Portfolio selection report for manager

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1 Introduction

1.1 Background

The stock market has had great fluctuations in the last 2 years. Major public events like the pandemic caused by Coronavirus, the trade war between China and the U.S. influenced the market remarkably. And recently it plummeted due to a loss of confidence as a result of the conflict between Ukraine and Russia. As a result, when putting together the portfolio, a conservative approach was used. The U.S. market is targeted at begin because it is stable and large. Firstly, it is widely known that the U.S. is the largest economy in the world, influencing the global economy and is a globalised investment. Additionally, the U.S. capital markets bring together capital from all over the world and most of the world's leading companies choose to list in the U.S., even if some do not list directly in the U.S. but choose to issue in the U.S. That means that there are more options to invest in compared to other stock markets. Hence, we have decided to invest in the U.S. market.

1.2 Portfolio Establishing Steps

· Come up with a Mathematical Model
· Solve the model
· Deduce the actual decision

2 Modeling

By constructing a mathematical model which consists of two specific modules, the financial decision can be quantified, this helps us to distinguish the merits of our decisions.

2.1 Stocks Choosing

To effectively resist market shocks and turbulence, it is a good choice to select stocks from the S&P500. The logic behind this is equivalent to focusing on the U.S. Stocks market: big companies are more resilient to risk than smaller companies. S&P 500 is consists of the largest companies' stocks in the U.S. market. After deciding the general range, an initial screening of the industries is required, due to the restriction on the scale of the portfolio.

And at the same time, the covariance tables and the S&P500 industry composition weightings are taken into account to determine which industry to invest in and the weighting of inputs. The reason for taking this action is that the lower the total correlation of a stock with the total return, the more desirable the particular stock is to the portfolio. The correlation table is shown below:

Table 1 – Correlation Analysis

	Consumer Staples	Consumer Discretionary	Energy	Financials	Health-Care	Industrials	Information Technology	Materials	Real Estate	Communication Services	Utilities	Overall
Consumer Staples	1	0.825948352	0.803812053	0.758929608	0.84306807	0.838403217	0.821037065	0.789596135	0.749730146	0.811327071	0.815905829	0.879531243
Consumer Discretionary	0.825948352	1	0.875480464	0.882583767	0.840330535	0.938802974	0.911031912	0.888599359	0.894979076	0.773647166	0.785404611	0.958656375
Energy	0.803812053	0.875480464	1	0.859842468	0.842365224	0.90839511	0.84513993	0.902284659	0.822065932	0.764198266	0.839680635	0.938663019
Financials	0.758929608	0.882583767	0.859842468	1	0.790502634	0.896222584	0.841165737	0.873209758	0.883661708	0.738000176	0.772924251	0.937475069
Health-Care	0.84306807	0.840330535	0.842365224	0.790502634	1	0.852168544	0.848599162	0.801971895	0.753409551	0.776845588	0.804116774	0.902868658
Industrials	0.838403217	0.938802974	0.90839511	0.896222584	0.852168544	1	0.901144552	0.918647909	0.874430223	0.779386878	0.81700894	0.969039162
Information Technology	0.821037065	0.911031912	0.84513993	0.841165737	0.848599162	0.901144552	1	0.83631739	0.811452672	0.754776399	0.793361499	0.945684732
Materials	0.789596135	0.888599359	0.902284659	0.873209758	0.801971895	0.918647909	0.83631739	1	0.853707445	0.749118742	0.768952507	0.926970202
Real Estate	0.749730146	0.894979076	0.822065932	0.883661708	0.753409551	0.874430223	0.811452672	0.853707445	1	0.718232156	0.772477471	0.894079736
Communication Services	0.811327071	0.773647166	0.764198266	0.738000176	0.776845588	0.779386878	0.754776399	0.749118742	0.718232156	1	0.754573978	0.822970168
Utilities	0.815905829	0.785404611	0.839680635	0.772924251	0.804116774	0.81700894	0.793361499	0.768952507	0.772477471	0.754573978	1	0.860427666
Overall	0.879531243	0.958656375	0.938663019	0.937475069	0.902868658	0.969039162	0.945684732	0.926970202	0.894079736	0.822970168	0.860427666	1

