Ahmedabad University

Project: Portfolio Analysis and Optimization

TOD212: Decision Science (Section 1)

Submitted to: Dr. Neha Gadhvi

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Acknowledgment

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Introduction

Perfect market efficiency only exists in the books of finance. The world that we live in is full of uncertainty and has various factors affecting the capital markets. As to beat inflation and yield returns on the liquid funds that one has we tend to direct our energy in managing our funds based on our risk appetite to get the desired returns.

Let us assume a company or people which has a platform which wants to maximize their returns while minimizing the risk taken. The platform seeks to provide customers with a low-cost, high-quality, one-stop online investment solution for their retirement portfolios. The company builds each client's portfolio using algorithms to keep prices down. The algorithms select from a range of investing possibilities and styles.

Our Project includes research that selects the fund with the greatest investment potential using important risk-management indicators which are going to be backed with some visualized stats that helps us understand the outcomes clearly. The funds are American-based private investment management companies which are then compared with the S&P 500 index of the American Equity Markets.

Characteristics of the taken data set:

- The **Net Asset Value** of the specialized funds is presented in the data set of **four different American-based private investment management companies** which are in comparison in **one of the benchmark return indices of the American equity markets.**
- The funds are concocted for people who are securing enough capital for their **retirement** in the form of **passive investment returns**.
- The Unit of the given values are in **United States dollars ($)**.
- The Adjusted prices of the relative companies are taken from **2014 1st Nov - 11th Sept 2020** which creates a total of six years of the dataset.

The Problem:

We have chosen a problem which in sync with one of the key pillars of finance and problems relating to it persist in the financial world and are ubiquitous in every market, Risk and Return. It is one of the fundamental principles which is taken into consideration while building a portfolio or indulging in such markets to yield a return that beats inflation- safeguarding your capital from degrading over time.

The evolution of capital markets has provided us with various options for investment and hence we are focusing on the same dilemma which tries to provide the best investment opportunity for the targeted segment of investors.

Exploratory Data Analysis:

The dataset consists of the Net Asset Value (NAV) prices of four major funds: Soros Fund Management LLC [1] , Paulson & Co. Inc. [2], Tiger Global Management LLC [3], Berkshire Hathaway Inc. [4] and the closing prices of an index fund in the S&P 500 [5].

The data points captured start from 1st October, 2014 to 11th September, 2020 thus comprising 1498 rows. Note that we will consider the holding period of the funds to be the aforementioned dates respectively even though the funds are still holding their positions in the market today.

Date	SOROS FUND MANAGEMENT LLC	PAULSON & CO.INC.	TIGER GLOBAL MANAGEMENT LLC	BERKSHIRE HATHAWAY INC	S&P 500
01/10/2014	31.95024006	14.99182631	59.97783039	51.94871249	194.35
02/10/2014	31.93610976	14.99407161	59.97862619	51.95761875	194.38
03/10/2014	31.96970694	14.99959647	60.00226392	52.02248371	196.52
06/10/2014	32.04821518	14.9994708	60.0062441	52.03638729	196.29
07/10/2014	31.96421642	14.99471977	59.99373505	52.00586448	193.26
08/10/2014	31.97669396	15.00025954	60.00824916	52.04966209	196.64
09/10/2014	31.86398521	14.98873029	59.98625285	52.00202841	192.74
10/10/2014	31.88830328	14.98511317	59.96751602	51.94757417	190.54
13/10/2014	31.78440961	14.98005635	59.94523082	51.88873577	187.41
14/10/2014	31.8903595	14.98038838	59.93449472	51.86015333	187.7
15/10/2014	31.91112176	14.97303879	59.93436874	51.85144164	186.43
16/10/2014	31.8920965	14.98217315	59.92177862	51.81285509	186.27
17/10/2014	31.8813262	14.98605358	59.94098439	51.87580127	188.47
20/10/2014	31.95516026	14.98993525	59.9700842	51.95186205	190.3
21/10/2014	32.13905998	14.99657841	60.0018306	52.02685217	194.07

First few rows of the dataset

Columns:

- **Dates:** The official trading days of the week
- **Soros Fund Management LLC:** It is a private investment management company based in America. It was once organized as a hedge fund, but it is now a family office.
- **Paulson & Co .Inc.:** It is an employee-owned hedge fund company.
- **Tiger Global Management LLC:** It is an investing company. The Internet, software, consumer, and financial technology sectors are primarily the emphasis.
- **Berkshire Hathaway Inc.:** It is an American multinational conglomerate holding company.
- **S&P 500:** It is an index of the stock market that tracks the performance of the 500 largest businesses listed on American stock exchanges.

Quantitative Analysis:

We shall seek to understand the best performing portfolios with the highest investment potentials based on risk-management metrics such as: volatility expressed as standard deviations, correlations, daily returns, Sharpe and Treynor ratios.

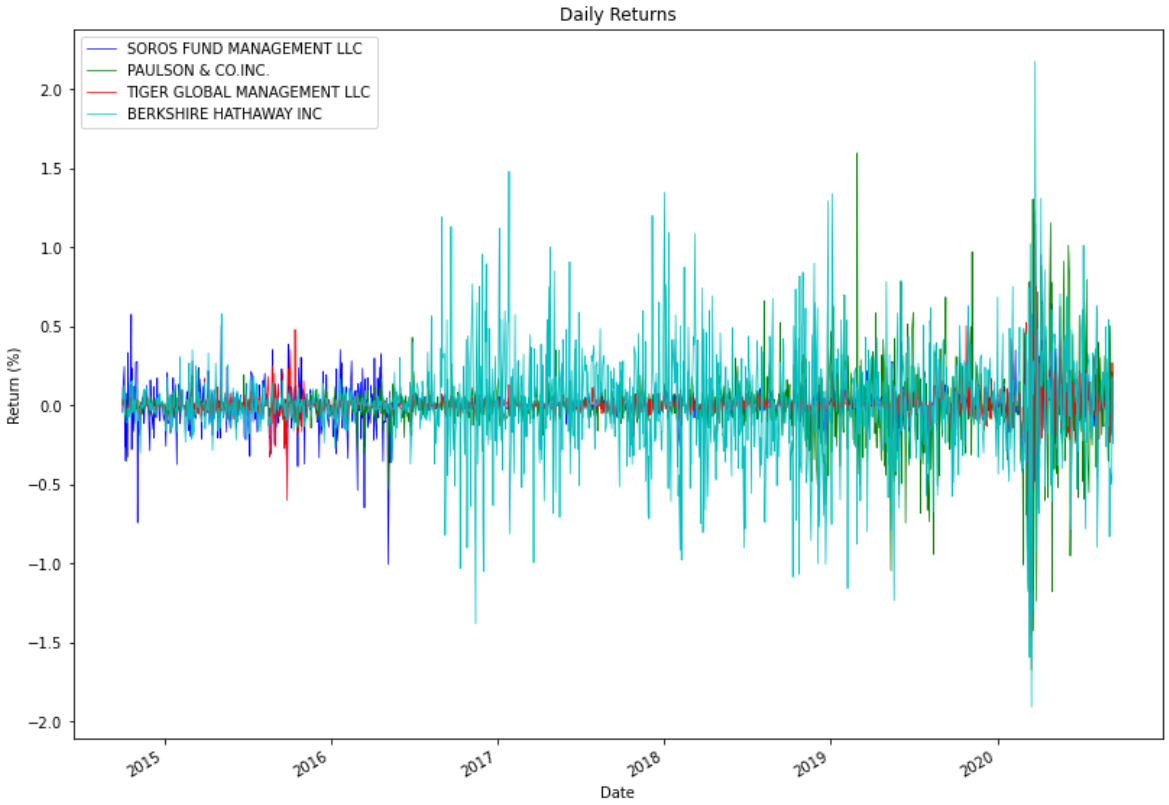
This will be accomplished via five central analyses all concerning the funds' profitability, their inherent volatility, the risk associated with them, a risk-return profile using Sharpe and Treynor ratios and how diverse the funds are relative to the broader market.

