series' is highlighted. The queries listed in both are: Alpha Assets, Alpha, Insight Count, Strategy Equity, and Benchmark.

STEP4d: Click "Record" under Equity

STEP4e: Click "List" under Values

The screenshots show the Power Query Editor interface. In the left screenshot, a red box highlights the 'Record' button under the 'Equity' column. In the right screenshot, a red box highlights the 'List' button under the 'Values' column.

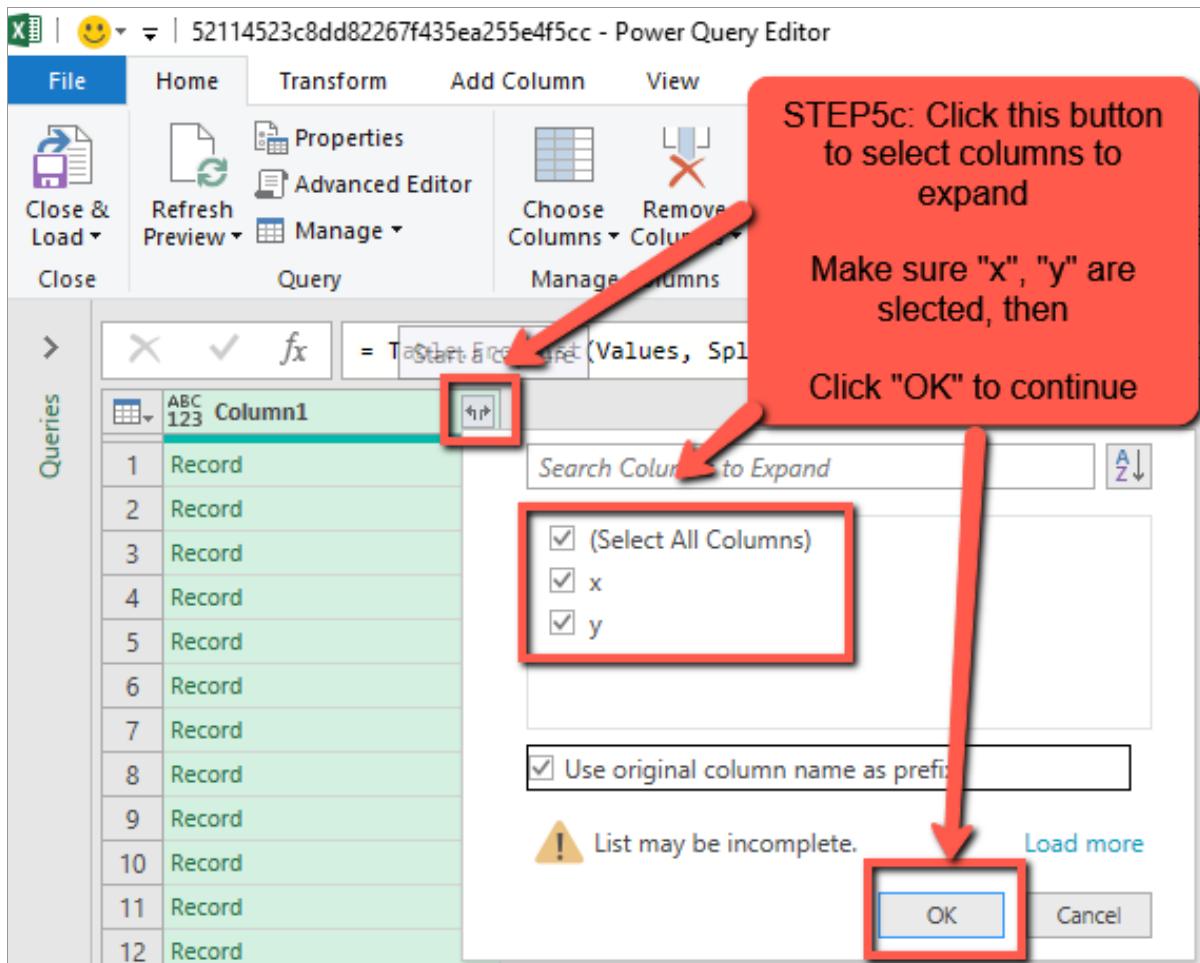
Step 5: Expansion of equity data fields

Following Step 4, the properly expanded record is almost ready to be converted into a table. The diagrams below detail the expansion of the equity data fields.

STEP5a: You should arrive to a page with many records.
Click "To Table Convert"

STEP5b: Delimiter should be "None"
Click "OK" to continue

The screenshots show the Power Query Editor. In the top screenshot, a red box highlights the 'To Table Convert' button. In the bottom screenshot, a red box highlights the 'None' option in the 'Delimiter' dropdown of the 'To Table' dialog box.



Step 6: Conversion of the equity data into a table and copying it to a Google Sheets spreadsheet

The diagrams below outline the conversion of the records into tabular form that can finally be used for analysis. For ease of analysis, the table is copied into a Google Drive spreadsheet that can be accessed by the MPT Python script for analysis.

The screenshot shows two windows side-by-side. On the left is the Power Query Editor window. The 'File' tab is selected, and the 'Close & Load' button is highlighted with a red box and arrow. A red callout box contains the text 'STEP6a: Columns x and y should now be expanded.' Below it, another red callout box says 'Click "Close & Load"' with an arrow pointing to the button. The main area shows a table with two columns: 'Column1.x' and 'Column1.y'. The data rows are 1381118400 and 1381167780, with values 100000 in both columns. On the right is a Google Sheets window with a table titled 'Frame1 Portfolio Equity'. The first row contains column headers 'Column1.x' and 'Column1.y'. The data rows show the same values as the Power Query table. A red callout box on the right says 'STEP6b: Copy all contents in the two columns to our Google Spreadsheet.' Below it, another red callout box says 'Link below "Frame1 Portfolio Equity" tab' with an arrow pointing to the table.

A	B
1 Column1.x	Column1.y
2 1451624400	100000
3 1451917860	100000
4 1451941200	100000

B. Preparation of Strategy Equity Data for Modern Portfolio Theory Framework

Comparing the performance(equity) between different strategies required the preparation of data to fit a common time-series. Most of the strategies backtested followed a 5-day trading week, however, some had more than 5 trading days a week. It was opted to down-sample the equity results of strategies with more than 5 trading days to fit 5 trading days a week.

Step 1: Conversion of UNIX timestamp to regular date

The QuantConnect results file stores date-time information as a UNIX timestamp. For purposes of subsequent analysis in the MPT framework, we convert the timestamp into regular date format and omit time information. The diagram below shows the spreadsheet formula used to convert the UNIX timestamp to a regular date format.

List of Strategies & Backtest Results

File Edit View Insert Format Data Tools Add-ons Help

100% Start % capture .00 123 Default (Ari...)

C3	fx	=TO_DATE(INT((A3/(60*60*24))+ "1/1/1970"))
1		Strategy - Pre-H OK
2	Column1.x	Column2.x
3	01/01/2016	1451624400
4	04/01/2016	1451919600
5	04/01/2016	1451941200
6	05/01/2016	1451970000
		100231.8395
		145205

Step1: Convert UNIX timestamp to regular date format

Step 2: Removing Duplicate Rows

Following Step 1, entries with duplicate dates will now be present in the table. These entries will need to be removed. The following diagrams outline the method to remove duplicate date rows from the data.

The screenshot shows two views of a Google Sheets spreadsheet titled "List of Strategies & Backtest Results".

Left View: The "Data" tab is selected. A red box highlights the "Data" tab in the menu bar. A red arrow points from the "Data" tab to the "Remove duplicates" option in the dropdown menu. A callout box contains the text: "Step2a: Select the 3 columns with which the duplicate dates are to be removed. From the "Data" tab, click "Remove duplicates"".

Right View: A "Remove duplicates" dialog box is open. It shows "4568 rows and 3 columns selected". Under "Columns to analyse", the checkbox for "Column C" is checked. A red box highlights the "Column C" checkbox. A red arrow points from the "Column C" checkbox to the "Remove duplicates" button. A callout box contains the text: "Step 2b: Select Column C (Date column) to analyse then click "Remove duplicates"".

Step 3: Down-sampling data series with more than 5 trading days per week

For equity data series that have more than 5 trading days per week, we use the INDEX and MATCH functions to match dates and equity data to a 5-day trading week. The diagram below shows the formula used to perform this operation.

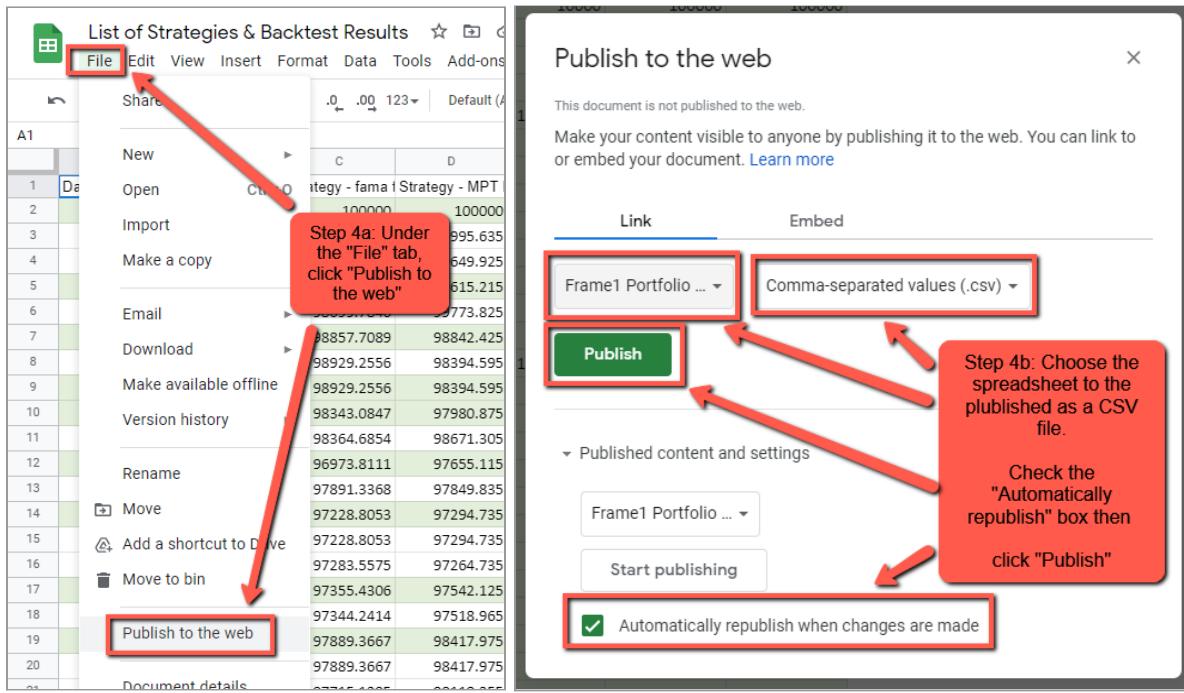
The screenshot shows a Google Sheets spreadsheet with multiple tabs visible at the bottom. The active tab is "Strategy - Carr OK".

A red box highlights the formula in cell P3: `=IFNA(INDEX(Q3:Q1823, MATCH(A1, O3:O1823, 0)), AN2)`. A red arrow points from this formula to the cell A1, labeled "Date series to look through". Another red arrow points from the formula to the range \$O\$3:\$O\$1823, labeled "Date to match to".

A red box highlights the formula in cell AN3: `=IFNA(INDEX(Q3:Q1823, MATCH(A13, O3:O1823, 0)), AN2)`. A red arrow points from the cell A13 to the formula, labeled "Data series used to populate fields when a matching date is found".

Step 4: Publishing of Spreadsheet data for access by MPT Python Script

Once all strategies have been processed to fit a common time-series, the data can be published to allow access by the MPT Python Script. The diagrams below outline the steps to accomplish this.