Figure 1: The correlation between industries

As a result, the selected sectors are: The technology industry, Medical industry, Financial industry, Raw material industry and Industrial. Among all these sectors, we decide to invest most of our money in the technology industry which is the most popular industry of the moment, attracting investors from all over the world. And medical stocks make up a large part of our portfolio since they have grown spectacularly in previous years due to the coronavirus pandemic. Raw material industry and Industrial are chosen because the tensions between Russia and Ukraine may create a need for countries to prepare large amounts of energy and materials for war. Last but not least, we choose the financial industry because its correlation is lower compared to other industries that have not been selected. The next step is choosing stocks from each industry. Tesla and SQ in the technology industry were added to the stock list at the very beginning since they are excellent in some respects. Then a rating system was created and applied to select the top 30 stocks. This system is consists of 5 key scoring criteria: P/E Ratio (Price to Earnings ratio), QEG (Quarterly Earnings Growth), ROE(Return on Equity), TADY(Trailing Annual Dividend Yield), PEG(Price Earnings to growth). Reasons for choosing these ratios are listed below:

- P/E Ratio: Assessing the reasonableness of the share price level.

- Quarterly Earning Growth: This gives an idea of how much a company's sales are increasing over time.

- Return on Equity: a gauge of a corporation's profitability and how efficient it is in generating profits.

- Trailing Annual Dividend Yield: an estimation of a year's dividend expressed as a percentage of the current stock price.

- Price /Earnings to Growth: Consider the future growth prospects and a dividend yield of the stock.

2.2   The Construction of optimal portfolio

The theoretical basis for portfolio construction is CAPM(Capital Asset Pricing Model), which gives parameters to judge whether a portfolio is efficient. And it describes the relationship between the systematic risk and expected return of an asset, assessing whether it is appropriately valued by comparing its risk and time value with its expected return, where the risk-free rate is used to calculate the time value and the other components taken into account the additional risk borne by the investor. By this model, we can determine the highest return with fixed volatility by maximising the Sharpe ratio — the average return earned more than the risk-free rate per unit of volatility or total risk.

3   Solve the Model

3.1   Data collection

The major tool used to obtain the data from Yahoo Finance is Python, and all data was obtained across a long period (From 2001/12 to 2021/12) to ensure the reliability and accuracy of the information.

3.2   Obtain parameters

The major parameters involved in the previously mentioned rating modules (P/E, QEG, ROE, TADY, PEG) were obtained directly from Yahoo Finance. For some annual data that could not be collected directly, the average of four quarters was used instead. For the few stocks for which historical statistics were not available, the appropriate method was chosen (shortening the number of years for which data were required, etc.). The recommended criteria of each parameter are listed below:
(Points are awarded in descending order of ranking, except the P/E ratio which the lower they prefer.)

$\cdot ROE$: The higher the better —multiply 1 in calculating the score

$\cdot P/E$: lager than 10 less than 20 —multiply 1/4 in calculating the score, since there are around 120 stocks been chosen

$\cdot QEG$: larger than 0.25—multiply 1 in calculating the score

$\cdot TADY$: The higher the better—multiply 1 in calculating the score

$\cdot PEG$: The growth of P/E ratio—multiply 1 in calculating the score

3.3 Identify stocks to get an Optimal portfolio

All of the stocks were rated through the rating system by group according to their industry. Combine the screened stocks based on sector (like, choose 10 out of 15 technology stocks every time) use python to estimate their performance and decide the final 17 stocks as the components of the portfolio. The basic parameters involved in the second stage are expected return, volatility and beta(Systematic risk measure for a particular stock) The expected return is calculated by $E[r_i] = r_f + \beta * E[r_{market}]$ and volatility is calculated by $\sigma_i = \sqrt{x_i^2 * \sigma_i^2 + x_j^2 * \sigma j^2 + 2 * x_i * x_j * \sigma i * \sigma j}$ which can help determine some advanced parameters: such as risk-premium(expected return - risk-free rate) , Sharpe ratio — the key parameter to get optimal portfolio was calculated by $\frac{E[r_p]-r_f}{\sigma_i}$ and the percentage of each stock to achieve the optimal portfolio can be obtained by maximising the Sharpe ratio. The maximising step is mainly by the solver of Excel and key feature about our portfolio stocks are showed below.