These analyses are as follows: Profitability Analysis, Volatility Analysis, Risk Analysis, Risk-Return Profile Analysis, Diversification Analysis.

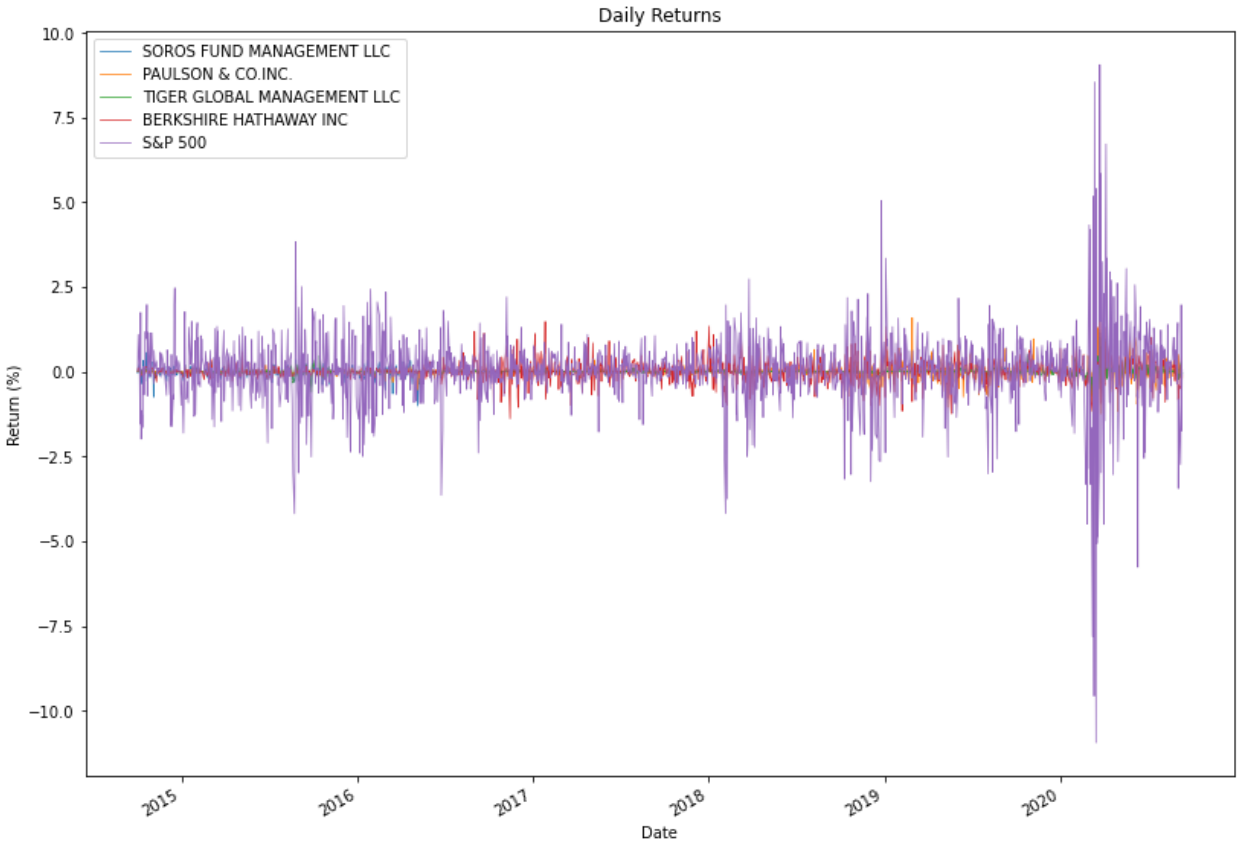
Note: We first need to obtain the daily returns by calculating the percent change between each successive row of each column.

Profitability Analysis:

With the aforementioned daily returns, we construct a line plot to view the cumulative daily returns of the four funds to view their respective performances:



This is without the performance of the broader stock market characterized by the S&P 500:

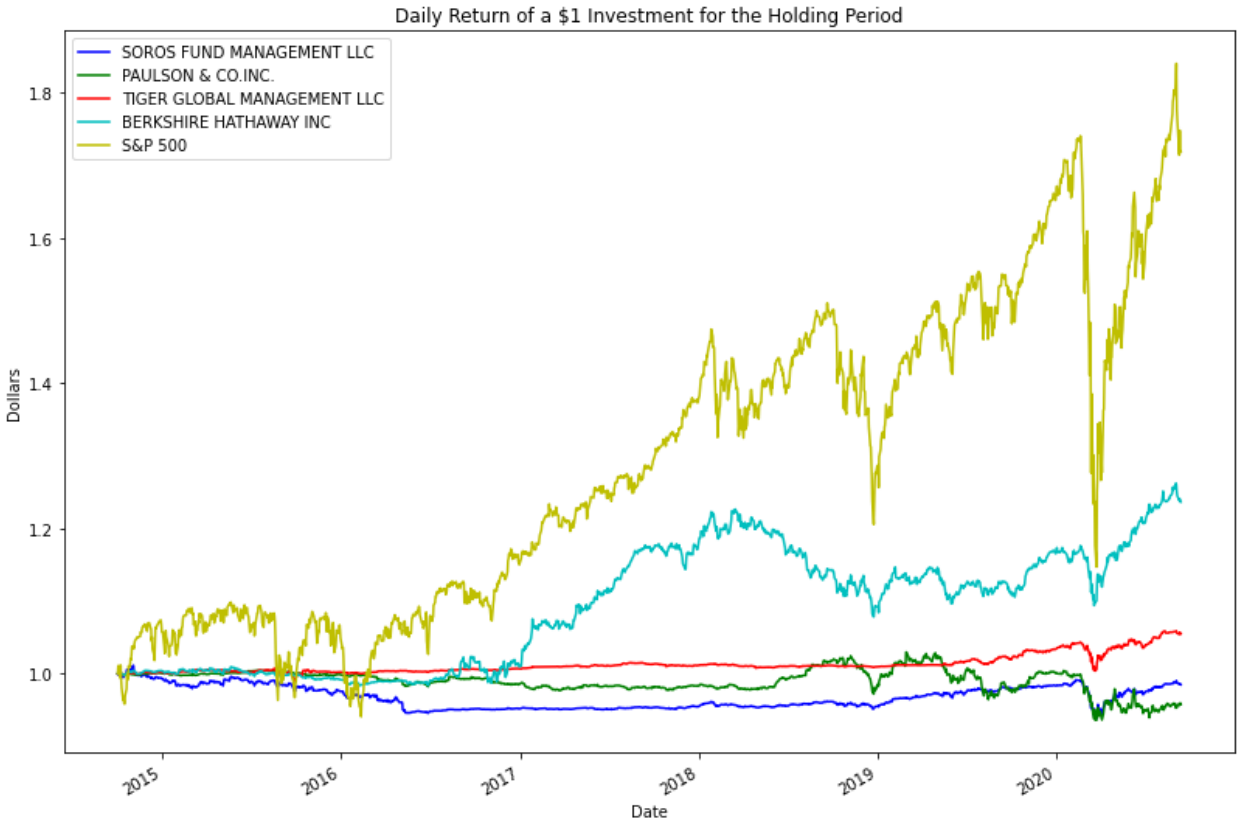


It is clear to see from comparing the figures that Berkshire Hathaway having a larger holding of high returning stocks most closely mimics the S&P 500. As we know that index funds generally outperform non-index funds [5], it leads us to suggest that investing in Berkshire Hathaway for an extended holding period might be advantageous to one-stop retirement portfolios.

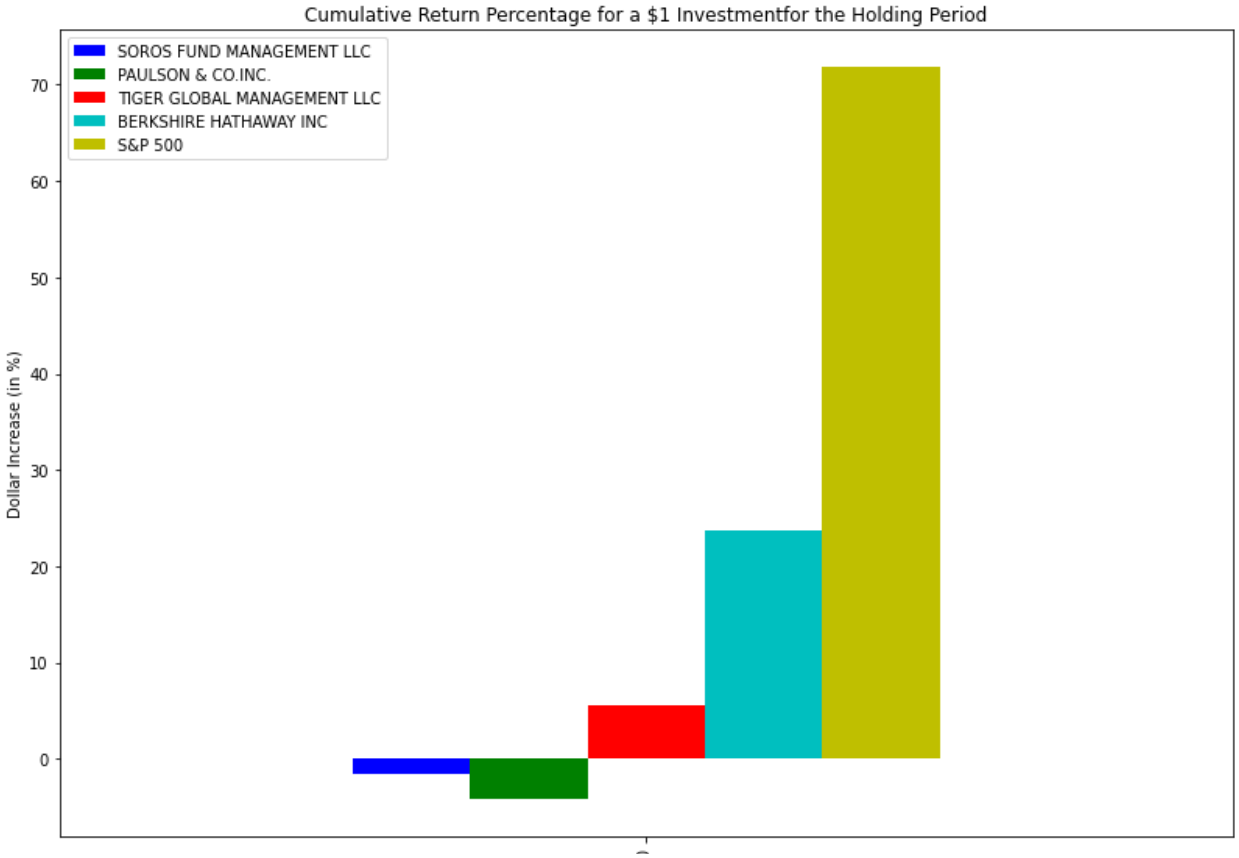
We now calculate the Holding Period Return (HPR) of the four funds and the index via the formula[6]:

$$HPR = \frac{(P_t - P_{t-1} + dividends_t)}{P_{t-1}}$$

Note here that we do not include the dividends, and that we assume an initial investment of $1 on the start of the holding period (1st October, 2014).