Modern Portfolio Theory (MPT) Framework Analysis

The processed strategy equity data can now be processed within the MPT Google Colab Notebook. After we paste the URL of the published Google spreadsheet containing the processed strategy equity data into the Python Script (shown below), all the notebook cells can be run to produce analysis using the MPT framework.

```
[1] import numpy as np
    import pandas as pd
    import matplotlib.pyplot as plt
    %matplotlib inline
    import seaborn as sns
```

Paste the URL of the published Google spreadsheet housing the processed strategy equity data here.

Date	Strategy - Pre-Holiday Effect	Strategy - fama french 5 factor	Strategy - MPT EFT alloc
0 1546318800	97070.4781	131094.205	
1 1546441200	97070.4781	131094.205	

Step 1: Analysing Strategy Correlation

The MPT script produces a correlation matrix using the Seaborn library. Strategies with a high correlation should be noted and considered for exclusion. Having multiple strategies with high correlation may expose the portfolio to greater risks and drawdown should market conditions go against the strategies.

From the correlation matrix shown in Figure 1, it is observed that 2 pairs of strategies have a high correlation (above 0.5). The highly correlated strategy pairs are:

- 1) Asset Class Momentum (ETFs) - MPT EFT allocation (SPY, QQQ, TLT, GLD) - correlation 0.72
- 2) Asset Class Momentum (ETFs) - Tiingo News NLP - correlation 0.53

The exclusion of 1 or 2 of these strategies from the overall portfolio should be considered after further analysis of the risks & returns of these strategies.

```
[7] #Correlation matrix
corr_matrix = df.pct_change().apply(lambda x: np.log(1+x)).corr()

[8] plt.figure(figsize=(12,7))
corr_matrix_plot = sns.heatmap(corr_matrix, vmin=-1, vmax=1, annot=True)
```

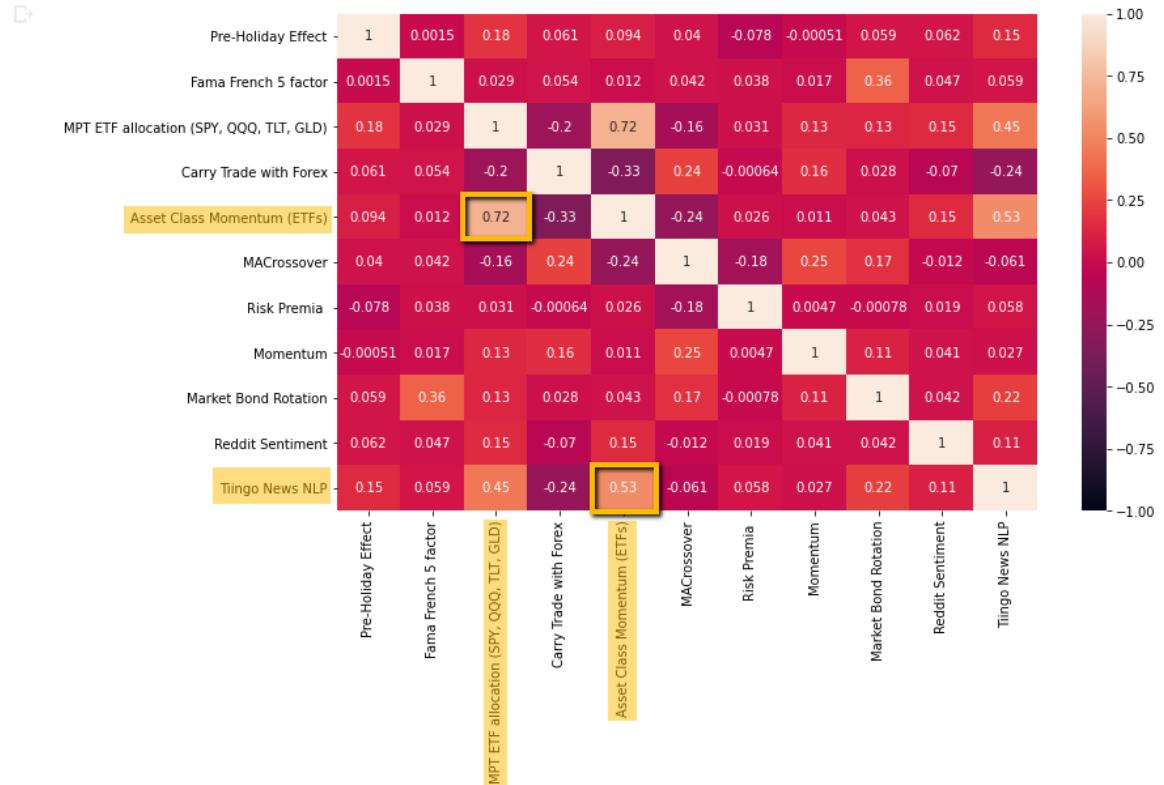


Figure 1: Strategy Correlation Matrix

Step 2: Analysing Returns vs Risk

Figure 2 below shows the Returns vs Risk of the strategies under comparison. The return values are the mean yearly returns calculated over a 2 year backtest period. The volatility figures(annual standard deviation) which represents the riskiness of the strategy are derived from the daily standard deviation figures of individual strategies' daily equity figures.

The screenshot shows a Jupyter Notebook cell. On the left, there is a play button icon followed by the Python code:

```
# Creating a table for visualising returns and volatility of assets/strategies
assets = pd.concat([ind_er, ann_sd], axis=1)
assets.columns = ['Returns', 'Volatility']
assets
```

To the right of the code is a table with two columns: 'Returns' and 'Volatility'. The table lists ten strategies, each with its corresponding mean yearly return and annual standard deviation. The strategies are listed in descending order of mean return. The 'MPT ETF allocation (SPY, QQQ, TLT, GLD)' strategy is highlighted in yellow. The 'Asset Class Momentum (ETFs)' strategy is highlighted in red.

	Returns	Volatility
Pre-Holiday Effect	0.120012	0.036998
Fama French 5 factor	0.426970	0.229962
MPT ETF allocation (SPY, QQQ, TLT, GLD)	0.325569	0.201672
Carry Trade with Forex	0.085539	0.050871
Asset Class Momentum (ETFs)	-0.042183	0.205385
MACrossover	0.035480	0.019159
Risk Premia	0.073794	0.058815
Momentum	0.147510	0.058204
Market Bond Rotation	1.178451	0.217444
Reddit Sentiment	0.185401	0.125153
Tiingo News NLP	0.567022	0.196713

Figure 2: Returns & Volatility Comparison

The annualized volatility of the S&P of 0.177 over the last 5-year period was chosen as the benchmark for classifying strategies into high-risk(volatility >0.177) and low-risk(volatility <0.177).

The strategies highlighted in yellow were shown to have a high correlation(higher than 0.5). It was observed that over the last 2 years, the Asset Class Momentum (ETFs) strategy was not profitable and should be omitted from the final portfolio.

Omitting the Asset Class Momentum (ETFs) strategy from the portfolio eliminated strategy pairs with a high correlation. The remaining strategies shall be included in the overall portfolio.

Step 3: Plotting the Efficient Frontier & Obtaining Portfolio Weights for the Portfolio incorporating High-risk and Low-risk Strategies

Following the decision to omit the Asset Class Momentum (ETFs) from the final portfolio, the MPT script is re-run to obtain the portfolio weights using the Markowitz Efficient Frontier.

The MPT script assigns a user configurable number of permutations of random weights to the different strategies and plots the corresponding return & volatility figures to create the Efficient Frontier plot. The number of permutations was set at 100000 for the analysis.

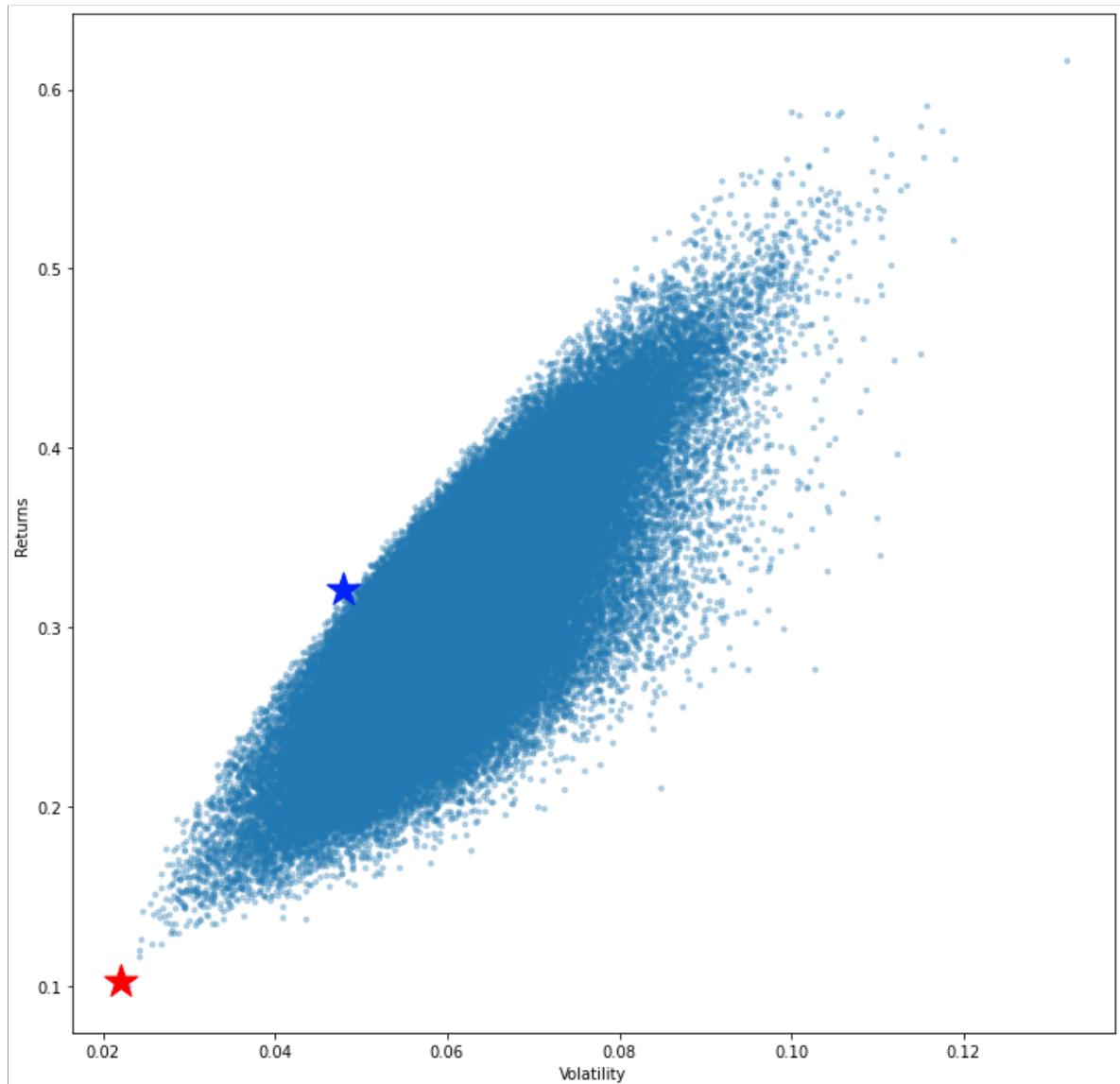


Figure 3a: Efficient Frontier for the Portfolio Incorporating high-risk & low-risk strategies

Figure 3a shows the Efficient Frontier Plot. The red star represents the point of portfolio allocation with the lowest volatility while the blue star represents the point of portfolio allocation with the highest Sharpe Ratio.

