An Investigation of Analyzing Portfolio Performance Under Different Conditions

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ABSTRACT

This paper analyzes the portfolio performance under different conditions, utilizes the adjusted total return of one equity index and 10 company stocks from Bloomberg API, and examines the Markowitz Model and Index Model data. In both models, different constraints are settled to the minimum variance portfolio and maximum Sharpe ratio portfolio to find the best portfolio performance. In the selected 10-year (January 2011 to May 2021), the minimum variance portfolio has the best performance when the weight on the broad index (S&P 500) equals zero, and the maximum Sharpe portfolio has the highest Sharpe ratio with the arbitrary box constraint or without any constraints under Markowitz Model. In the Index Model, the minimum variance model can be maximized without short positions. The maximum variance model can achieve the best performance with the arbitrary box constraint or without any constraints. With the global emergency of the COVID-19 outbreak in 2020, the U.S. stock market had experienced significant challenges when several circular breakers happened in March 2020. Therefore, this paper divided the overall data in March 2020 to analyze if this global crisis would change the portfolio management strategy. The most significant finding is that the best portfolio performance happens when the short position is constrained after the COVID-19 pandemic in the minimum variance portfolio under both models. It might give some suggestions for investors to tackle their strategy in maximizing their portfolio with the emergency of any other global crisis.

Keywords: *COVID-19, portfolio, Markowitz Model, Index Model, the short position*

1. INTRODUCTION

2020 is not an easy year due to the emergency of Coronavirus disease (Covid-19). To stop the spread of the Coronavirus efficiently, some governments enforced travel restrictions, border closures, quarantine, and phased lockdown regulation, which negatively impacted the business and economy. Therefore, the COVID-19 pandemic has affected almost every part of human life and caused financial fluctuation in the world.

For example, the U.S. stock markets had experienced four circular breakers in March 2020 in the Standard and Poor's 500 index (S&P 500) and Dow Jones Industrial Average (DJIA) [1]. My aim in this paper is dual. First, this paper analyzed the adjusted total return on one index and 10 company stocks in U.S. stock markets from January 2011 to May 2021. Second, since the data period includes the COVID-19 pandemic period, the data is split at the point of March 2020, when circuit breakers halted the U.S. stock trading, to investigate if investors need to change their portfolio strategies acknowledging the COVID-19 pandemic in the U.S. To help researchers and business practitioners understand the pandemic's impact on the future global financial market, this study analyzes the portfolio performance on the equity index and company stocks under each constraint from two time periods.

In previous research, researchers found the persistent correlation between the first and second waves of COVID-19 pandemic, U.S. stock market, and uncertainty, which illustrate pandemic has harmful consequences in financial markets in general and the U.S. economy in particular [2]. Szczygielski et al. compare the COVID-19 impacts on the financial market in Asian countries and the United States [3]. In addition, the paper finds out that returns for all six examined regional markets are negatively impacted by the COVID-19 pandemic and its uncertainty on the market. According to Kawas and Thiele, when the financial market was under a relatively normal condition in 2011, the financial managers could either short-sell or not short-sell to manage the Log-robust portfolio [4]. In

addition, the COVID-19 outbreak also negatively impacts different sectors in industries. S&P Global claims that COVID-19 negatively impacted the supply chain, which disrupted several industries in 2020 [5]. The six industries most impacted by COVID-19 are Automobile, energy and power, agriculture, education, travel and tourism, and consumer electronics [6]. Therefore, due to the current market volitation during the COVID-19 pandemic, Deloitte claims that investment managers need to deal with the potential long-term impact on the financial activities to seek change and opportunities [7].

Given the above literature, this paper contributes to the existing literature in the following ways. First, the Markowitz Model and Index Model are utilized to analyze the data on Standard and Poor's 500 Index (S&P 500) and ten company stocks within a 10-year-period from January 2011 to May 2021. Second, the data used in the two models are adjusted for corporate events. Third, this is the first study investigating the relationship between the COVID-19 outbreak impact and portfolio performance on company stocks from different fields. In addition, the data used in this paper is updated to May 2021, which is relatively recent data compared to that of other papers. This paper aims to help investors adjust their investment strategies as the emergency of the COVID-19 outbreak or another global crisis.