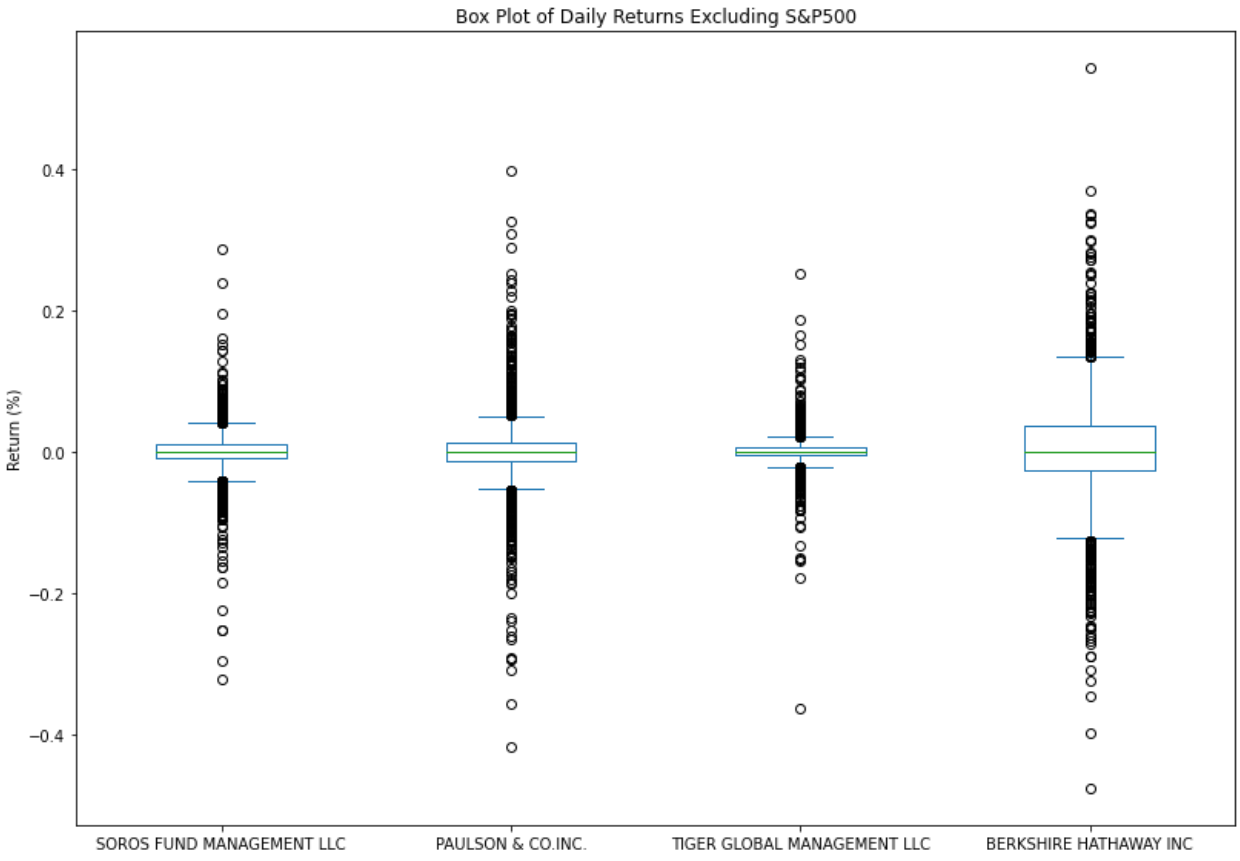


None of the funds analyzed compete with the S&P 500 index in terms of the HPR for a unit investment. The best performing fund was Berkshire Hathaway with a 24% cumulative return versus the S&P500's 72%. Other funds like Paulson & Co. and Soros Fund Management. lose money. The chart displayed here shows the relative percentage increase per fund:

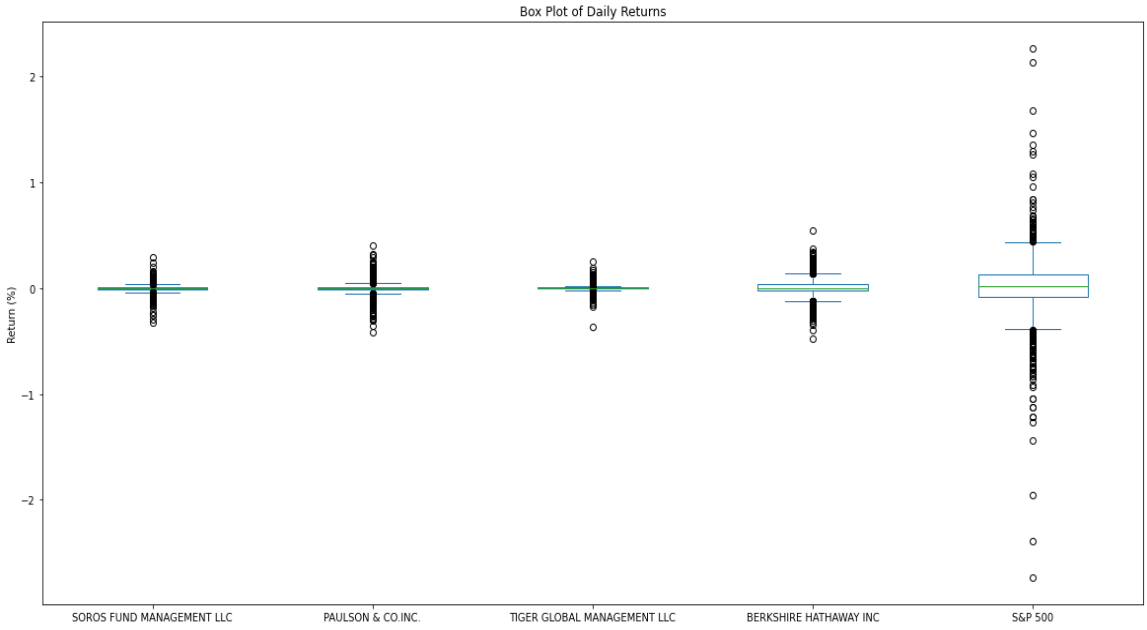

Cumulative Return Percentage for a $1 Investmentfor the Holding Period
SOROS FUND MANAGEMENT LLC
PAULSON & CO.INC.
TIGER GLOBAL MANAGEMENT LLC
BERKSHIRE HATHAWAY INC
S&P 500
Dollar Increase (in %)
70
60
50
40
30
20
10
0

Volatility Analysis:

We use box plots on the cumulative daily returns to view the medians and their 'minimums' and 'maximums', and also to generally survey any outliers. The corresponding box plots of the funds are as follows:



It is clear that Berkshire Hathaway is the most volatile whereas Tiger Global is the least. Berkshire Hathaway, as explained earlier, most clearly mimics the S&P500 hence the higher number of outliers as well. We can contrast this with the stock market as:



As evident from the plot, the volatility of the S&P500 index fund is higher than all the other funds *combined*. This is also due to the index fund capturing the extreme highs and extreme lows of specific stocks as well hence the higher number of outliers and their more significant magnitudes.