	Returns	Volatility
Pre-Holiday Effect	0.120012	0.036998
Fama French 5 factor	0.426970	0.229962
MPT ETF allocation (SPY, QQQ, TLT, GLD)	0.325569	0.201672
Carry Trade with Forex	0.085539	0.050871
MACrossover	0.035480	0.019159
Risk Premia	0.073794	0.058815
Momentum	0.147510	0.058204
Market Bond Rotation	1.178451	0.217444
Reddit Sentiment	0.185401	0.125153
Tiingo News NLP	0.567022	0.196713

Figure 3b: Returns & Volatility of Strategies for the Portfolio Incorporating high-risk & low-risk strategies

▶	#Getting parameter/weights of the point with minimum volatility min_vol_port = portfolios.iloc[portfolios['Volatility'].idxmin()] # idxmin() gives us the minimum value in the column specified. min_vol_port	
⇨	Returns Volatility Pre-Holiday Effect weight Fama French 5 factor weight MPT ETF allocation (SPY, QQQ, TLT, GLD) weight Carry Trade with Forex weight MACrossover weight Risk Premia weight Momentum weight Market Bond Rotation weight Reddit Sentiment weight Tiingo News NLP weight Name: 27880, dtype: float64	0.102699 0.021967 0.203089 0.015064 0.027895 0.092707 0.266673 0.230906 0.093418 0.000830 0.067445 0.001973

Figure 3c: Returns, Volatility & Strategy Weights for the Portfolio Incorporating high-risk & low-risk strategies (Lowest Risk)

```

# Finding the optimal portfolio (i.e. Highest Sharpe Ratio)

# risk factor(risk-free rate)
rf = 0.0161 # 1.61% Average return of Singapore Savings Bonds over 10 years https://www.mas.gov.sg

optimal_risky_port = portfolios.iloc[((portfolios['Returns']-rf)/portfolios['Volatility']).idxmax()]
optimal_risky_port

Returns          0.320604
Volatility       0.047891
Pre-Holiday Effect weight 0.207079
Fama French 5 factor weight 0.004470
MPT ETF allocation (SPY, QQQ, TLT, GLD) weight 0.020180
Carry Trade with Forex weight 0.180610
MACrossover weight 0.064733
Risk Premia weight 0.120258
Momentum weight 0.139403
Market Bond Rotation weight 0.172059
Reddit Sentiment weight 0.037709
Tiingo News NLP weight 0.053499
Name: 19502, dtype: float64

```

Figure 3d: Returns, Volatility & Strategy Weights for the Portfolio Incorporating high-risk & low-risk strategies (Highest Sharpe Ratio)

The risk-free return rate used to calculate the Sharpe Ratios is 1.61%. This value is the average return of the Singapore Savings Bonds over 10 years.

Step 4: Plotting the Efficient Frontier & Obtaining Portfolio Weights for the Portfolio Incorporating Low-risk Strategies

Similar to Step 3, the MPT script is re-runned to obtain the portfolio weights for the Portfolio incorporating only low-risk strategies ($\text{volatility} < 0.177$).

Figure 4a shows the Efficient Frontier Plot. The red star represents the point of portfolio allocation with the lowest volatility while the blue star represents the point of portfolio allocation with the highest Sharpe Ratio.

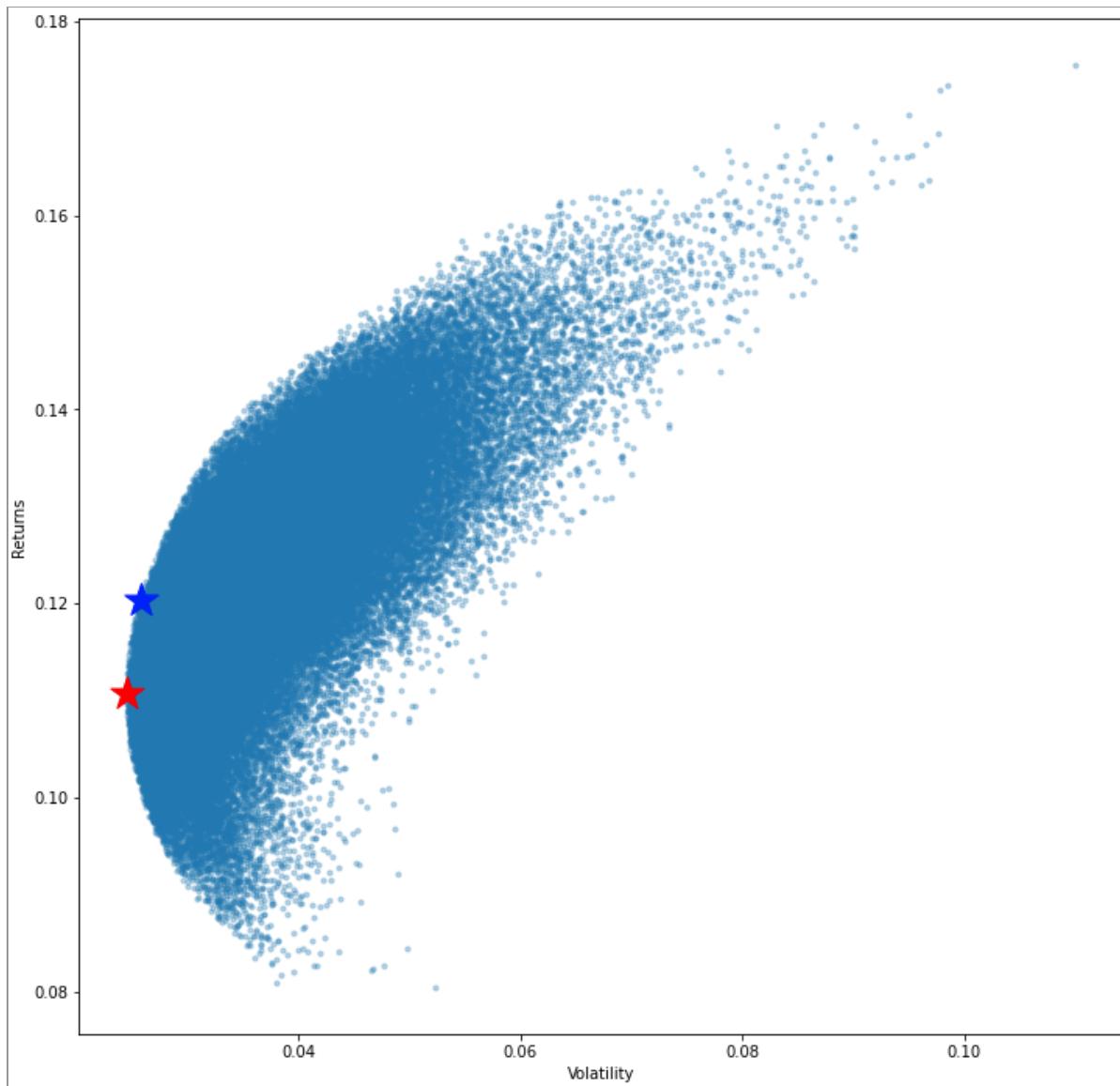


Figure 4a: Efficient Frontier for the Portfolio Incorporating only low-risk strategies

	Returns	Volatility
Pre-Holiday Effect	0.120012	0.036998
Carry Trade with Forex	0.085539	0.050871
Risk Premia	0.073794	0.058815
Momentum	0.147510	0.058204
Reddit Sentiment	0.185401	0.125153

Figure 4b: Returns & Volatility of Strategies for the Portfolio Incorporating only low-risk strategies

```
#Getting parameter/weights of the point with minimum volatility
min_vol_port = portfolios.iloc[portfolios['Volatility'].idxmin()]
# idxmin() gives us the minimum value in the column specified.
min_vol_port

Returns          0.110787
Volatility       0.024545
Pre-Holiday Effect weight 0.423380
Carry Trade with Forex weight 0.210414
Risk Premia weight 0.176291
Momentum weight 0.164745
Reddit Sentiment weight 0.025171
Name: 17948, dtype: float64
```

Figure 4c: Returns, Volatility & Strategy Weights for the Portfolio Incorporating only low-risk strategies (Lowest Risk)

```
# Finding the optimal portfolio (i.e. Highest Sharpe Ratio)

# risk factor(risk-free rate)
rf = 0.0161 #1.61% Average return of Singapore Savings Bonds over 10 years https://www.mas.gov.sg/b

optimal_risky_port = portfolios.iloc[((portfolios['Returns']-rf)/portfolios['Volatility']).idxmax()]
optimal_risky_port

Returns          0.120382
Volatility       0.025777
Pre-Holiday Effect weight 0.469496
Carry Trade with Forex weight 0.137043
Risk Premia weight 0.110352
Momentum weight 0.219509
Reddit Sentiment weight 0.063600
Name: 8033, dtype: float64
```

Figure 4d: Returns, Volatility & Strategy Weights for the Portfolio Incorporating only low-risk strategies (Highest Sharpe Ratio)

The risk-free return rate used to calculate the Sharpe Ratios is 1.61%. This value is the average return of the Singapore Savings Bonds over 10 years.

Step 5: Plotting the Efficient Frontier & Obtaining Portfolio Weights for the Portfolio Incorporating High-risk Strategies

The MPT script is re-run to obtain the portfolio weights for the Portfolio incorporating only high-risk strategies ($\text{volatility} > 0.177$).

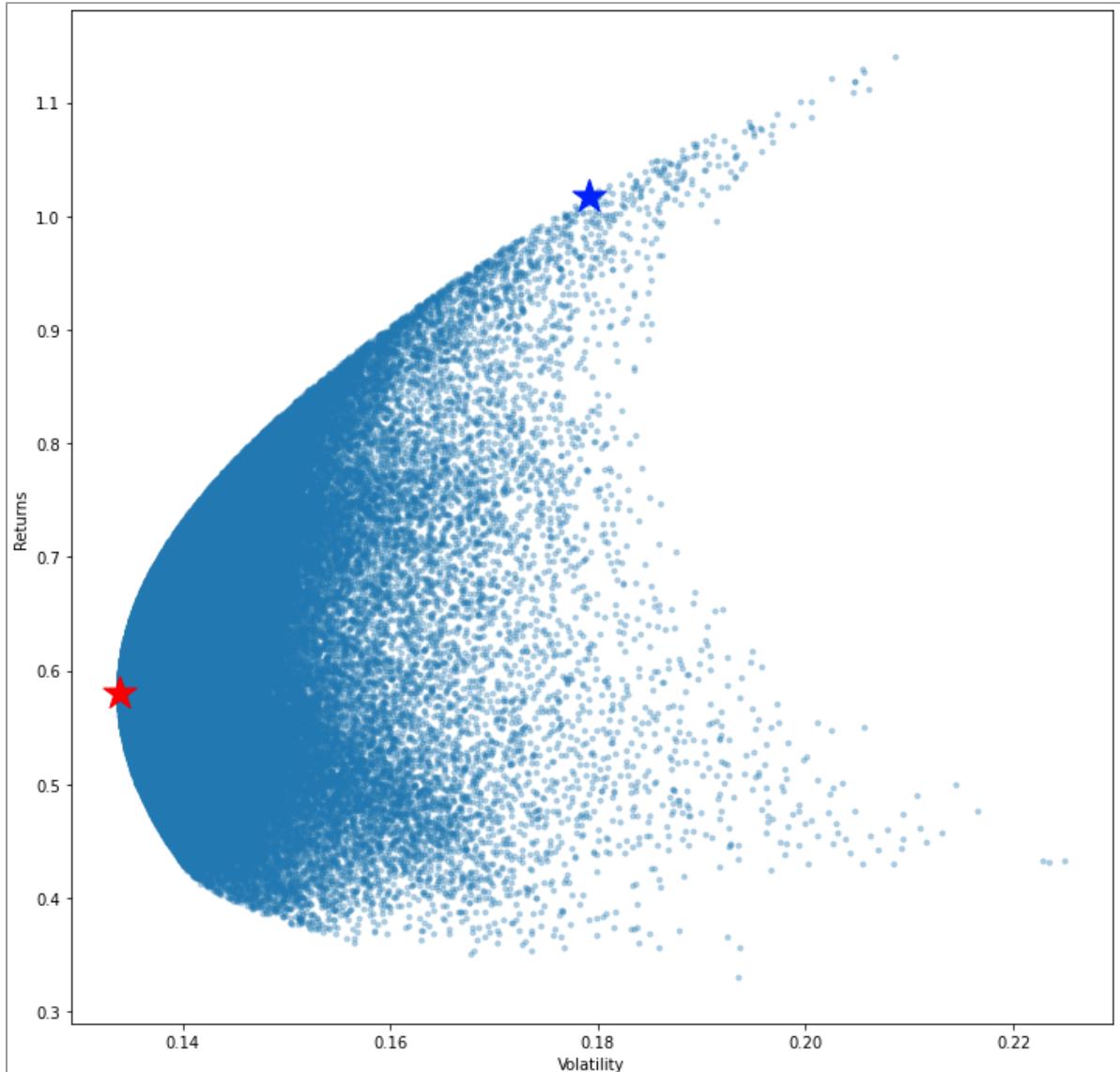


Figure 5a: Efficient Frontier for the Portfolio Incorporating only high-risk strategies

Figure 5a shows the Efficient Frontier Plot. The red star represents the point of portfolio allocation with the lowest volatility while the blue star represents the point of portfolio allocation with the highest Sharpe Ratio.