According to the comprehensive data from January 2011 to May 2021, my findings suggest that the SPX index and the company stocks have increased significantly in these 10 years. In Markowitz Model, the minimum variance portfolio is maximized when the weight on the broad index (S&P 500) is zero, and the maximum Sharpe ratio portfolio is maximized under the benchmark (no constraint) and when the weight for each index and stock is less than or equal to 1. In the Index Model, the minimum variance portfolio is maximized without any short positions. The maximum Sharpe ratio portfolio is maximized under the benchmark and when the weight for each index and stock is less than or equal to 1. However, the COVID-19 outbreak disrupts not only everyone's lifestyle but also the world economy due to the shutdown of different financial market indices. Therefore, this pandemic may influence the U.S. stock markets, and that is why this paper split the data to before and since the COVID-19 outbreak. In both Markowitz Model and Index Model, the constraint in minimum variance portfolio to maximum the Sharpe ratio has changed from Constraint 1, allowing positions, to Constraint 3, without any positions as time goes through before COVID-19 outbreak to since COVID-19 outbreak. By analyzing the data and results based on two different periods, investors should adjust their portfolios in this COVID-19 pandemic.

2. DATA

In this paper, to form a portfolio, 10 stocks (ticker symbols see the table below) are selected from various industries and S&P 500 equity index (ticker symbol "SPX"). This paper chose the recent 10 years (January 2011 – May 2021) of historically daily adjusted return data, which are adjusted for corporate events (the most important ones are dividends and stock splits). These data are available at Bloomberg API.

The individual stocks selected cover four different sectors: Technology, Consumer Defensive, Consumer Cyclical, and Industrial.

Below is the table of stock ticker symbols used in the analysis (Table 1):

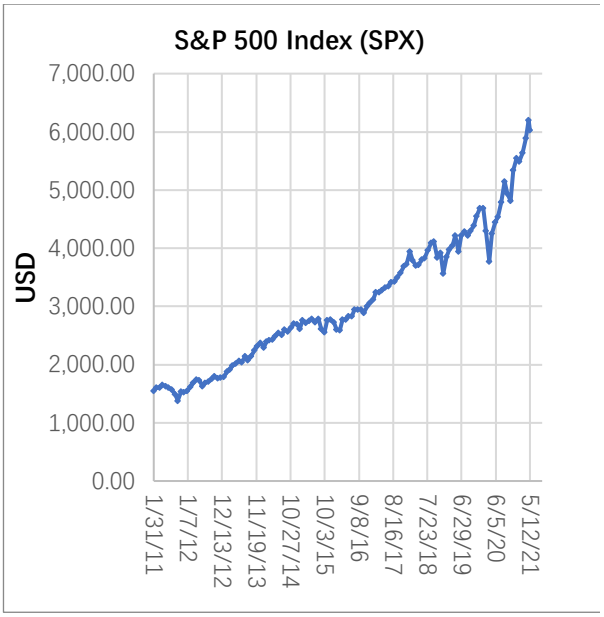
Table 1. Key variables

	Ticker	Full Name	Sector
Index	SPX	S&P 500 index	Index
Stock 1	QCOM	Qualcomm Incorporated	Technology
Stock 2	MSFT	Microsoft Corporation	Technology
Stock 3	NVDA	NVIDIA Corporation	Technology
Stock 4	KO	The Coca-Cola Company	Consumer Defensive
Stock 5	CL	Colgate-Palmolive Company	Consumer Defensive
Stock 6	AMZN	Amazon.com, Inc.	Consumer Cyclical
Stock 7	MCD	McDonald's Corporation	Consumer Cyclical
Stock 8	LUV	Southwest Airlines Co.	Industrial
Stock 9	FDX	FedEx Corporation	Industrial
Stock10	LSTR	Landstar System, Inc.	Industrial