While volatility is inherently an important characteristic in portfolios that have a shorter holding period, in this case study, we primarily focus on retirement portfolios - as their holding periods are significantly longer (decades for some)[7], we assume the average investor will be less risk-averse and will not react as strongly to a sudden change in their portfolio performance.

Risk Analysis:

We similarly seek to quantify the risk through a simple but reliable metric in the *standard deviation* and the *beta*.

Note that we use beta against the overall market through the S&P500. By definition, the market, such as the S&P 500 Index, has a beta of 1.0, and individual stocks are ranked according to how much they deviate from the market.

"A stock that swings more than the market over time has a beta above 1.0. If a stock moves less than the market, the stock's beta is less than 1.0. High-beta stocks are supposed to be riskier but provide higher return potential; low-beta stocks pose less risk but also lower returns." [8]

Also note that we assume the number of trading days to roughly be 252. On average, from 1 990 to 2020, there have been 251.9 trading days per year. [9] We roughly assume this to be 252 for our analysis.

We calculate the standard deviations for each fund and the index fund, and also their annualized standard deviation (simply multiplying the standard deviation with the square root of 252).

The standard deviations and annualized standard deviations respectively are:

TIGER GLOBAL MANAGEMENT LLC	0.000996
SOROS FUND MANAGEMENT LLC	0.001405
PAULSON & CO.INC.	0.002199
BERKSHIRE HATHAWAY INC	0.003256
S&P 500	0.011550

Standard Deviations of Daily Returns

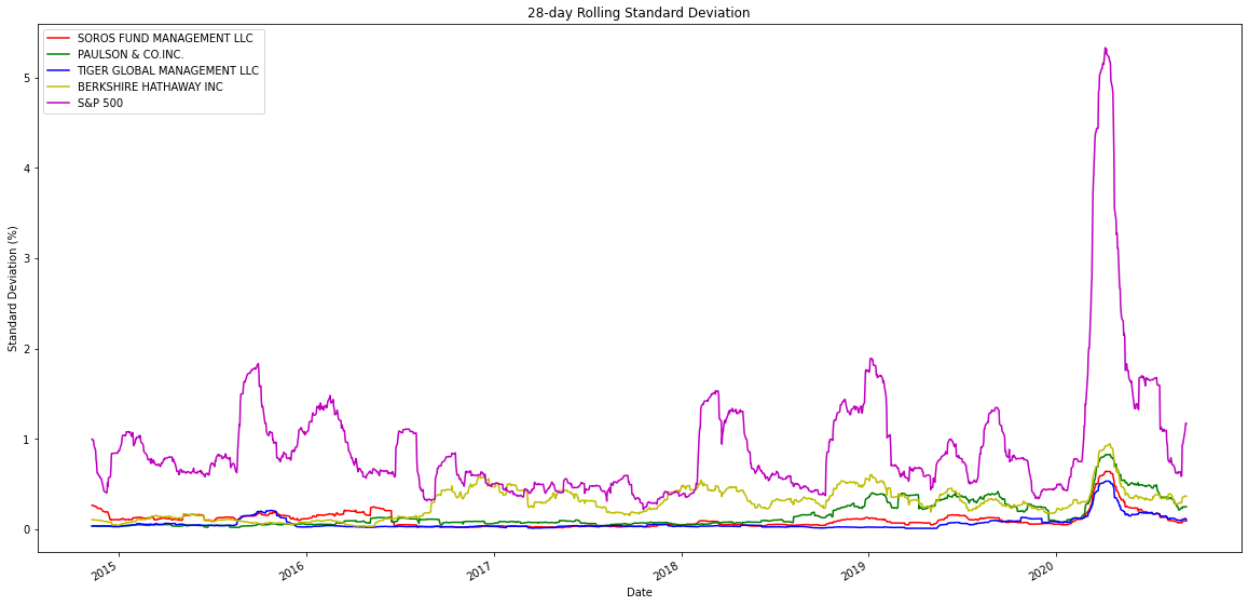
TIGER GLOBAL MANAGEMENT LLC	0.015804
SOROS FUND MANAGEMENT LLC	0.022297
PAULSON & CO.INC.	0.034912
BERKSHIRE HATHAWAY INC	0.051692
S&P 500	0.183345

Annualized Standard Deviations of Daily Returns

The S&P500 index has more risk than any of the other funds, with Tiger Global Management showing the least amount of risk and Berkshire Hathaway showing the highest risk of all of the investment funds.

It is fundamentally clear that, as with any portfolio, we expect the standard deviations to change over time. We take the standard deviation over a 28-day window. Due to the dataset covering a sufficiently large number of months, we are comfortable with a 1 month window of roughly 4 weeks or 28 days.

We find the 28-day rolling standard deviation of the daily returns that are expressed as:



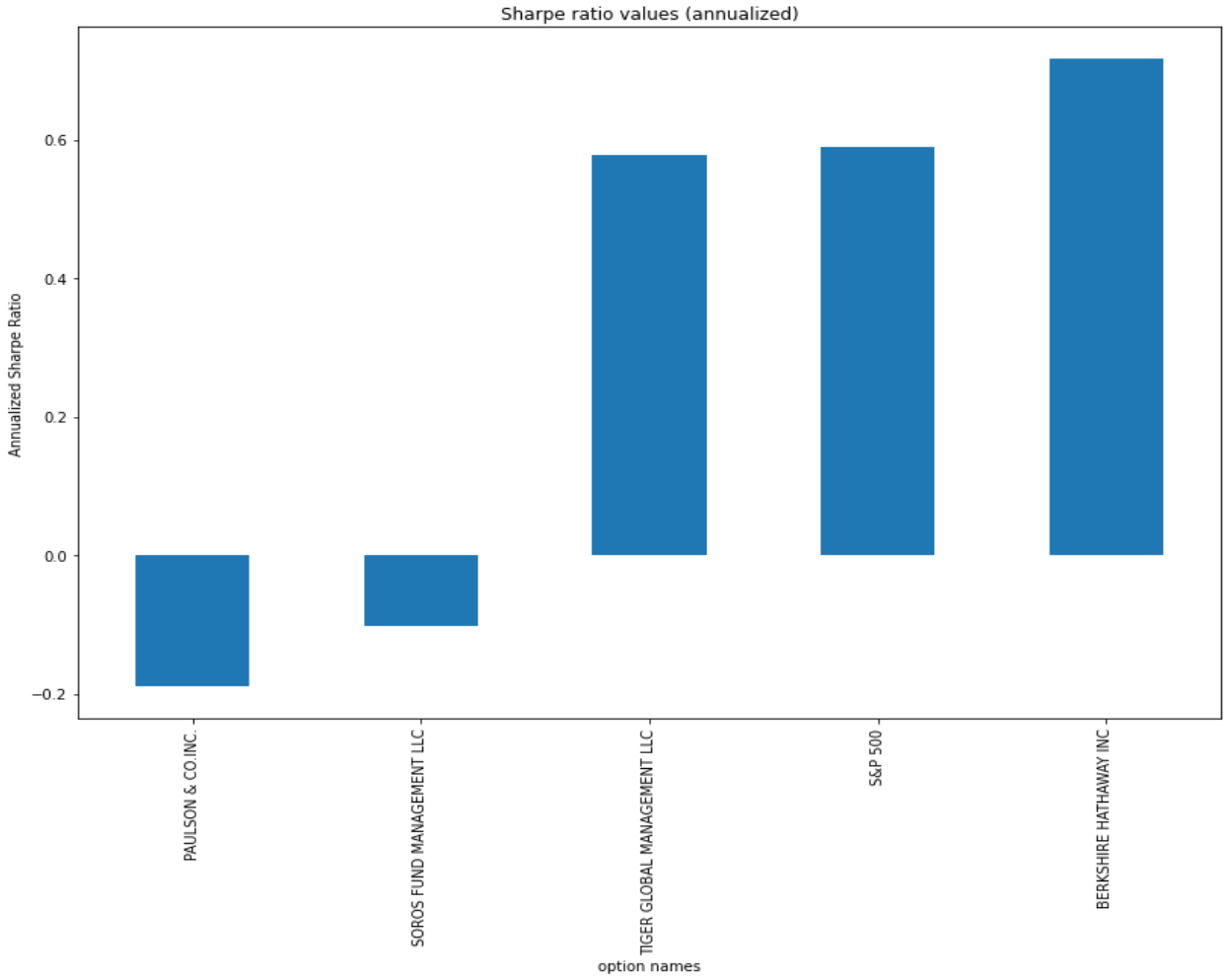
The sharp increase in February-March 2020 is due to the 2020 Stock Market Crash due to the rising instability in the stock market following the 2020 Covid Pandemic [10]. All other funds consequently fluctuate. Some funds move with the S&P500 indicating a strong correlation between them, hence suggesting that the beta will also increase. Soros Fund Management and Tiger Global Management however do not follow the market as much.

Risk-Return Profile:

We similarly seek to understand the returns of the funds relative to their inherent risk. While risk in this instance is not the leading criterion due to the nature of its investors being less risk averse, we nonetheless always prefer investing in low-risk, high-yield portfolios: hence the need for the Sharpe ratio.

The Sharpe ratio evaluates the relationship between an investment's return and corresponding risk. The idea that excess returns over time may indicate greater volatility and risk rather than investment expertise is expressed mathematically in this way. [11]

To determine the overall risk of an asset or a portfolio, quantitative analysts and investment managers consider not only its risk metrics but also its risk-return profile, which, here, is the Sharpe ratios plotted below for all the given portfolios:



- **Covariance Matrix**

Variance-Covariance Matrix (VCV) of a portfolio comprising n securities 1 to n. It is used to determine the stock portfolio's standard deviation, which portfolio managers use to determine the level of risk associated with a certain portfolio. The end goal, allocate optimal capital to each of these stocks, such that our risk is minimum.

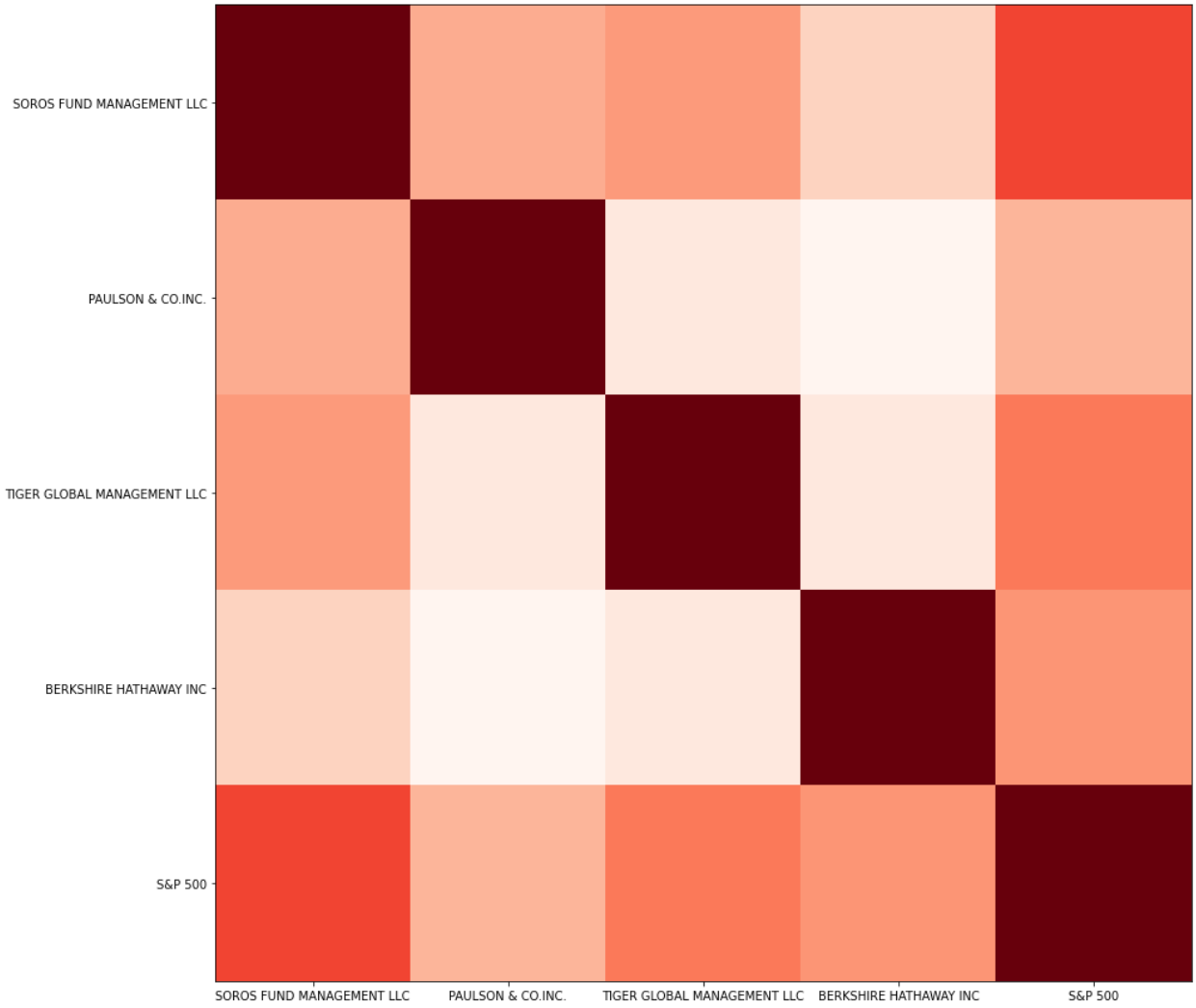
$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{1,2} & \sigma_{1,3} & \dots & \sigma_{1,n} \\ \sigma_{2,1} & \sigma_2^2 & \sigma_{2,3} & \dots & \sigma_{2,n} \\ \sigma_{3,1} & \sigma_{3,2} & \sigma_3^2 & \dots & \sigma_{3,n} \\ \vdots & \vdots & & & \\ \sigma_{n,1} & \sigma_{n,2} & \sigma_{n,3} & \dots & \sigma_n^2 \end{bmatrix}$$