	Returns	Volatility
Fama French 5 factor	0.426970	0.229962
MPT ETF allocation (SPY, QQQ, TLT, GLD)	0.325569	0.201672
Market Bond Rotation	1.178451	0.217444
Tiingo News NLP	0.567022	0.196713

Figure 5b: Returns & Volatility of Strategies for the Portfolio Incorporating only high-risk strategies

```
#Getting parameter/weights of the point with minimum volatility
min_vol_port = portfolios.iloc[portfolios['Volatility'].idxmin()]
# idxmin() gives us the minimum value in the column specified.
min_vol_port

Returns                               0.580181
Volatility                            0.133867
Fama French 5 factor weight          0.250886
MPT ETF allocation (SPY, QQQ, TLT, GLD) weight 0.290691
Market Bond Rotation weight          0.193783
Tiingo News NLP weight               0.264641
Name: 40448, dtype: float64
```

Figure 5c: Returns, Volatility & Strategy Weights for the Portfolio Incorporating only high-risk strategies (Lowest Risk)

```
# Finding the optimal portfolio (i.e. Highest Sharpe Ratio)

# risk factor(risk-free rate)
rf = 0.0161 #1.61% Average return of Singapore Savings Bonds over 10 years https://www.mas.gov.sg

optimal_risky_port = portfolios.iloc[((portfolios['Returns']-rf)/portfolios['Volatility']).idxmax()]
optimal_risky_port

Returns                               1.017960
Volatility                            0.179061
Fama French 5 factor weight          0.002179
MPT ETF allocation (SPY, QQQ, TLT, GLD) weight 0.010629
Market Bond Rotation weight          0.742211
Tiingo News NLP weight               0.244981
Name: 31617, dtype: float64
```

Figure 5d: Returns, Volatility & Strategy Weights for the Portfolio Incorporating only high-risk strategies (Highest Sharpe Ratio)

The risk-free return rate used to calculate the Sharpe Ratios is 1.61%. This value is the average return of the Singapore Savings Bonds over 10 years.

Recommendations & Conclusion

The table below summarizes the returns and volatility of the different portfolio types.

Portfolio Type	Annual Returns	Volatility	Sharpe Ratio
High & Low Risk (Lowest Volatility)	0.107	0.0220	4.68
High & Low Risk (Highest Sharpe Ratio)	0.321	0.0479	6.69
Low Risk (Lowest Volatility)	0.111	0.0245	4.51
Low Risk (Highest Sharpe Ratio)	0.12	0.0258	4.67
High Risk (Lowest Volatility)	0.58	0.1339	4.33
High Risk (Highest Sharpe Ratio)	1.018	0.1791	5.69

Table 1: Comparison of Portfolio Allocations using MPT Efficient Frontier

It is interesting to note that the values of both low-risk portfolios and the High & Low Risk (Lowest Volatility) portfolio are very similar. On further inspection, the individual weights vary across the three cases.

The High & Low Risk (Highest Sharpe Ratio) portfolio offers an annual return at least 20% higher than the 3 previously mentioned portfolios for a corresponding increase in volatility of about 0.02. This substantial improvement in returns for a small increase in volatility offers an enticing proposition and should be thoroughly considered for implementation.

The high-risk portfolios offer very substantial annual returns of 58.0% & 101.8% at a substantially increased risk of 0.1339 and 0.1791. These portfolios may be suitable for investors with a big risk appetite looking for the potential of large returns.

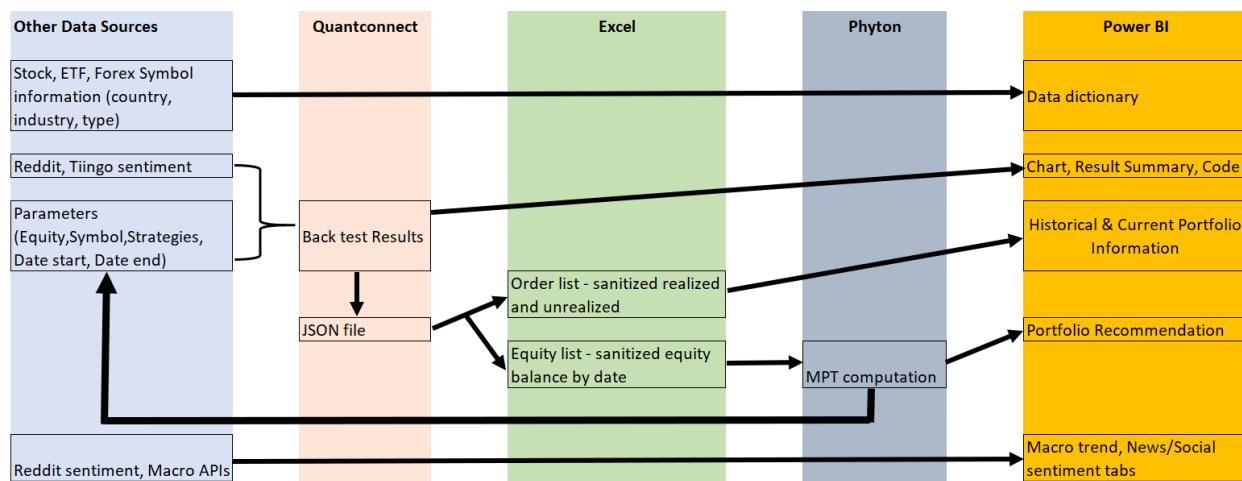
Although some of the portfolios look very promising, it is important to note that past performance is not a guarantee of future returns. Frequent performance monitoring, review and re-assessment of the portfolio allocation should be conducted for whichever portfolio allocation is chosen to be implemented.

For the entire extract of the strategies and the MPT used, please refer to the [Phase 2 Strategy Documentation Report](#).

Phase 3 - Deployment

The last phase where we integrate our selected strategies and MPT portfolio management developed in Phase 2 from Quantconnect and also sources of information into PowerBi.

Below table is the simplified data schema:



Other Data Sources

Stocks, ETF, symbol datas are obtained from downloading the report from stockmarketMBA⁷⁵. ETF's country are defaulted to US as the volume of manual update required is taxing. For forex pair countries, it is defaulted to the currency used to trade the pair i.e. JPY:USD will have the country assigned as USD. All this information are imported into Power Bi to form part of the data dictionary.

For Reddit, a python script is used to scrape and collate the information from Reddit, while Tiingo, it has API linkage with QuantConnect to obtain the data. [Phase 2 Strategy Documentation Report](#).

Parameters set up mentioned for each strategy are documented in [Phase 2 Strategy Documentation Report](#).

For the Reddit Sentiment it uses the results from the python script generated to create the charts while the Macro APIs, aside from VIX\$ Key Interest Rates and BTCUSD which are the same as in the [Phase 1 Documentation](#), we replaced the forex chart with the Financials, Futures & Options Positioning (no. of contracts) from the Commodity Futures Trading Commission (CFTC) website.

Quanconnect to Excel

As all the backtested and 'live datas' are being generated from QuantConnect, all the trade information needs to be sanitized as it does not have direct information to derive the realized and realized positions.

⁷⁵ Stock/Symbol detail list are found at this site : <https://stockmarketmba.com/stockresearchtools.php>

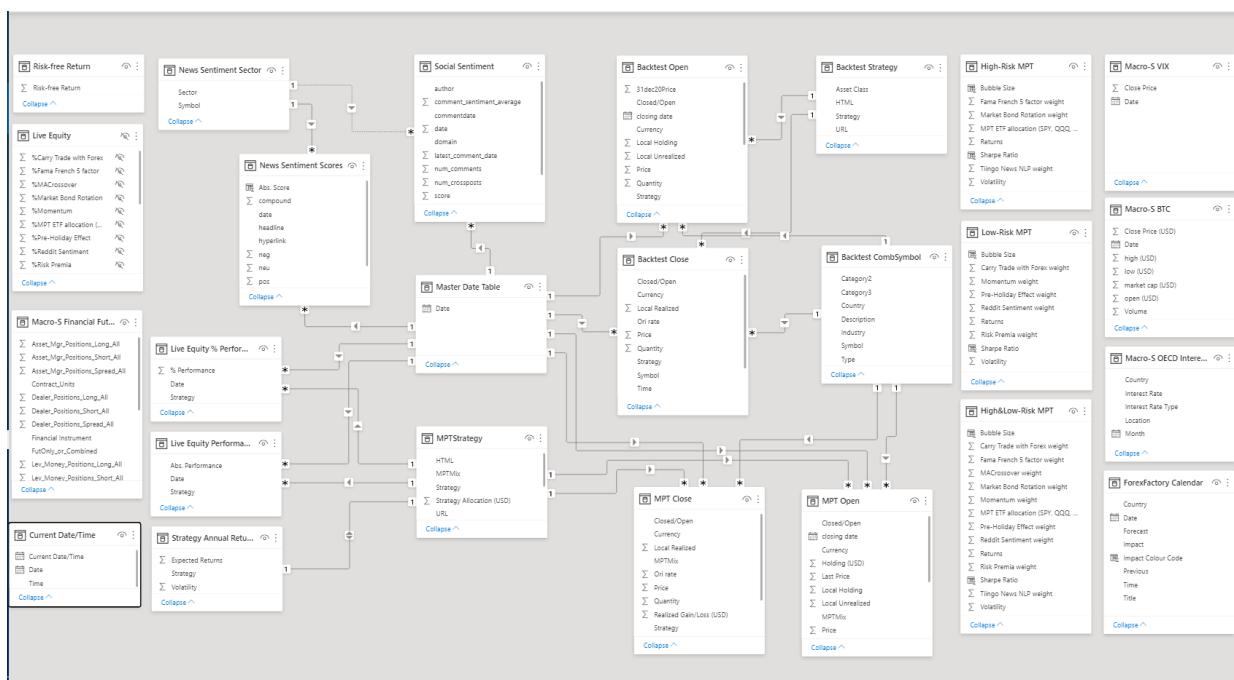
For the unrealized positions, we used the Excel function of HistoryStock to get the closing price for both equities and forex. QuantConnect allows the publishing of the backtest results via the HTML link which we have incorporated in the backtesting tab.

Phyton

Obtained the sanitized equity return by date data to use it for MPT computation using Python and extract the results which will be used to tabulate the graph. The result of MPT, which is the recommended equity mix, will form as a parameter to re-run the backtest again but on the current date in QuantConnect to get the datas for the overview and portfolio tab.