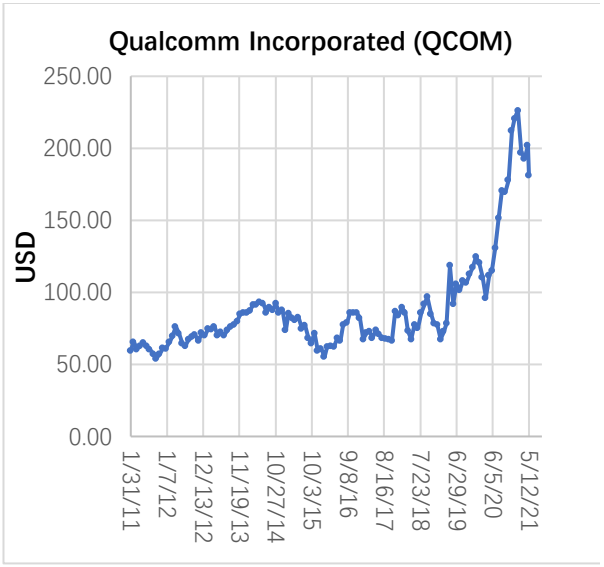
To reduce non-Gaussian effects, I aggregated the daily data to the monthly observations in this paper. The following charts are the trends of the S&P 500 Index and 10 companies' stock dated from January 31st, 2011, to May 12th, 2021 (Figure 1). Even though there are some fluctuations every year, the prices are increasing for each company over 10 years.

Figure 1 Adjusted total return for S&P 500 Index (SPX) and individual stocks

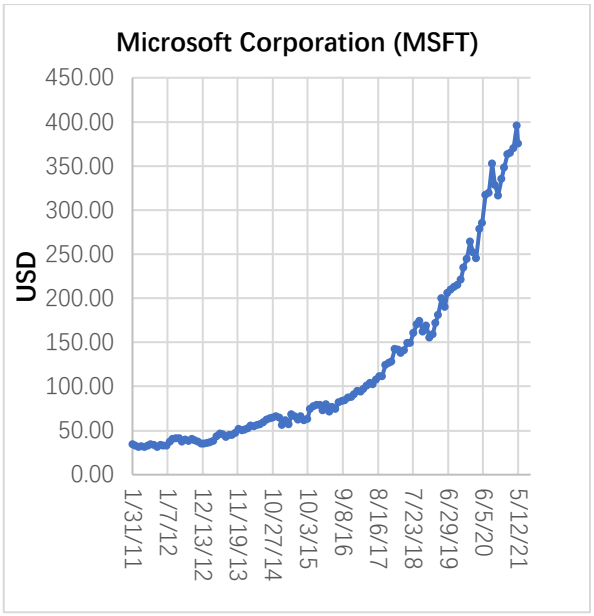
(a) Adjusted total return for S&P 500 Index (SPX)



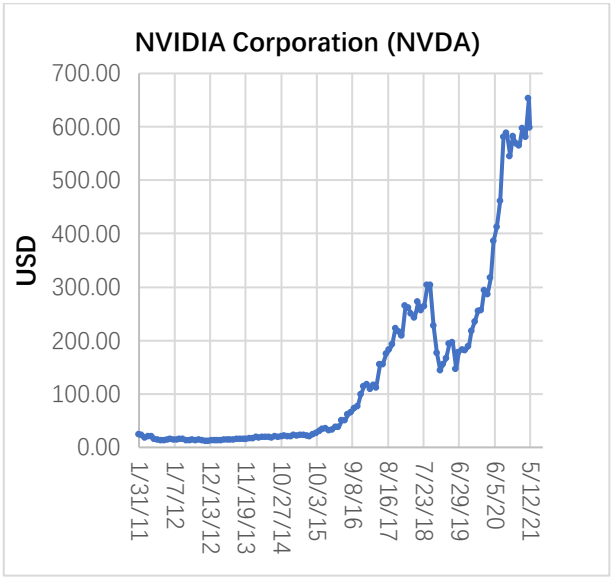
(b) Adjusted total return for Qualcomm Incorporated (QCOM)



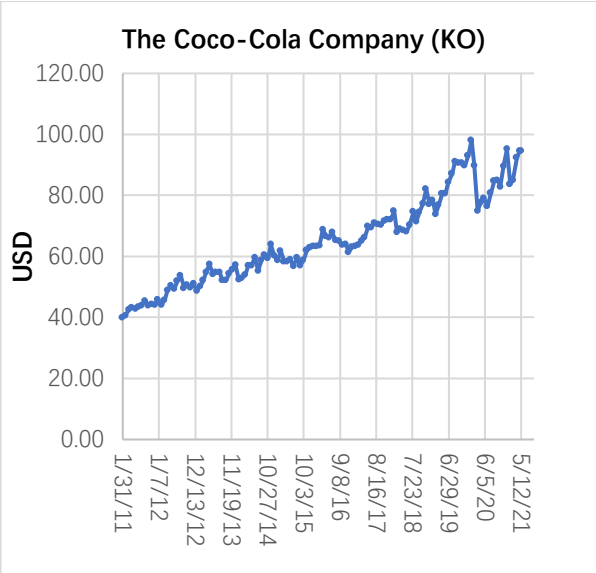
(c) Adjusted total return for Microsoft Corporate (MSFT)