The selected stocks list and their data for five parameters are:

Stocks	CSCO	QCOM	AMAT	LRCX	KLAC	LMT
ROE(%)	30.08	106.74	56.07	76.64	85.36	74.31
P/E	20.09	19.58	18.9	17.88	18.41	17.99
QEG(%)	16.8	38.5	58.6	37.5	56.9	14.3
TADY(%)	2.7	1.6	0.72	0.99	1.09	2.68
PEG	2.79	0.94	2.01	1.25	1.63	3.84
Stocks	TSLA	AAPL	CI	REGN	PFE	BX
ROE	20.43	145.57	11.1	54.21	31.87	68.19
P/E	165.28	27.34	14.8	8.6	12.14	15.84
QEG	759.6	20.4	-73	94	301.1	86.7
TADY	0	0.53	1.78	0	3.39	3.35
PEG	2.39	3.2	0.92	5.04	1	1.56
Stocks	HII	NVDA	SQ	AMCR	MS	
ROE	23.1	44.83	5.3	20.52	14.38	
P/E	14.8	62.75	363.09	19.16	11.77	
QEG	-11.8	106.1	N/A	2.7	9.2	
TADY	2.4	0.07	0	4.14	2.67	
PEG	1.18	3.19	1.38	N/A	3.87	

Figure 2: Data for 5 parameters

Most of these are chosen due to high points in their industry, from the table we can see that they are either well-balanced or well-performed in some indicators.
The selected stocks' correlation are:

Asset Correlations

Name	Ticker	CSCO	QCOM	AMAT	LRCX	KLAC	LMT	TSLA	AAPL	CI	REGN	PFE	BX	HII	NVDA	SQ	AMCR	MS
Cisco Systems, Inc.	CSCO	1.00	0.14	0.57	0.41	0.51	0.39	0.08	0.31	0.58	0.00	0.52	0.41	0.60	-0.05	0.20	0.64	0.56
QUALCOMM Incorporated	QCOM	0.14	1.00	0.34	0.52	0.46	0.26	0.44	0.68	0.07	-0.06	0.63	0.28	-0.10	0.47	0.28	0.28	0.31
Applied Materials, Inc.	AMAT	0.57	0.34	1.00	0.82	0.78	0.28	0.21	0.23	0.56	-0.09	0.27	0.44	0.50	0.14	0.49	0.43	0.72
Lam Research Corporation	LRCX	0.41	0.52	0.82	1.00	0.69	0.24	0.19	0.33	0.31	-0.25	0.34	0.30	0.32	0.13	0.37	0.20	0.56
KLA Corp	KLAC	0.51	0.46	0.78	0.69	1.00	0.27	0.29	0.39	0.45	-0.24	0.27	0.46	0.29	0.11	0.29	0.30	0.59
Lockheed Martin Corporation	LMT	0.39	0.26	0.28	0.24	0.27	1.00	0.29	0.40	0.33	-0.29	0.45	0.36	0.54	0.00	0.21	0.53	0.44
Tesla Inc	TSLA	0.08	0.44	0.21	0.19	0.29	0.29	1.00	0.72	0.22	-0.08	0.17	0.37	0.03	0.41	0.65	0.36	0.47
Apple Inc.	AAPL	0.31	0.68	0.23	0.33	0.39	0.40	0.72	1.00	0.22	-0.00	0.43	0.37	0.13	0.45	0.48	0.51	0.51
Cigna Holding Co	CI	0.58	0.07	0.56	0.31	0.45	0.33	0.22	0.22	1.00	0.07	0.28	0.31	0.58	-0.13	0.15	0.43	0.50
Regeneron Pharmaceuticals, Inc.	REGN	0.00	-0.06	-0.09	-0.25	-0.24	-0.29	-0.08	-0.00	0.07	1.00	0.07	-0.07	-0.16	0.42	0.11	0.11	-0.13
Pfizer, Inc.	PFE	0.52	0.63	0.27	0.34	0.27	0.45	0.17	0.43	0.28	0.07	1.00	0.31	0.27	0.28	0.04	0.41	0.26
Blackstone Inc	BX	0.41	0.28	0.44	0.30	0.46	0.36	0.37	0.37	0.31	-0.07	0.31	1.00	0.50	0.26	0.43	0.48	0.68
Huntington Ingalls Industries, Inc.	HII	0.60	-0.10	0.50	0.32	0.29	0.54	0.03	0.13	0.58	-0.16	0.27	0.50	1.00	-0.19	0.18	0.56	0.63
NVIDIA Corporation	NVDA	-0.05	0.47	0.14	0.13	0.11	0.00	0.41	0.45	-0.13	0.42	0.28	0.26	-0.19	1.00	0.38	0.27	0.19
Square, Inc.	SQ	0.20	0.28	0.49	0.37	0.29	0.21	0.65	0.48	0.15	0.11	0.04	0.43	0.18	0.38	1.00	0.49	0.66
Amcor plc	AMCR	0.64	0.28	0.43	0.20	0.30	0.53	0.36	0.51	0.43	0.11	0.41	0.48	0.56	0.27	0.49	1.00	0.74
Morgan Stanley	MS	0.56	0.31	0.72	0.56	0.59	0.44	0.47	0.51	0.50	-0.13	0.26	0.68	0.63	0.19	0.66	0.74	1.00