Power BI

Based on all the sources received, the following relationship matrix are established below:

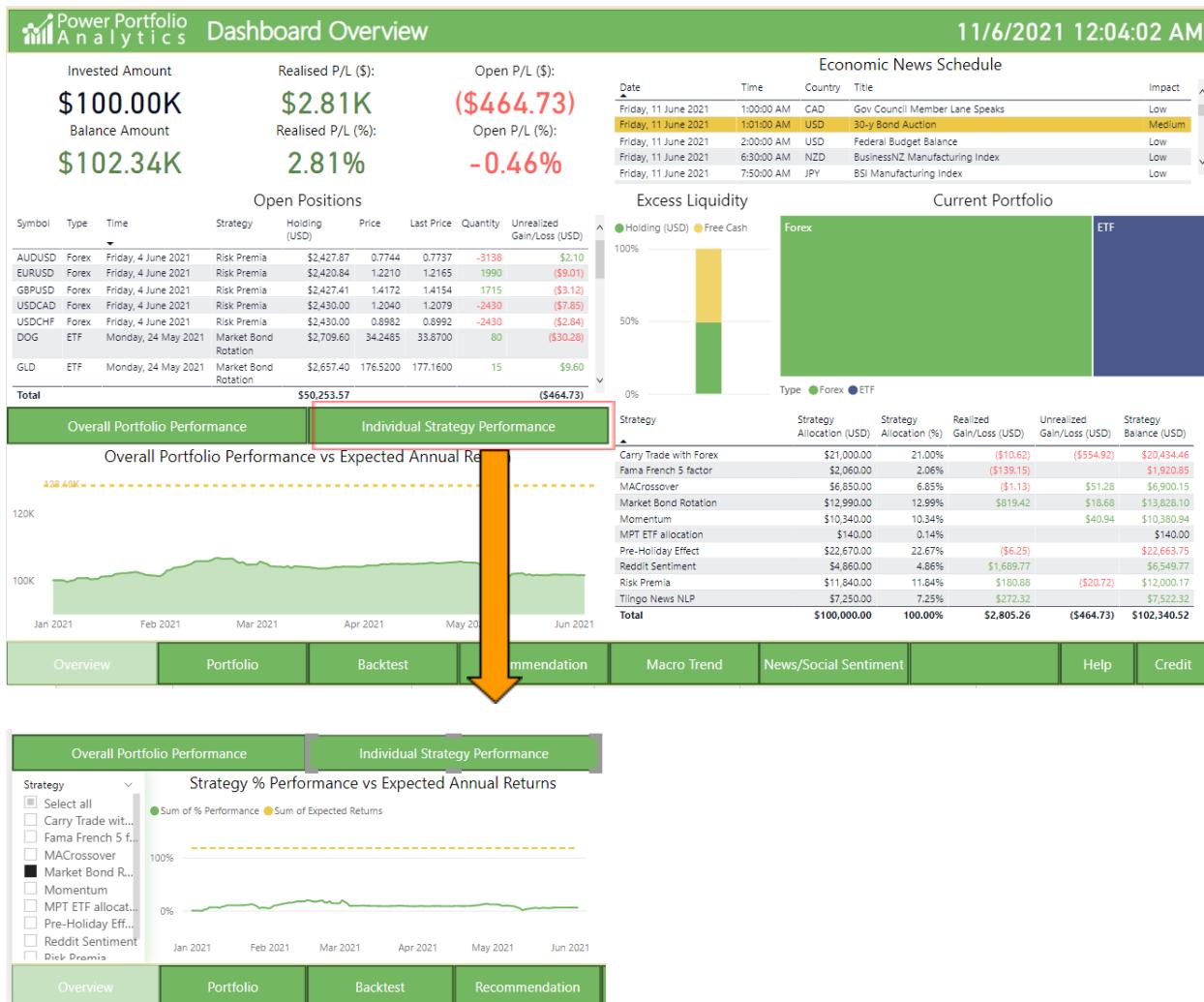


The following are the relationships set up, except for MPT Strategy(Strategy) to Strategy Annual Return/Volatility (Strategy) the rest are all set to one to many relationships.

Active	From: Table (Column)	To: Table (Column)
✓	Backtest Close (Strategy)	Backtest Strategy (Strategy)
✓	Backtest Close (Symbol)	Backtest CombSymbol (Symbol)
✓	Backtest Close (Time)	Master Date Table (Date)
✓	Backtest Open (Strategy)	Backtest Strategy (Strategy)
✓	Backtest Open (Symbol)	Backtest CombSymbol (Symbol)
✓	Backtest Open (Time)	Master Date Table (Date)
✓	Live Equity % Performance (Date)	Master Date Table (Date)
✓	Live Equity % Performance (Strategy)	MPTStrategy (Strategy)
✓	Live Equity Performance (Date)	Master Date Table (Date)
✓	Live Equity Performance (Strategy)	MPTStrategy (Strategy)
✓	MPT Close (Strategy)	MPTStrategy (Strategy)
✓	MPT Close (Symbol)	Backtest CombSymbol (Symbol)
✓	MPT Close (Time)	Master Date Table (Date)
✓	MPT Open (Strategy)	MPTStrategy (Strategy)
✓	MPT Open (Symbol)	Backtest CombSymbol (Symbol)
✓	MPT Open (Time)	Master Date Table (Date)
✓	MPTStrategy (Strategy)	Strategy Annual Returns/Volatility (Strategy)
✓	News Sentiment Scores (date)	Master Date Table (Date)
✓	News Sentiment Scores (ticker)	News Sentiment Sector (Symbol)
✓	Social Sentiment (commentdate)	Master Date Table (Date)

Prototype Power BI Dashboard⁷⁶

Below are the Overview Tab:



The Overview tab has some minor changes from the original dashboard in Design Stage in which we added the Overall Portfolio Performance and Individual Strategy Performance graph which show the current performance against the expected returns generated from the MPT.

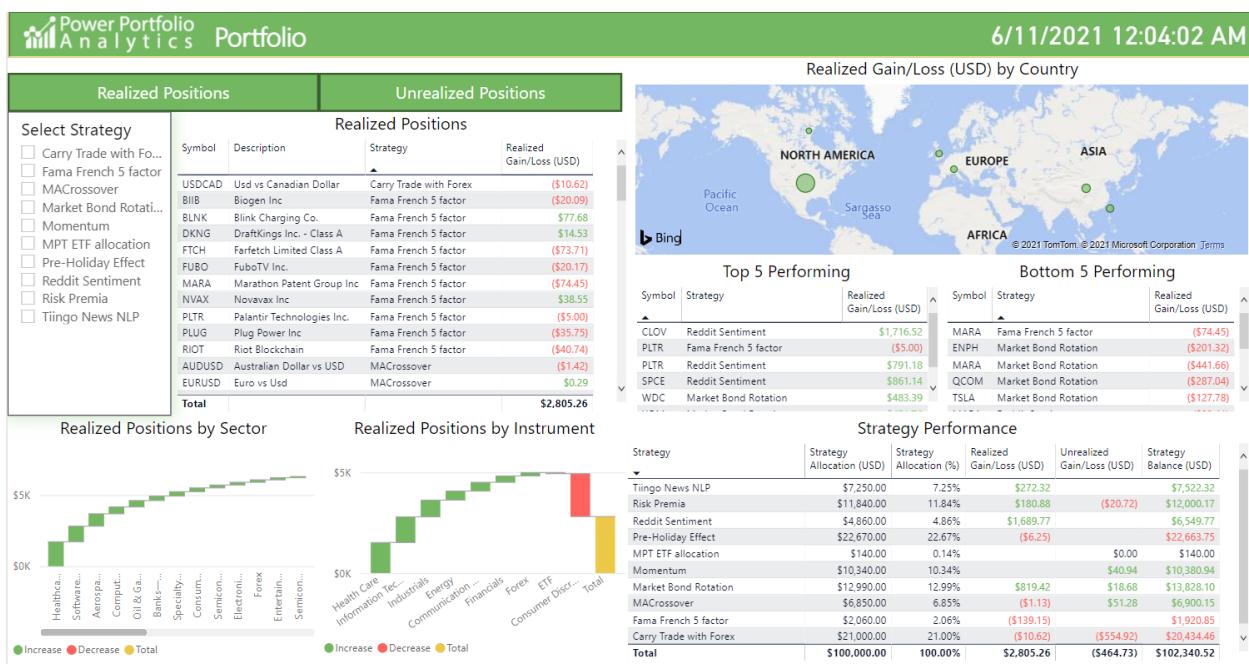
⁷⁶ Phase 3 [Power BI PBIX File](#)

Portfolio Tab

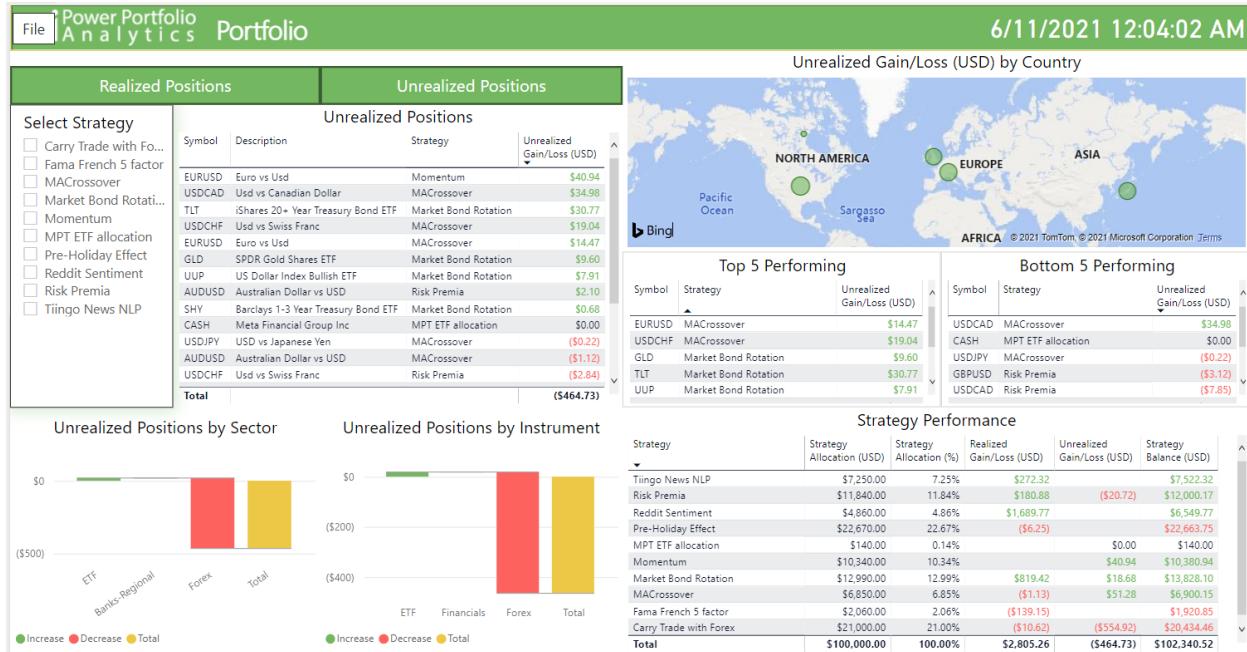
Similar to the original dashboard in Design Stage, the main difference are:

- Added Headings to navigate the realized and unrealized positions,
- Used 'Waterfall' chart method instead of pie chart to represent the positions by Sector and Instruments instead of pie chart as pie chart cannot provide % for those with negative positions,
- The Strategy Performance table is also replicated from the Overview Tab.