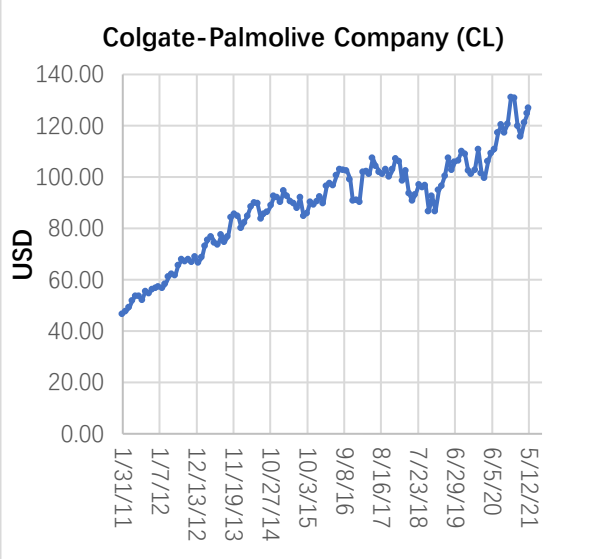
(d) NVIDIA Corporation (NVDA)



(e) Adjusted total return for The Coco-Cola Company (KO)

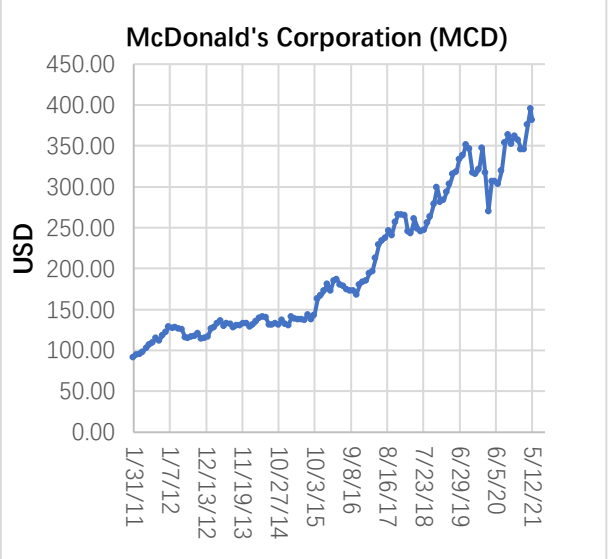


(f) Adjusted total return for Colgate-Palmolive Company (CL)

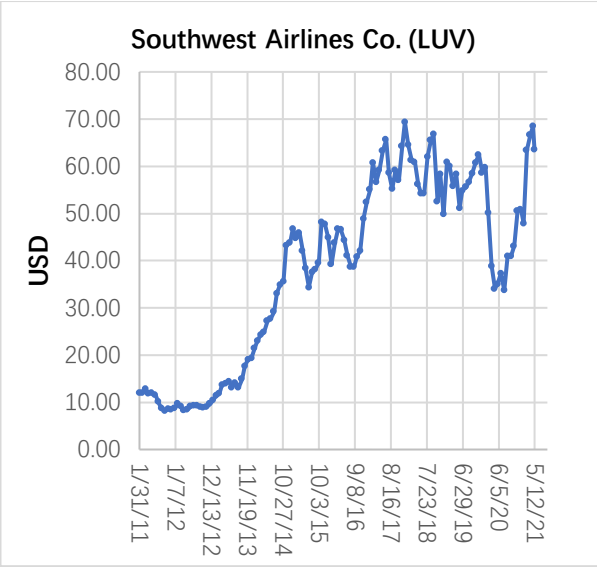


(g) Adjusted total return for Amazon.com, Inc. (AMZN)