Figure 3: Stock's correlation

The correlations between them are low overall so they are unlikely to move together when some surprising news is released, and the portfolio could better resilience to risk, reducing the situation that most of the stocks fall at the same time.

The selected stocks list and their betas are:

Stocks	CSCO	QCOM	AMAT	LRCX	KLAC	LMT
BETA	0.98	1.26	1.41	1.25	1.23	0.85
Stocks	TSLA	AAPL	CI	REGN	PFE	BX
BETA	2.01	1.19	0.88	0.19	0.68	1.3
Stocks	HII	NVDA	SQ	AMCR	MS	
BETA	0.98	1.38	2.37	0.41	1.45	

Figure 4: Consists of chosen portfolio and their betas

The beta shows stocks sensitive to the market, the portfolio contains both high beta stocks and low beta stocks. Achieving that the portfolio increasing while the market performs well, and keep stable or reduce loss when market performing poorly.

The selected stocks list and their historical monthly returns are:

Year	Month	Maximum Sharpe Ratio Return	Balance	Vanguard 500 Index Investor Return	Balance	Cisco Systems, Inc. (CSCO)	QUALCOMM Incorporated (QCOM)	Applied Materials, Inc. (AMAT)	Lam Research Corporation (LRCX)	KLA Corp (KLAC)	Lockheed Martin Corporation (LMT)	Tesla Inc (TSLA)	Apple Inc. (AAPL)	Cigna Holding Co (CI)	Regeneron Pharmaceuticals, Inc. (REGN)	Pfizer, Inc. (PFE)	Blackstone Inc (BX)	Huntington Ingalls Industries, Inc. (HII)	NVIDIA Corporation (NVDA)	Square, Inc. (SQ)	Amcor plc (AMCR)	Morgan Stanley (MS)
2019	7	6.71%	$10,671	1.43%	$10,143	1.85%	-3.83%	9.93%	11.06%	15.33%	-0.38%	8.12%	7.64%	7.85%	-2.63%	-10.34%	9.07%	1.58%	2.73%	10.86%	-7.75%	2.51%
2019	8	-0.27%	$10,642	-1.59%	$9,981	-15.51%	6.30%	-2.90%	0.91%	9.12%	6.67%	-6.62%	-1.64%	-9.39%	-4.83%	-7.61%	3.71%	-8.07%	-0.62%	-23.09%	-7.36%	-6.89%
2019	9	3.91%	$11,058	1.86%	$10,167	5.55%	-1.15%	3.92%	10.33%	7.81%	1.55%	6.76%	7.30%	-1.42%	-4.36%	1.07%	-1.85%	1.33%	3.92%	0.18%	0.47%	2.84%
2019	10	12.94%	$12,489	2.15%	$10,386	-3.13%	5.45%	8.74%	17.28%	6.01%	-3.43%	30.74%	11.07%	17.57%	10.41%	6.79%	8.85%	6.55%	15.48%	-0.84%	-2.36%	8.74%
2019	11	5.88%	$13,223	3.62%	$10,762	-4.63%	3.87%	7.08%	-1.55%	-2.60%	4.45%	4.77%	7.75%	12.03%	20.48%	1.37%	2.93%	11.98%	7.90%	12.52%	8.99%	7.45%
2019	12	8.48%	$14,345	3.01%	$11,085	5.85%	6.40%	5.42%	10.05%	8.73%	-0.42%	26.79%	9.88%	2.29%	1.76%	1.71%	3.17%	-0.31%	8.56%	-9.49%	5.65%	3.31%
2020	1	4.40%	$14,977	-0.05%	$11,080	-3.46%	-3.31%	-5.00%	1.99%	-6.98%	9.95%	55.52%	5.40%	-5.92%	-10.00%	-3.98%	9.17%	4.03%	0.48%	19.39%	-2.31%	2.89%
2020	2	2.89%	$15,409	-8.24%	$10,167	-13.14%	-8.22%	0.55%	-1.60%	-6.79%	-13.05%	2.68%	-11.47%	-4.91%	31.55%	-10.26%	-10.98%	-20.88%	14.30%	11.57%	-11.99%	-13.83%
2020	3	-8.61%	$14,082	-12.37%	$8,909	-1.55%	-12.95%	-21.16%	-17.80%	-6.49%	-8.36%	-21.56%	-6.98%	-3.13%	9.83%	-2.33%	-15.36%	-11.35%	-2.40%	-37.14%	-11.83%	-24.49%
2020	4	14.91%	$16,181	12.81%	$10,050	8.78%	16.29%	8.42%	6.37%	14.16%	14.78%	49.21%	15.54%	10.50%	7.70%	17.52%	14.64%	5.05%	10.88%	24.36%	10.47%	16.97%