Portfolio dashboard showing the realized positions:



Portfolio dashboard showing the unrealized positions:

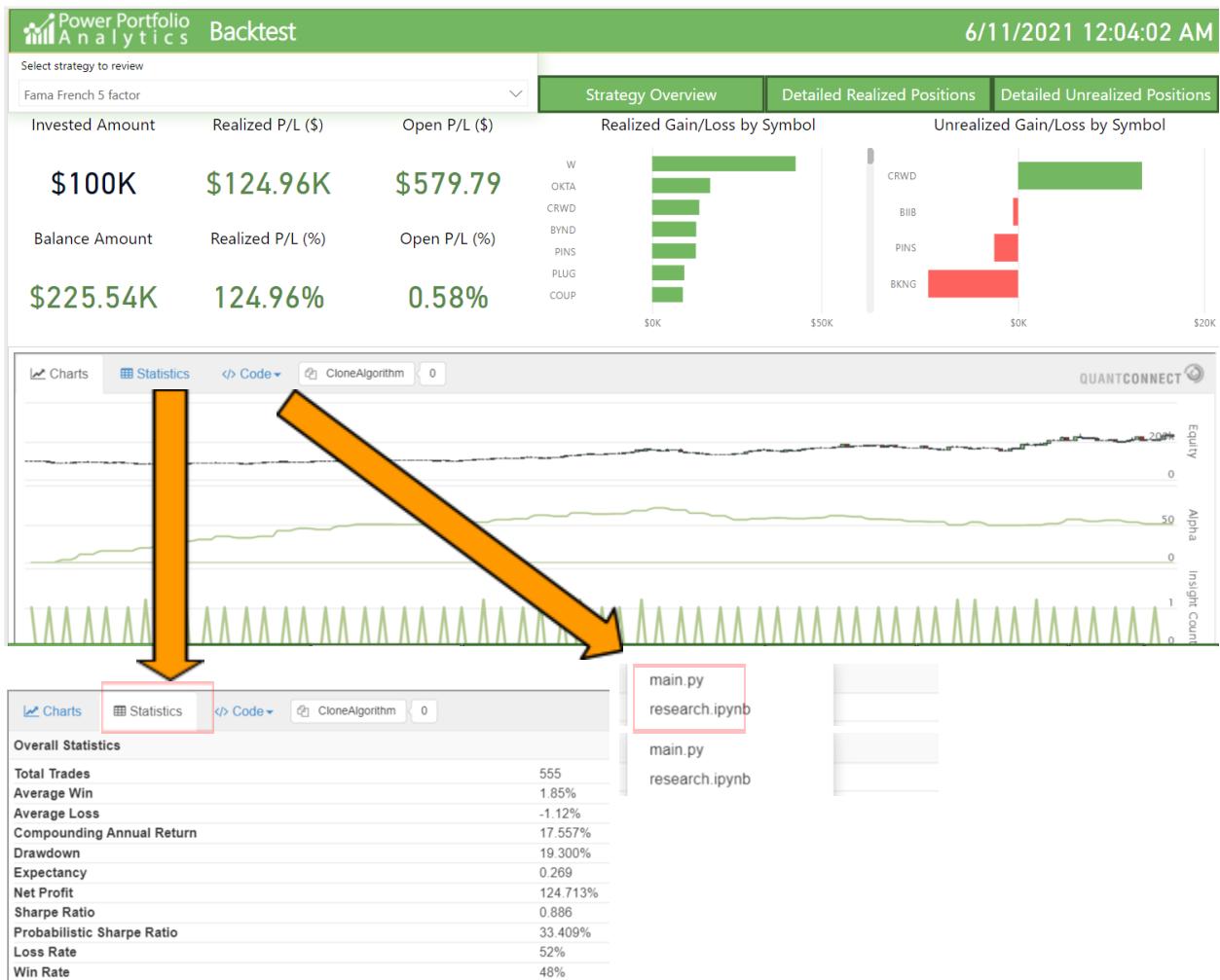


Backtest Tab

As this tab is not present in the Phase 1 as it requires the backtest results from QuantConnect to be extracted and embedded into Power BI. Only Power BI Service can view the results of the QuantConnect as it is an HTML embed.

To embed the HTML strategy results from Quantconnect, we use the add-on HTML-Viewer in Power BI store and add the following DAX code during data transformation:

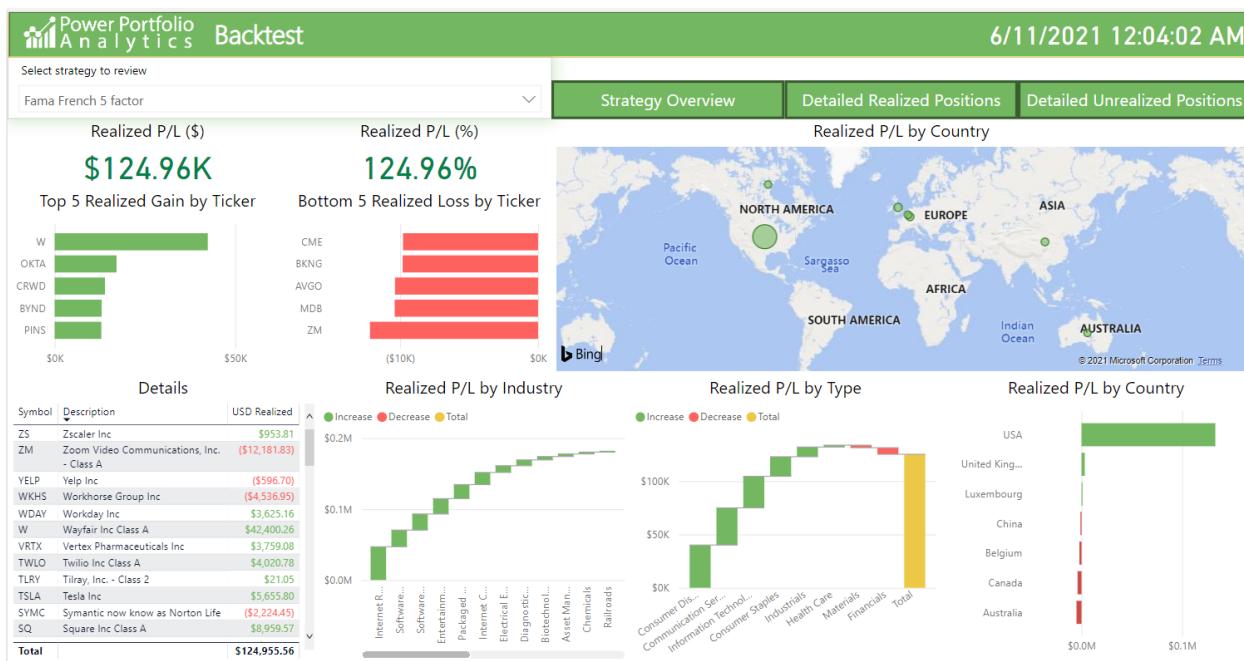
```
HTML = "<iframe src=" & Strategy[URL] & " style='position: fixed; width: 100%; height: 100%'></iframe>"
```



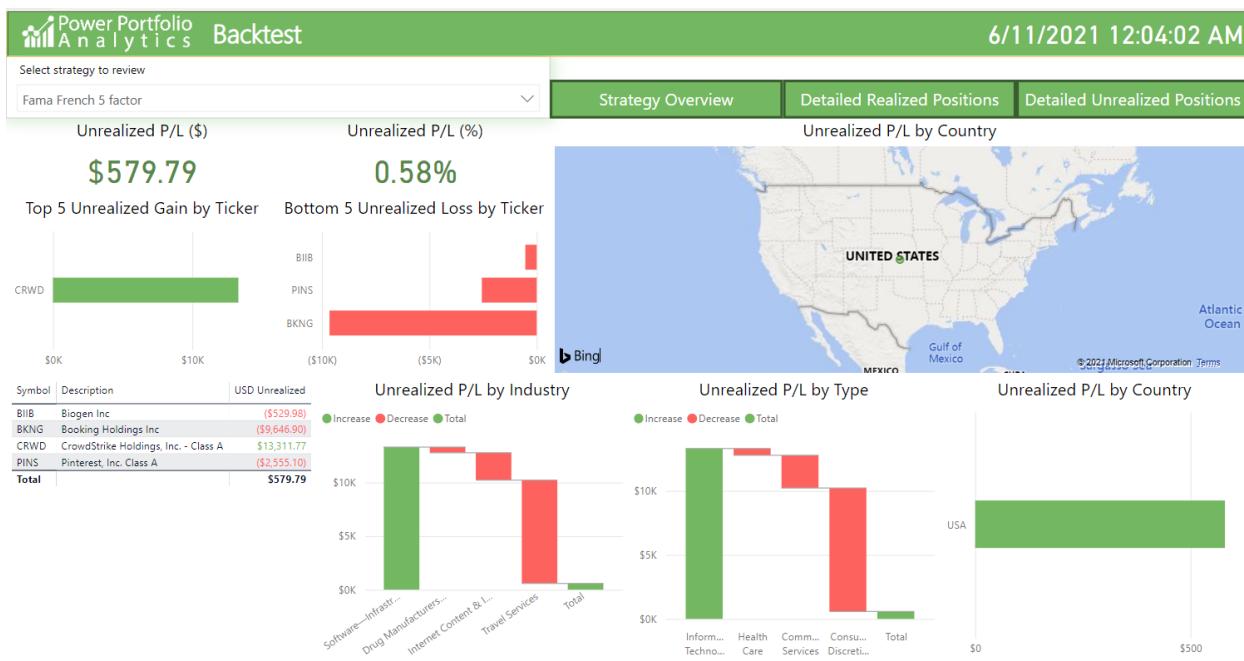
From the charts above, QuantConnect table has a backtesting chart, results statistics tab and also the code tab which you can clone directly if you have a QuantConnect account.

All the remaining setup of the results is similar to what is in the Overview and Portfolio tab as it has the breakdown of realized or unrealized trades by symbol, top 5 highest and lowest, country instruments and industries as shown below:

Backtest - Realized tab:



Backtest - Unrealized tab:



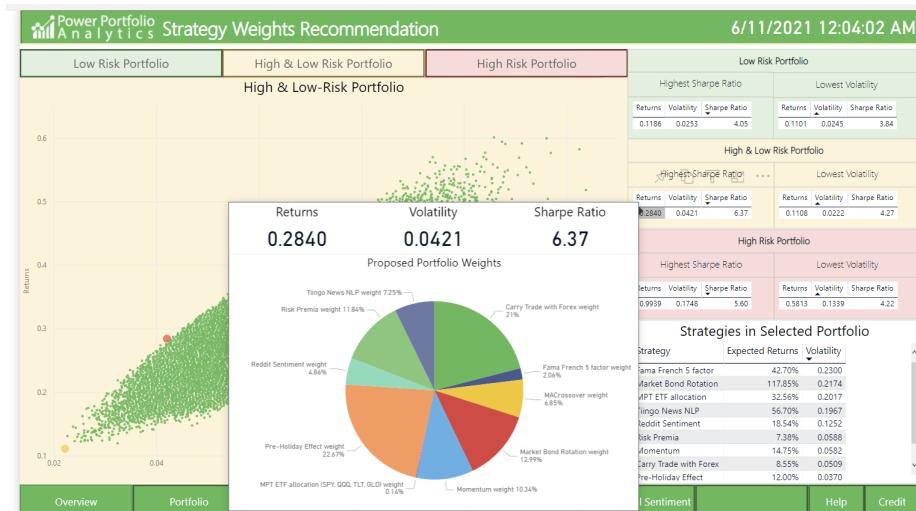
Recommendation Tab

This tab uses the results obtained from the MPT python script (documented in [Phase 2 Strategy Documentation Report](#)). The results are divided into 3 portfolio categories: Low Risk, High & Low Risk and High Risk.