$$\sigma_p^2 = W \times \Sigma \times W'$$

Diversification Analysis:

The portfolios' relative reaction to the market can be studied from the correlations between each and every portfolio considered. Better diversification and lesser risk in the market is ensured by the funds that are less correlated and less sensitive to the majority of the funds representing the market.

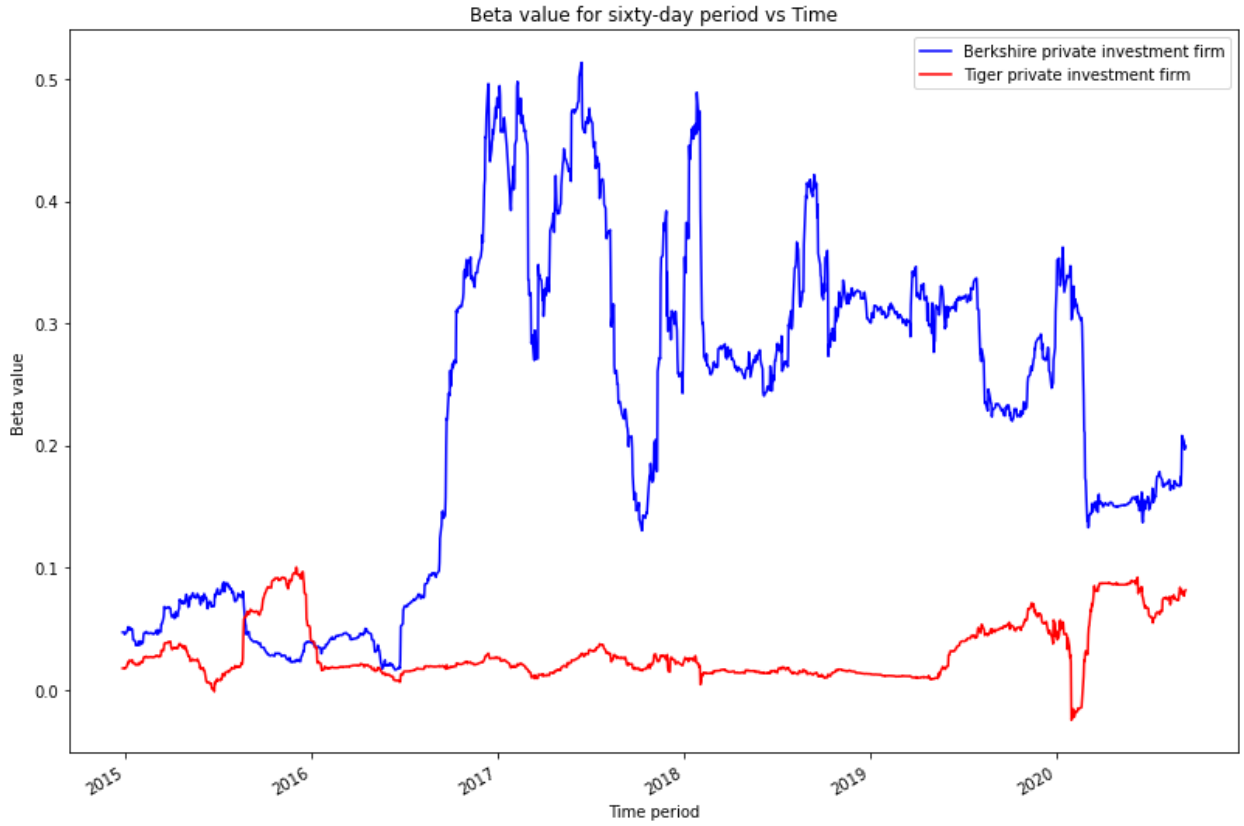
Correlation analysis of all the funds is as follows:



The two filtered candidates, Tiger and Berkshire Hathaway, are the ones with the least correlation with the rest of the market.

Further, we analyze the covariance of these candidates, followed by calculating their beta values, using the 60-day rolling window:

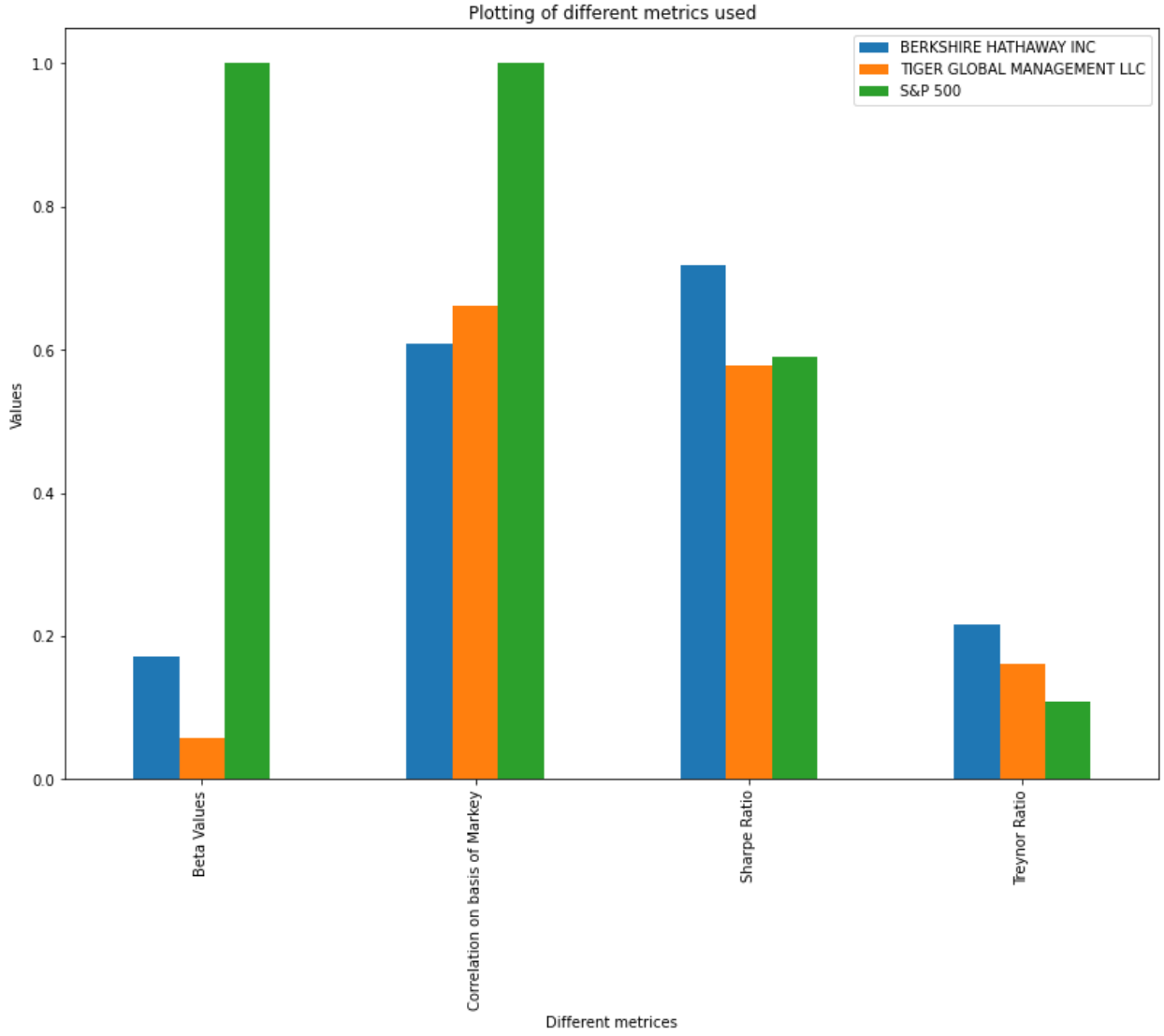
date		BERKSHIRE HATHAWAY INC	TIGER GLOBAL MANAGEMENT LLC	S&P 500
2020-09-08	S&P 500	0.000023	0.000009	0.000116
2020-09-09	BERKSHIRE HATHAWAY INC	0.000012	0.000002	0.000024
	TIGER GLOBAL MANAGEMENT LLC	0.000002	0.000002	0.000010
	S&P 500	0.000024	0.000010	0.000120
2020-09-10	BERKSHIRE HATHAWAY INC	0.000012	0.000002	0.000024
	TIGER GLOBAL MANAGEMENT LLC	0.000002	0.000002	0.000010
	S&P 500	0.000024	0.000010	0.000121
2020-09-11	BERKSHIRE HATHAWAY INC	0.000012	0.000002	0.000024
	TIGER GLOBAL MANAGEMENT LLC	0.000002	0.000002	0.000010
	S&P 500	0.000024	0.000010	0.000120



These beta values help us understand the sensitivity of these funds to the overall movement observed in the market.

Findings:

The below figure concisely presents all the the above analyses to provide evidence for the conclusion following it:



1. When compared with S&P 500 Index, none of the other funds were successful at outperforming the Index within the time frame presented here. Among the other four candidates, Berkshire Hathaway Inc. was the best performer in given years with a cumulative return of 23.66% over the period. However,judging by the box-plots, it was also the most volatile fund among all. Tiger Global Management LLC. was the least volatile one with only 5% of cumulative returns.
2. Risk analysis using the rolling standard-deviations suggests that, although the S&P Index provided the highest returns, it was the riskiest fund compared to the other four. Within the four candidate funds, Berkshire Hathaway Inc. is the riskiest in the most of the given years. However, since 2019, Paulson appears to be as risky as Berkshire, if not more.

3. There is negligible correlation between all the funds that can suggest that any of the funds are increasing or decreasing in value together. While the Index remains extremely volatile throughout, Paulson moves from a lower volatility to a higher level at the end of 2018 and Tiger does not showcase any significant change like the rest of the market and remains stagnant for most part of the duration.
4. With an annualized Sharpe ratio of 0.71, Berkshire Hathaway offers the strongest risk/return profile. Paulson & Co Inc. offers the worst, with an annualized Sharpe Ratio of -0.19. The Sharpe ratio is a measure of return that has been risk-adjusted. A negative Sharpe ratio indicates that the fund didn't rent any more throughout the time period than the treasury bills. Soros and Paulson are no longer in the game as a result. Berkshire and Tiger are the only plausible options after them.
5. The beta analyses reveal that, since the second half of 2016, Berkshire Hathaway has been more sensitive to the market, with a beta several times higher, than Tiger. But a consistent beta, which is less than 1, throughout makes it as safe as Tiger for investment.
6. With comparatively lesser correlation than Tiger with the rest of the market during increasing or decreasing movements, Berkshire Hathaway provides a better source of diversification with the market.
7. Thus, from these analyses, we can claim that Berkshire Hathaway, although volatile, is the best choice for investment by considering its high return percentage, beta value, and the Sharpe ratio.

Suggestions and Innovative ideas:

1. One of the suggestions to develop this project further can be to forecast these portfolios using time-series models and do the above analyses on the forecasted stock values to better anticipate the results of investing in them.

Links

[1] https://fintel.io/i/soros-fund-management-llc

[2] https://fintel.io/i/paulson

[3] https://fintel.io/i/tiger-global-management-llc

[4] https://fintel.io/i/berkshire-hathaway

[5] https://finance.yahoo.com/quote/%5EGSPC/history/

[6] https://www.investopedia.com/terms/h/holdingperiodreturn-yield.asp

[7] https://www.livemint.com/money/personal-finance/how-to-build-your-portfolio-for-retirement-in-current-bear-market-11664085139074.html

[8] https://www.investopedia.com/investing/beta-know-risk/\

[9] https://www.macroption.com/trading-days-per-year/#us-markets

[10] https://en.wikipedia.org/wiki/2020_stock_market_crash

[11] Evans, J. R. (2021). *Business analytics: Methods, models, and decisions* (3rd ed.). Pearson.

Details on the working part of each student in the group.

Name	**Work done**
Hirmay Sandesara	Python Notebook & Analysis
Christian N Warjri	Analysis, Report Writing
Dev N Mevada	Presentation, Report Writing
Chirayu Maniar	Data Collection, Presentation