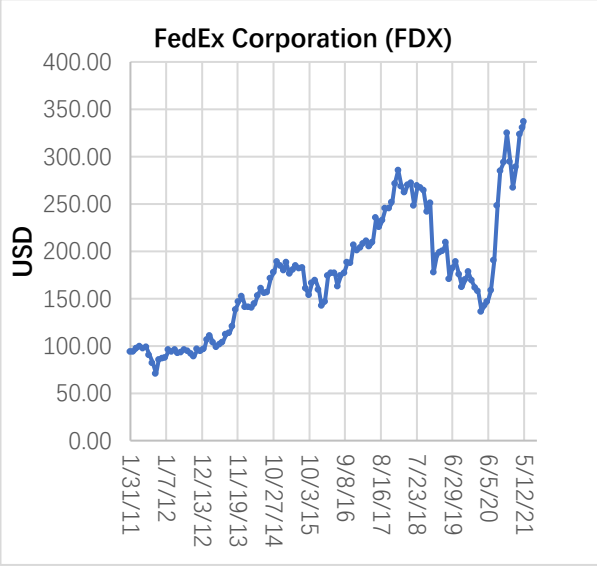
(h) Adjusted total return for McDonald's Corporation (MCD)



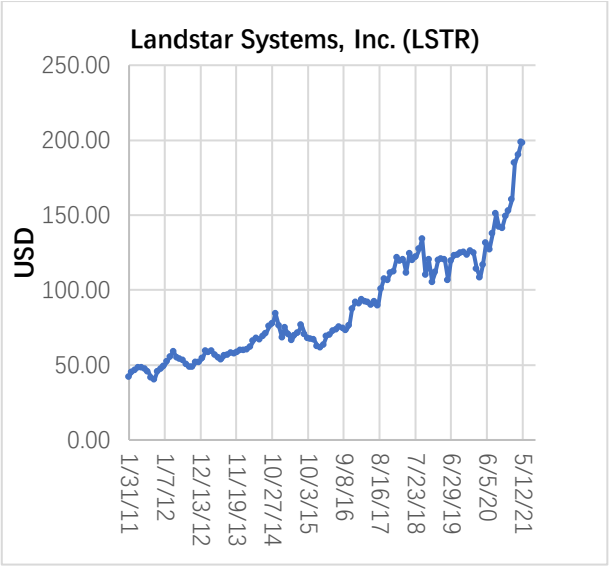
(i) Adjusted total return for Southwest Airlines Co. (LUV)



(j) Adjusted total return for FedEx Corporation (FDX)



(k) Adjusted total return for Landstar Systems, Inc. (LSTR)



Source: Bloomberg API

In addition, the correlation between each stock is calculated as shown in **Table 2**, and the numbers in correlation are relatively low, which means that there is a good diversification effect in the dataset.

Table 2. Correlation

	SPX	QCOM	MSFT	NVDA	KO	CL	AMZN	MCD	LUV	FDX	LSTR
SPX	1	0.528941	0.589053	0.495211	0.518598	0.527239	0.537537	0.521685	0.487482	0.647091	0.626574
QCOM	0.528941	1	0.400925	0.365216	0.204089	0.348277	0.292052	0.227894	0.166635	0.335657	0.349554
MSFT	0.589053	0.400925	1	0.457248	0.267675	0.223565	0.469798	0.366949	0.166819	0.331455	0.304217

NVDA	0.4952	0.3652	0.4572	1	0.0875	0.0884	0.3442	0.1359	0.2165	0.4043	0.3949
	11	16	48		75	45	85	25	61	83	44
KO	0.5185	0.2040	0.267675	0.0875	1	0.61	0.2543	0.6155	0.2736	0.3432	0.2462
	98	89		75		2852	31	11	75	27	31
CL	0.5272	0.3482	0.223565	0.0884	0.6128	1	0.3625	0.4490	0.3166	0.3527	0.2928
	39	77		45	52		29	1	21	71	26
AMZN	0.5375	0.2920	0.469798	0.3442	0.2543	0.36	1	0.2837	0.1937	0.3174	0.1884
	37	52		85	31	2529		68	39	5	84
MCD	0.5216	0.2278	0.366949	0.1359	0.6155	0.44	0.2837	1	0.2095	0.3418	0.2472
	85	94		25	11	901	68		12	32	45
LUV	0.4874	0.1666	0.166819	0.2165	0.2736	0.31	0.1937	0.2095	1	0.5109	0.4275
	82	35		61	75	6621	39	12		85	29
FDX	0.6470	0.3356	0.331455	0.4043	0.3432	0.35	0.3174	0.3418	0.5109	1	0.5604
	91	57		83	27	2771	5	32	85		93
LSTR	0.6265	0.3495	0.304217	0.3949	0.2462	0.29	0.1884	0.2472	0.4275	0.5604	1
	74	54		44	31	2826	84	45	29	93	