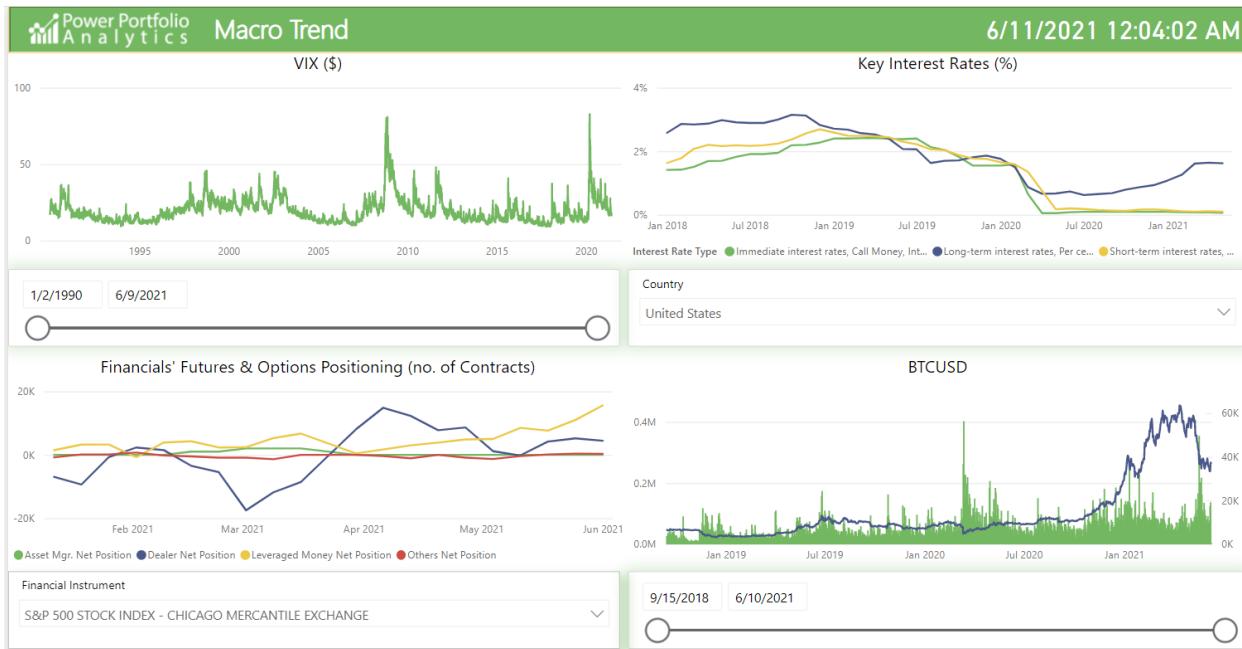


The table above uses the High & Low Risk portfolios mix and the red dot is the efficient frontier (i.e. highest returns with the lowest volatility).

If you hover at the red dot or on the results pane you can see it will show the recommended equity allocation for each strategy (as seen in the table below) . A note, you can select the non-red dot to see the selected equity allocation as well.



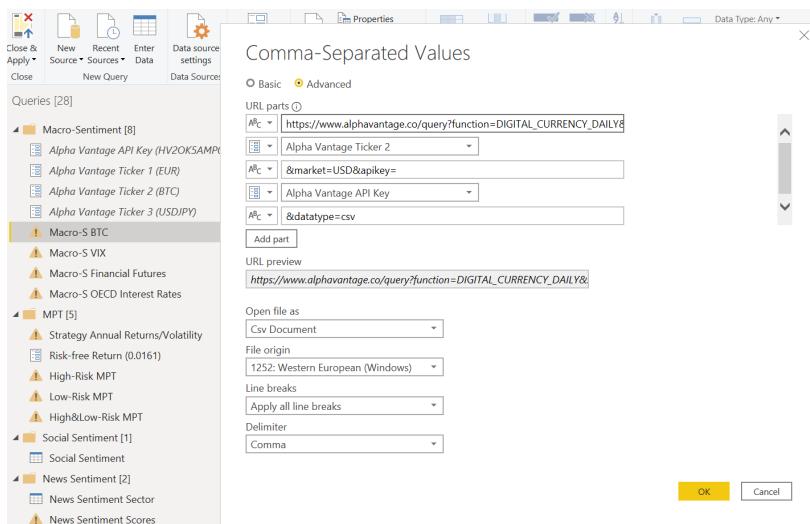
Macro Trend Tab



This tab set-up uses the same indicators for VIX and Key Interest Rates ((documented in [Phase 1 Documentation](#)) except for:

- Financials' Futures & Options (no. of Contracts) which is directly imported from Commodity Futures Trading Commission (CFTC) website and use pandas to extract the information into data frames before import into Power BI as below:

```
"import pandas
df = pd.read_csv("https://www.cftc.gov/files/dea/history/com_fin_txt_2021.zip")"
```
- BTC USD in which we use Alpha Vantage API to link to Power BI as shown below:



News/Social Sentiment Tab



The information used to populate the above dashboard above are from the information gathered from Reddit's Sentiment Strategy in Phase 2 to come out with the charts.

Link to the python scripts to extract the information - [link](#)

The sentiment news can be further selected by selecting through sector and or ticker.

If you select any of the headlines news, a separate browser page will show you the content of the selected headline news.

Help Tab

 By clicking in the Help Tab at selected tabs (Overview, Portfolio, Backtest, Recommendation, Macro Trend and News/Sentiment, an overlay over the tab will be shown with some explanations for each tab purpose and how to use it.

The overlay ‘Help’ function on Overview Tab:

File Power Portfolio Analytics Dashboard Overview

Invested Amount \$100.00K	Realised P/L (\$): \$281K	Open P/L (\$): (-\$464.73)
Balance Amount \$102.34K	Realised P/L (%): 2.81%	Open P/L (%): -0.46%

Date Time Impact

Open Positions

Symbol	Type	Time	Strategy	Holding (USD)	Price	Last Price	Quantity	Unrealized Gain/Loss (USD)
EURUSD	Forex	Wednesday, 10 February 2021	Shows open trading positions	8512	1.1913	1.1913	1	\$40.94
USDCAD	Forex	Wednesday, 10 February 2021		683	1.3828	1.3828	1	\$34.98
TLT	ETF	Monday, 24 May 2021	Market Bond Rotation	2,658.10	138.2807	139.9000	19	\$30.77
USDCHF	Forex	Saturday, 10 April 2021	MACrossover	682.00	0.9243	0.8992	-682	\$19.04
EURUSD	Forex	Tuesday, 13 April 2021	MACrossover	697.05	1.1913	1.2165	573	\$14.47
Total				\$50,393.57				(-\$464.73)

Excess Liquidity

Current Portfolio

Treemap of current portfolio by instrument type

Overall Portfolio Performance

Individual Strategy Performance

Strategy % Performance vs Expected Annual Returns

Sum of % Performance Sum of Expected Returns

Graphically shows performance of strategies within the overall portfolio.

Strategy Selection:

- Select all
- Carry Trade with...
- Fama French 5 f...
- MACrossover
- Market Bond R...
- Momentum
- MPT ETF allocat...
- Pre-Holiday Eff...
- Reddit Sentiment
- Risk Diversia...

Shows performance of strategies within the overall portfolio.

Click here to follow link ↗

The overlay help function on Portfolio Tab:

Power Portfolio Analytics Portfolio

Click to choose display either Realized or Unrealized positions.

Realized Gain/Loss (USD) by Country

Top 5 Performing

Symbol	Strategy	Realized Gain/Loss (USD)
CLOV	Reddit Sentiment	\$1,716.52
PLTR	Fama French 5 factor	(\$50.00)
PLTR	Reddit Sentiment	\$791.18
SPCE	Reddit Sentiment	\$861.14
WDC	Market Bond Rotation	\$483.39

Bottom 5 Performing

Symbol	Strategy	Realized Gain/Loss (USD)
MARA	Fama French 5 factor	(\$74.45)
ENPH	Market Bond Rotation	(\$201.32)
MARA	Market Bond Rotation	(\$441.66)
QCOM	Market Bond Rotation	(\$287.04)
TSLA	Market Bond Rotation	(\$127.78)

Realized Positions by Sector

Realized Positions by Instrument

Strategy Performance

Strategy	Strategy Allocation (USD)	Strategy Allocation (%)	Realized Gain/Loss (USD)	Unrealized Gain/Loss (USD)	Strategy Balance (USD)
Tingo News NLP	\$7,250.00	7.25%	\$272.32	(\$20,72)	\$7,522.32
Risk Premia	\$11,840.00	11.84%	\$180.88	(\$20,72)	\$12,000.17
Reddit Sentiment	\$4,860.00	4.86%	\$1,689.77		\$6,549.77
Pre-Holiday Effect	\$22,670.00	22.67%	(\$6.25)		\$22,663.75
MPT ETF allocation	\$140.00	0.14%			\$140.00
Momentum	\$10,340.00	10.34%	\$40.94		\$10,380.94
Market Bond Rotation	\$12,990.00	12.99%	\$19.42		\$13,828.10
MACrossover	\$6,850.00	6.85%	(\$1.13)		\$6,900.15
Fama French 5 factor	\$2,060.00	2.06%	(\$139.15)		\$1,92
Carry Trade with Forex	\$21,000.00	21.00%	(\$10.62)		(\$554.92)
Total	\$100,000.00	100.00%	\$2,805.26	(\$464.73)	\$102,34

Overview Portfolio Backtest Recommendation Macro Trend News/Social Sentiment Help Credit

The overlay help function on Backtest Tab:

Power Portfolio Analytics Backtest

Select strategy to review: Choose strategy back test results to view.

6/11/2021 12:04:02 AM

Invested Amount	Realized P/L (\$)	Open P/L (\$)	Realized Gain/Loss by Symbol	Unrealized Gain/Loss by Symbol
\$100K	\$124.96K	\$579.79	W OKTA CRWD BYND PINS PLUG COUP	CRWD BILB PINS BKNG
Balance Amount	Realized P/L (%)	Open P/L (%)	\$0K	\$0K
\$225.54K	124.96%	0.58%		

Realized Gain/Loss by Symbol

Unrealized Gain/Loss by Symbol

Choose to view the overview or realized or unrealized position details

Strategy Overview Details Realized Positions

Charts Statistics Code CloneAlgorithm 0 QUANTCONNECT

Shows the performance of the strategy. The tabs also show other back test performance figures and the code of the selected strategy.

Overview Portfolio Backtest Recommendation Macro Trend News/Social Sentiment Help Credit

The overlay help function on Recommendation Tab:

Power Portfolio Analytics Strategy Weights Recommender

Select the portfolio (Low, High, High&Low) efficient frontier plot from the tabs.

6/11/2021 12:04:02 AM

Low Risk Portfolio High & Low Risk Portfolio High Risk Portfolio

High-Risk Portfolio

This area is the efficient frontier plot which shows the returns/vs risk of a basket of strategies of varying risk.

1) Low-risk portfolio: Strategies with risk <0.177
2) High & low risk portfolio: Strategies with all variations of risk.
3) High & risk portfolio: Strategies with risk >0.177.

Mouse-over the data points to see the weights recommendation of varying returns vs risk.

Low Risk Portfolio

Returns	Volatility	Sharpe Ratio	Returns	Volatility	Sharpe Ratio
0.1186	0.0245	3.84	0.0245	0.0222	4.27

High Risk Portfolio

Returns	Volatility	Sharpe Ratio	Returns	Volatility	Sharpe Ratio
0.9939	0.1748	5.60	0.5813	0.1339	4.22

Mouse-over the table to see the strategy weights for the various optimized basket of strategies.