2020	5	11.09%	$17,976	4.76%	$10,528	12.84%	2.81%	13.52%	7.20%	7.78%	0.46%	6.79%	8.50%	0.79%	16.53%	0.58%	9.57%	4.97%	21.47%	24.47%	15.15%	12.10%
2020	6	9.61%	$19,703	1.98%	$10,737	-2.47%	13.64%	7.60%	18.64%	10.53%	-6.05%	29.32%	14.74%	-4.90%	1.77%	-14.38%	-0.25%	-12.71%	7.06%	29.43%	0.00%	9.28%
2020	7	9.56%	$21,587	5.63%	$11,341	1.78%	15.79%	6.42%	16.60%	2.75%	3.85%	32.50%	16.51%	-7.97%	1.35%	18.83%	-5.31%	-0.45%	11.76%	23.74%	0.88%	1.92%
2020	8	11.53%	$24,075	7.18%	$12,155	-10.36%	12.77%	-3.92%	-10.82%	3.09%	3.61%	74.15%	21.66%	2.71%	-1.92%	-1.79%	-0.62%	-12.19%	26.00%	22.88%	7.38%	6.91%
2020	9	-5.03%	$22,864	-3.81%	$11,691	-6.70%	-0.67%	-3.49%	-0.98%	-5.56%	-1.79%	-13.91%	-10.25%	-4.49%	-9.70%	-2.88%	-1.42%	-7.11%	1.20%	1.87%	0.91%	-7.48%
2020	10	-2.84%	$22,215	-2.67%	$11,379	-8.01%	4.83%	-0.37%	3.11%	1.78%	-8.65%	-9.55%	-6.00%	-1.44%	-2.90%	-3.32%	-3.41%	4.78%	-7.36%	-4.72%	-5.81%	0.31%
2020	11	20.25%	$26,714	10.94%	$12,623	19.83%	19.30%	39.66%	32.33%	28.27%	4.99%	46.27%	9.55%	25.26%	-5.06%	15.00%	19.25%	9.37%	6.82%	36.21%	9.74%	28.41%
2020	12	4.29%	$27,859	3.84%	$13,108	4.02%	3.96%	4.63%	4.60%	2.75%	-2.75%	24.33%	11.46%	-0.46%	-6.38%	-3.92%	8.83%	6.42%	-2.56%	3.17%	3.88%	10.84%
2021	1	4.35%	$29,071	-1.02%	$12,974	0.44%	2.59%	12.03%	2.47%	8.17%	-9.34%	12.45%	-0.55%	4.26%	4.29%	-1.41%	3.67%	-7.71%	-0.50%	-0.77%	-7.05%	-1.67%
2021	2	3.12%	$29,977	2.75%	$13,332	0.65%	-12.86%	22.47%	17.20%	11.43%	3.43%	-14.87%	-7.97%	-3.29%	-10.57%	-6.71%	4.43%	12.51%	5.58%	6.52%	1.04%	14.65%
2021	3	4.40%	$31,296	4.37%	$13,914	15.24%	-2.16%	13.04%	5.19%	6.15%	11.88%	-1.12%	0.73%	15.66%	5.01%	8.18%	7.66%	17.02%	-2.64%	-1.30%	6.76%	1.03%
2021	4	5.38%	$32,981	5.32%	$14,655	-0.85%	4.68%	-0.67%	4.24%	-4.56%	2.99%	6.21%	7.62%	3.01%	1.72%	6.68%	19.83%	3.14%	12.45%	7.83%	0.60%	6.74%
2021	5	1.90%	$33,608	0.69%	$14,755	3.91%	-3.07%	4.27%	4.74%	0.78%	1.11%	-11.87%	-5.05%	3.95%	4.39%	1.20%	4.72%	2.37%	8.23%	-9.11%	1.44%	10.18%
2021	6	7.63%	$36,172	2.31%	$15,096	0.19%	6.78%	3.09%	0.33%	2.31%	-1.01%	8.71%	9.91%	-8.04%	11.17%	1.11%	4.82%	-2.53%	23.16%	9.56%	-2.88%	0.81%
2021	7	3.32%	$37,375	2.38%	$15,455	5.19%	4.81%	-1.73%	-2.04%	7.39%	-1.77%	1.10%	6.50%	-3.20%	2.88%	10.32%	19.38%	-2.67%	-2.52%	1.42%	0.87%	5.44%
2021	8	5.29%	$39,353	3.03%	$15,923	6.59%	-2.08%	-3.26%	-5.11%	-2.04%	-2.49%	7.06%	4.25%	-7.77%	17.19%	7.62%	9.07%	0.09%	14.82%	8.42%	11.16%	8.80%
2021	9	-5.11%	$37,342	-4.66%	$15,180	-7.78%	-11.66%	-4.74%	-5.67%	-1.60%	-4.09%	5.40%	-6.80%	-4.99%	-10.13%	-6.64%	-7.47%	-5.44%	-7.46%	-10.53%	-8.93%	-6.82%
2021	10	13.18%	$42,263	6.99%	$16,242	3.53%	3.15%	6.15%	-0.98%	11.43%	-3.70%	43.65%	5.87%	6.72%	5.74%	1.70%	19.92%	5.01%	23.42%	6.11%	4.14%	6.34%
2021	11	10.60%	$46,744	-0.71%	$16,128	-2.02%	35.72%	7.89%	20.63%	9.77%	1.14%	2.76%	10.51%	-10.16%	-0.53%	23.93%	2.19%	-11.89%	27.81%	-18.14%	-6.26%	-7.74%
2021	12	0.39%	$46,925	4.47%	$16,848	15.55%	1.67%	6.91%	6.01%	5.39%	6.63%	-7.89%	7.42%	20.24%	-0.79%	9.90%	-8.53%	5.20%	-0.98%	-22.47%	6.10%	3.52%