3. METHOD

This paper formed the portfolio as:

$$\text{Portfolio} = \beta1 \times \text{SPX} + \beta2 \times \text{QCOM} + \beta3 \times \text{MSFT} + \beta4 \times \text{NVDA} + \beta5 \times \text{KO} + \beta6 \times \text{CL} + \beta7 \times \text{AMZN} + \beta8 \times \text{MCD} + \beta9 \times \text{LUV} + \beta10 \times \text{FDX} + \beta11 \times \text{LSTR} \quad (1)$$

Two models used to analyze the S&P 500 Index data and 10 company stocks in this paper are Markowitz Model and Index Model.

Markowitz Model

Markowitz Model (MM), also known as the mean-variance model, is a portfolio optimization model created by Harry Markowitz in 1952 [8]. This model selects the most efficient portfolio by analyzing various possible portfolios combinations of the given securities based on expected returns (mean) and standard deviations (variance) of the assets. Markowitz Model can show investors how to reduce their risk by utilizing it.

Index Model

Index Model (IM), also known as the single-index model (SIM), is an asset pricing model measuring the risk and the return of a stock developed by William Sharpe in 1963 [9]. In Index Model, only one macroeconomic factor, such as S&P 500, leads to the systematic risk, which affects all stock returns and the rate of return on a market index.

Benchmark and four constraints are applied to examine the portfolio performance in both models.

Benchmark and four constraints are applied to examine the portfolio performance in both models.

1. *The benchmark:* It is a "free" problem, without additional optimization constraints, to illustrate how the area of permissible portfolios in general and the efficient frontier looks if there are no constraints.

2. *Constraint 1:* This optimization constraint is designed to simulate the Regulation T by FINRA, which allows broker-dealers to allow their customers to have positions, 50% or more of which are funded by the customer's account equity (**Regulation T:** Regulation T, or Reg T, was established by the Board of Governors of the Federal Reserve System, providing regulations for extension of credit by brokers and dealers and regulating cash account. All broker-dealers in the U.S. are regulated by Regulation T, limiting their margin exposure at the end of every trading date. [10]):

$$\sum_{i=1}^{11} |\text{Wi}| \leq 2; \quad (2)$$

3. *Constraint 2:* This optimization constraint is designed to simulate some arbitrary "box" constraints on weights, which the client may provide (**arbitrary "box" constraint**: it simulates a hypothetical condition when clients impose their constraint, which may function as the instrument, on maximum risk exposure in portfolio management.):

$$|\text{Wi}| \leq 1, \text{for } \forall i; \quad (3)$$

4. *Constraint 3:* This additional optimization constraint is designed to simulate the typical limitations existing in the U.S. mutual fund

industry: a U.S. open-ended mutual fund is not allowed to have any short positions. For details, see the Investment Company Act of 1940:

$$Wi \geq 0, \text{for } \forall i; \quad (4)$$

5. *Constraint 4:* This additional optimization constraint is designed to see if the inclusion of the broad index into the portfolio has a positive or negative effect:

$$Wspx = 0. \quad (5)$$

4. RESULT

The paper and data analysis will illustrate the analysis results in both the graphical and tabular form to compare and infer between different constraints for each optimization problem and between the Markowitz and Index models. Only the risk is considered in the minimum variance (minimum risk) portfolio while analyzing the index and company stocks. On the other hand, the maximum Sharpe ratio portfolio also considers the return besides the risk.

Markowitz Model

The table (Table 3) below illustrates the weights for the index and company stocks in the minimum variance portfolio under the benchmark and four constraints.