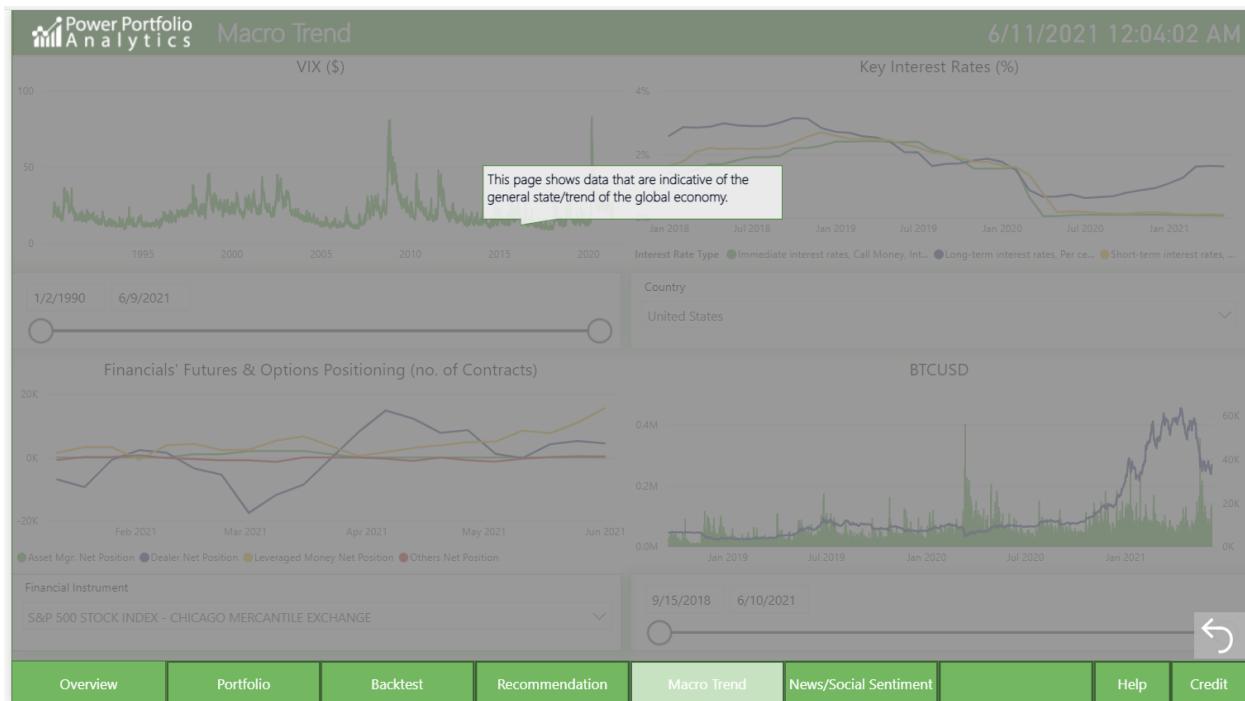
Shows the strategies under consideration in each of the portfolios.

Strategy Expected Returns Volatility

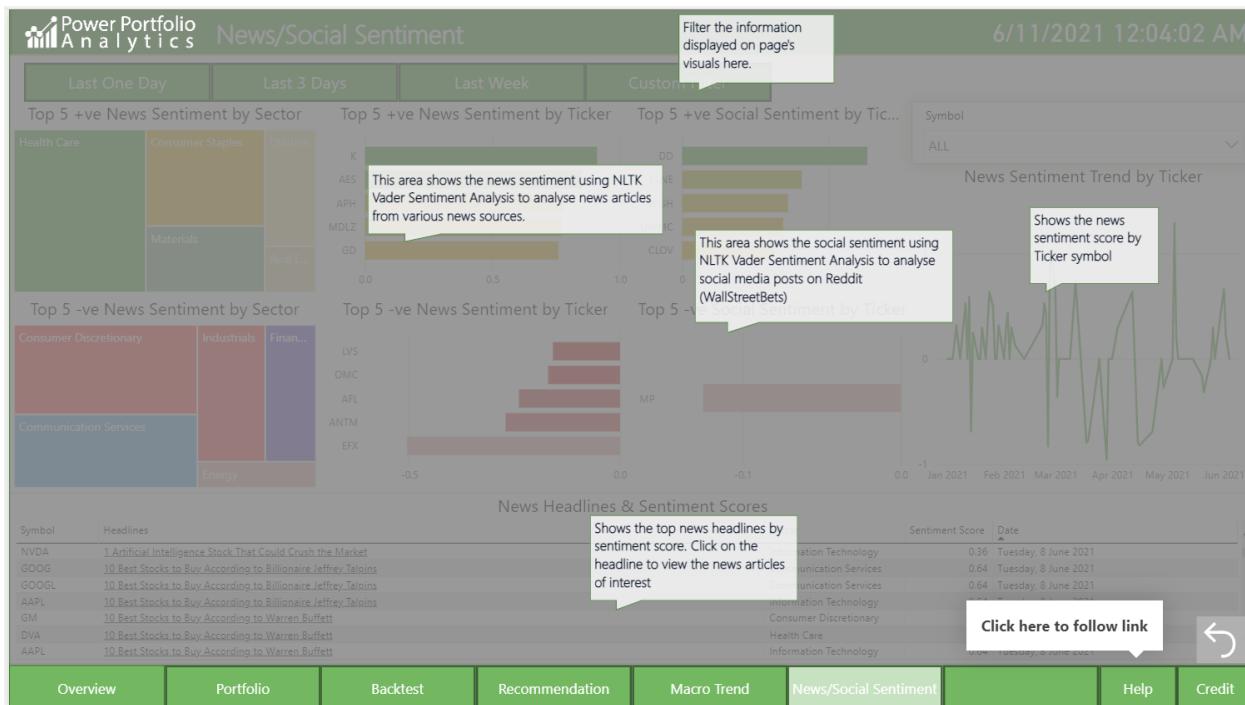
Strategy	Expected Returns	Volatility
Fama French 5 factor	42.70%	0.2300
Market Bond Rotation	117.85%	0.2174
MPT ETF allocation	32.56%	0.2017
Tilango News NLP	56.70%	0.1967

Overview Portfolio Backtest Recommendation Macro Trend News/Social Sentiment Help Credit

The overlay help function on Macro Trend Tab:



The overlay help function on News/Social Sentiment Tab:



Feasibility Analysis

I. Economic Feasibility

The tables below show the estimated annual costs involved for implementing the project as a business and minimum number of subscribers required for the business to breakeven.

Operating Costs ⁷⁷	Cost/Annum (USD)
Power BI	\$480
Financial Data	\$600
Cloud Computing Services	\$1,350
Python/BI Developer	\$84,000
Compliance/Regulatory Executive	\$60,000
Marketing Executive	\$60,000
	\$206,430

Table 1: Estimated Annual Operating Costs

User Numbers Analysis	Numbers/ Month
Breakeven revenue /month (USD)	\$17,203
Minimum number of subscribers required to breakeven	174
Minimum number of platform users required to breakeven	1337

Table 2: User Numbers Analysis

From table 2, it is observed that a minimum of 174 subscribers per month are required for the business to breakeven. This figure can be extrapolated to the minimum number of platform users of 1,337 (free & paid) based on our survey results which show that a rough 13% of users are likely to subscribe to the paid plan.

It is important to note that the calculations do not take into account revenue generated by optional strategy subscriptions and also the potential of tie-ups with brokers and financial data providers. The minimum number of subscribers and platform users will be reduced should these additional revenue streams be considered.

⁷⁷ Estimated cost, it excludes hardware (i.e. laptop), infrastructure (office, utilities) and license cost requirement by MAS. The costs of the founders are part of the suggested manpower cost. The computation also excludes possible grants that can be obtained from SG government.

II. Technology Feasibility

This project utilises Microsoft Power BI as a reporting platform. Most potential users may be unfamiliar with Power BI as a tool but its similarity to Microsoft Excel and Powerpoint, as well as its ability to offer a mobile application-like experience will allow users to quickly learn how to use and consume the product. In addition, published Power BI reports can be directly viewed across the internet without the requirement of local software installation. Developers will likewise find the similarity to other Microsoft applications and systems an advantage when building product features.

The project also heavily utilizes Quantconnect as a platform for building, developing and testing trading/investing algorithms. Quantconnect offers developers the choice of Python or C# (the 2nd and 5th most popular programming languages as of June 2021 (TIOBE Software BV, 2021))⁷⁸ as the programming language of choice. Sourcing developers for Python should be relatively easy given the current popularity of the Python programming language.

Should the product go into production, backend services enabling constant data and financial markets & news data gathering & processing, will need to be set-up. The solution of choice would be to procure processing and storage from a cloud services provider such as Microsoft Azure, Amazon Web Services(AWS) or Google Cloud Platform(GCP). Such services offer the advantages of low start-up costs and time overheads and offer dynamic resource allocation. In addition, they offer advanced computing monitoring tools.

⁷⁸ From the Article: [TIOBE - The Software Quality Company.](https://www.tiobe.com/tiobe-index/)

Future Enhancements

Area	Enhancement
Backtesting	<p>Upgrade Quantconnect to premium member to:</p> <ul style="list-style-type: none"> • Lift backtest time delay (20 sec delay) and transaction limit (limited to 10k per backtest). • Allow deployment of the strategy straight to live paper trading mode (instead performing backtest). • Use the optimization function instead of manually optimizing the parameters to get the best mix of results. • Ability to identify the fees incurred by the trades (currently it only provide a lump sum figure with no breakdown by trades)
Strategies	<ul style="list-style-type: none"> • All equity strategies - To consider having other non-US exchange strategies on top of existing US exchange strategies. Potential to explore other deep and liquid markets such as Japan, Germany, United Kingdom and Hong Kong for increased diversification and opportunities. • Crypto currencies as an alternative investment strategy subject to regulatory acceptance. • ESG equities. (data need to be paid to obtain) • Twitter sentiment. • MPT to have minimum amount placement for the strategy to run. (Currently the strategy won't run if the amount recommended by the MPT is less than what it need to run) • To roll out features where MPT can be customised based on strategies chosen. • Introduce a strategy marketplace where the choice of strategies offered to the users can be expanded.
Backend Processing	<ul style="list-style-type: none"> • Establish a server/service able to constantly run backend Python scripts to enable near real-time information gathering and processing of data feeds leading into Power BI.
Power BI Data Integration	<ul style="list-style-type: none"> • Dashboards - to hide the strategy code (currently the quantconnect table includes the code tab as well). • Dashboards - to provide fees breakdown. • Dashboards - to introduce a 'beginner' dashboard to cater to the beginner to immediate users. • Dashboards - to introduce mobile versions of the dashboard. (currently the dashboard is configured for computer screen viewing) • Direct import of trading data with less or automated sanitization - currently need to download the orders and manually sanitize to get the datas. • Introduce more direct data feeds to Power BI to address performance issues and eliminate potential sources of failure (currently some data passes through Python scripts to a file in Google Drive and then published to the web for import into Power BI)

	<ul style="list-style-type: none"> • Introduce real-time streaming data into Power BI for near real-time data changes and updates. • Mining customer favorite instruments in their pick list to test against the strategies. • MPT of the strategies being refreshed quarterly to ensure the mix of high and low is up to date. • APIs to connect to various brokerage firms • Allow datasets (i.e. interest rate information) to be downloaded by users. • To explore other news feed sources such as company announcements and corporate actions. • Video demos/ academy to increase user familiarity and adoption.
Integrate with other trading platforms	<ul style="list-style-type: none"> • Opportunity for partnerships with financial/trading providers to integrate our prototype's features and functionality into their trading platforms.

Conclusion

The objective of this project has been to design and develop an intelligent systematic trading system leveraging the fundamentals of investing, data visualisation and automation.

During the design thinking phase of the project, we have been able to define metrics important to our targeted user defined as the trading/investing enthusiast.

Subsequently, we were able to connect to a multitude of data sources including web-scraping data off financial internet websites and connect to freely available financial APIs.

We explored different fundamental and technical trading indicators and developed automated trading strategies, backtested them, and obtained the expected returns and risk involved. These strategies were packaged into several sets of portfolios based on different risk profiles (Modern Portfolio Theory Efficient Frontier) which are user-selectable.

Finally, we have integrated all the above features into a user-friendly Power BI dashboard with highly-interactive visualizations and including features such as a news & social sentiment indicator based on Natural Language Processing. This allows the user to make profitable trading/investing decisions.

Overall, the learning objectives of the project have been met.

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 - 4.3. Detail of backtest results for Forex Carry Trade: [Frame 1](#), [Frame 2](#), [Frame 3](#), [Frame 4](#)
 - 4.4. Details of backtest results for MA Crossover: [Frame 1](#), [Frame 2](#), [Frame 3](#) and [Frame 4](#)
 - 4.5. Details of backtest results for Risk Premia [Frame 1](#), [Frame 2](#) and [Frame 3](#)
 - 4.6. Details of backtest results for Momentum Strategy [Frame 1](#), [Frame 2](#) and [Frame 3](#)
 - 4.7. Details of backtest results for MPT ETF Allocation Strategy [Frame 1](#), [Frame 2](#), [Frame 3](#) and [11 years](#)
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