Figure 5: Monthly return

And finally, the efficient frontier is drawn with a Sharpe ratio of 2.98. This portfolio gives an expected return of 89.43% (annualized monthly) and volatility is 21.83%.
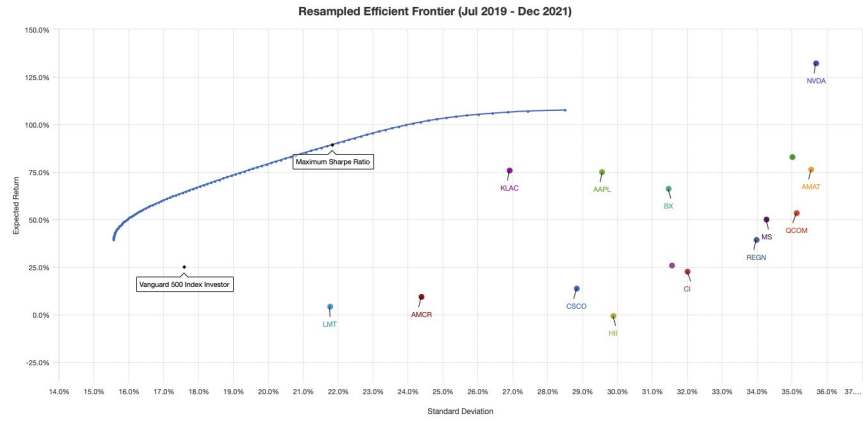
Figure 6: Efficient frontier

And the details is showed below:

Metric	Maximum Sharpe Ratio	Vanguard 500 Index Investor
Arithmetic Mean (monthly)	5.47%	1.88%
Arithmetic Mean (annualized)	89.51%	25.03%
Geometric Mean (monthly)	5.29%	1.75%
Geometric Mean (annualized)	85.59%	23.20%
Standard Deviation (monthly)	6.30%	5.08%
Standard Deviation (annualized)	21.83%	17.59%
Downside Deviation (monthly)	2.11%	2.99%
Maximum Drawdown	-8.61%	-19.63%
US Market Correlation	0.80	1.00
Beta[*]	0.98	1.00
Alpha (annualized)	43.49%	0.00%
R^2	62.75%	100.00%
Sharpe Ratio	2.98	1.25
Sortino Ratio	8.83	2.10
Treynor Ratio (%)	66.20	21.99
Active Return	62.39%	N/A
Tracking Error	13.33%	N/A
Information Ratio	4.68	N/A
Skewness	-0.07	-0.59
Excess Kurtosis	0.34	1.66
Historical Value-at-Risk (5%)	-5.07%	-6.63%
Analytical Value-at-Risk (5%)	-4.72%	-6.47%
Conditional Value-at-Risk (5%)	-6.86%	-10.31%
Upside Capture Ratio (%)	202.76	100.00
Downside Capture Ratio (%)	3.14	100.00
Safe Withdrawal Rate	77.14%	42.98%
Perpetual Withdrawal Rate	38.56%	13.55%
Positive Periods	25 out of 30 (83.33%)	21 out of 30 (70.00%)
Gain/Loss Ratio	1.70	1.12

Figure 7: All details

S&P 500 is treated as a market portfolio that provides a market expected return. U.S. 10 years treasure bond was regarded as the risk-free rate in this model.

4 Superiority and Limitations

4.1 Superiority

The performance of our portfolio is significantly better than the market since our portfolio has a larger expected return while the volatility rarely increased. As you can see in the graphs, the expected return has a tremendous growth while the risk—the value of standard deviation which is also known as volatility only has only arisen 6% which is extremely important in today's circumstances.

Trailing Returns

Name	Total Return			Annualized Return
	3 Month	Year To Date	1 year	Full
Maximum Sharpe Ratio	25.66%	68.44%	68.44%	85.59%
Vanguard 500 Index Investor	10.99%	28.53%	28.53%	23.20%

Trailing returns are as of last full calendar month ending December 2021

Figure 8: comparation

This figure shows the comparison between our portfolio and S&P 500's historical return.

Figure 9: comparation

Figure 10: comparation

Portfolio Performance Summary

Metric	Maximum Sharpe Ratio	Vanguard 500 Index Investor
Start Balance	$10,000	$10,000
End Balance	$46,925	$16,848
Annualized Return (CAGR)	85.59%	23.20%
Expected Return	89.51%	25.03%
Standard Deviation	21.83%	17.59%
Best Year	94.21%	28.53%
Worst Year	43.45%	10.85%
Maximum Drawdown	-8.61%	-19.63%
Sharpe Ratio (ex-ante)	2.98	1.25
Sharpe Ratio (ex-post)	2.98	1.25
Sortino Ratio	8.83	2.10
Active Return	62.39%	N/A
Tracking Error	13.33%	N/A
Information Ratio	4.68	N/A

Figure 11: comparation

4.2 Limitations

Firstly, the stock ratios we considered are limited, which may cause some mistakes. Secondly, the data is not the same every day, which means the risk-free rate is not fixed. Hence, some of the data is inaccuracy.

The four assumptions of CAPM is difficult to satisfy in real-world which are: · All investors

are rational which means only efficient portfolios would be held. · All investors only have homogeneous expectations regarding volatility, correlations, and expected returns. · There exist risk-free bonds and market portfolios which are contradicting the reality. · Investors are invested in a perfect capital market. Additionally, this model does not have a situation-specific discussion. It does not consider the expectation under different situations (like good, normal, bad), but just analysed in a single scenario simply.

5 Conclusions

Generally, a prudent portfolio is constructed due to the instability of the recent market. The portfolio showed below:

Figure 12: The portfolio

The monthly return is 5.47%, the 6-month return is 37.63%, annualized monthly expected return is 89.43% and volatility is 21.83%. With an initial fund of £300,000, we can receive £412,890 after 6 months.