Table 3. Weights in minimum variance portfolio (Markowitz Model)

	SPX	QCOM	MSFT	NVDA	KO	CL	AMZN	MCD	LUV	FDX	LSTR
Benchmark	0.395683	-0.06103	0.104002	0.005078	0.111071	0.313107	-0.04623	0.183548	-0.02062	-0.09978	0.115143
Constraint 1	0.395683	-0.06103	0.104002	0.005078	0.111071	0.313107	-0.04623	0.183548	-0.02062	-0.09978	0.115143
Constraint 2	0.395683	-0.06103	0.104002	0.005078	0.111071	0.313107	-0.04623	0.183548	-0.02062	-0.09978	0.115143
Constraint 3	0.185269	0	0.092718	0	0.145752	0.279832	0	0.202789	0	0	0.093639
Constraint 4	0	-0.03964	0.158073	0.018935	0.167419	0.358986	-0.01325	0.23623	2.22E-05	-0.07562	0.188826

The table (Table 4) below illustrates the weights for the index and company stocks in the maximum Sharpe ratio (efficient risky) portfolio under the benchmark and four constraints.

Table 4. Weights in maximum Sharpe ratio portfolio (Markowitz Model)

	SPX	QCOM	MSFT	NVDA	KO	CL	AMZN	MCD	LUV	FDX	LSTR
Benchmark	-0.57345	-0.07277	0.377971411	0.159121	-0.08638	0.219571577	0.249524	0.45383	0.128992841	-0.15629	0.299877
Constraint 1	-0.29405	-0.06672	0.318842061	0.135418	-3.8E-08	0.146057858	0.209355	0.35894	0.099012871	-0.13923	0.232379
Constraint 2	-0.57345	-0.07277	0.377971411	0.159121	-0.08638	0.219571547	0.249524	0.45383	0.128992852	-0.15629	0.299877
Constraint 3	0	0	0.2578	0.0991	0	0.0226	0.1825	0.2875	0.0538	0	0.0964

			2413	63		6429	54	39	1395		41
Constraint 4	0	-	0.2900	0.1308	-	0.1670	0.1871	0.3678	0.0923	-	0.1928
		0.0994	0432	89	0.1452	5028	92	96	5059	0.1834	01
		1			8					9	
						14.011	11.304	1.2394	24.428	14.926	1.6366
						%	%	7	%	%	1

Note: StDev stands for standard deviation

The table (Table 5) below illustrates the Sharpe Ratio in minimum variance and maximum Sharpe ratio portfolios under the benchmark and four constraints.

Table 5. Sharpe ratio under Markowitz Model

Minimum Variance Portfolio			Maximum Sharpe Portfolio		
Return	StDev	Sharpe	Return	StDev	Sharpe
12.404	11.016	1.1259	27.514	16.407	1.6769
%	%	9	%	%	8
12.404	11.016	1.1259	24.952	15.009	1.6624
%	%	9	%	%	5
12.404	11.016	1.1259	27.514	16.407	1.6769
%	%	9	%	%	8
13.343	11.398	1.1706	22.930	14.824	1.5468
%	%	9	%	%	6

In Markowitz Model, applying the Constraint 4, excluding the broad index, in the minimum variance portfolio can offer the highest Sharpe ratio of 1.23947, and applying the benchmark, no constraint, and Constraint 2, arbitrary "box" constraints on weights, in the maximum Sharpe portfolio can offer the highest Sharpe ratio of 1.67698. Therefore, adjusting the portfolio with the appropriate constraints allows the investors to achieve the best performance in their investments.

Index Model

The table (Table 6) below illustrates the weights for the index and company stocks in the minimum variance portfolio under the benchmark and four constraints:

Table 6. Weights in minimum variance portfolio (Index Model)

	SPX	QCOM	MSFT	NVDA	KO	CL	AMZN	MCD	LUV	FDX	LSTR
Benchmark	0.251837	-0.03887	0.05173127	-0.03724	0.281421	0.30548299	-0.02135	0.267181	-0.01937	-0.07101	0.030191
Constraint 1	0.251837	-0.03887	0.05173127	-0.03724	0.281421	0.30548299	-0.02135	0.267181	-0.01937	-0.07101	0.030191
Constraint 2	0.251837	-0.03887	0.05173127	-0.03724	0.281421	0.30548299	-0.02135	0.267181	-0.01937	-0.07101	0.030191
Constraint 3	0.013889	0	0.05450042	0	0.296485	0.32183537	0	0.281483	0	0	0.031807
Constraint 4	0	-0.02555	0.08153887	-0.02693	0.31773	0.34406431	-0.00446	0.303071	-0.00691	-0.04603	0.063573

The table (Table 7) below illustrates the weights for the index and company stocks in the maximum Sharpe ratio portfolio under the benchmark and four constraints.

Table 7. Weights in maximum Sharpe ratio portfolio (Index Model)

	SPX	QCOM	MSFT	NVDA	KO	CL	AMZN	MCD	LUV	FDX	LSTR
Benchmark	-0.76733	-0.02743	0.4955216199	0.179499	0.072949	0.1679060732	0.301432	0.399405	0.0667792611	-0.047311	0.158563
Constraint 1	-0.41253	-0.03187	0.4254931791	0.150191	0.042693	0.1299947237	0.256337	0.345709	0.0439641809	-0.055599	0.105618
Constraint 2	-0.76733	-0.02743	0.4955216199	0.179499	0.072949	0.1679060732	0.301432	0.399405	0.0667792611	-0.047311	0.158563
Constraint 3	0	0	0.3537425141	0.125341	0	0.0253505208	0.216408	0.254923	0.0099245301	0	0.014311
Constraint 4	0	-0.06569	0.3858951912	0.137912	-0.017	0.0674486	0.235563	0.290811	0.0267197901	-0.118911	0.057245

The table (Table 8) below illustrates the Sharpe Ratio in both minimum variance and maximum Sharpe ratio portfolios under the benchmark and four constraints.

Table 8. Sharpe ratio under Index Model

Minimum Variance Portfolio			Maximum Sharpe Portfolio		
Return	StDev	Sharpe	Return	StDev	Sharpe
10.408%	10.233%	1.017112	29.089%	17.107%	1.700397
10.408%	10.233%	1.017112	26.664%	15.795%	1.688143
10.408%	10.233%	1.017112	29.089%	17.107%	1.700397
11.962%	10.503%	1.138852	24.668%	15.414%	1.600432
11.280%	10.338%	1.091094	25.551%	15.560%	1.642124

Note: StDev stands for standard deviation

In Index Model, applying Constraint 3, no short positions in the minimum variance portfolio can offer the highest Sharpe ratio of 1.138852, indicating that the portfolio performance under Constraint 3 outperforms other constraints. Also, by applying the benchmark, no constraint, and Constraint 2, arbitrary "box" constraints on weights in the maximum Sharpe portfolio, investors can have the highest Sharpe ratio of 1.700397. Thus, investors can determine the maximum Sharpe ratio and maximize their economic return from their portfolios by utilizing different constraints. It is needed to point out that the United States experienced the COVID-19 pandemic in 2020 during this 10-year-period in my data, and there may be some potential impacts on the U.S. stock market. As shown in Figure 1, the S&P 500 index had experienced a significant fluctuation in the American stock market in March 2020. Therefore, this paper will spilt the 10-year data into two sub-periods before and since March 2020 (January 2011 to March 2020, and April 2020 to May 2021) to see if there are any impacts on the American stock markets due to the COVID-19 outbreak.

As the same analysis for the whole period, this paper will apply the same methods to examine the portfolio performance under two sub-periods.

Markowitz Model

The table (Table 9) below illustrates the Sharpe Ratio in the minimum variance portfolio under the benchmark and four constraints before and since the COVID-19 pandemic in America.

Table 9 Performance of minimum variance portfolio under Markowitz Model

Before COVID-19			Since COVID-19		
Return	StDev	Sharpe	Return	StDev	Sharpe
9.817%	10.673%	0.91981	27.585%	12.063%	2.28678
24.863%	15.440%	1.61034	27.585%	12.063%	2.28678
9.817%	10.673%	0.91981	27.585%	12.063%	2.28678
10.474%	11.039%	0.94882	32.701%	12.669%	2.58124

%	%	8	%	%	3
12.062	11.133	1.0834	27.739	12.072	2.2977
%	%	4	%	%	5

Note: StDev stands for standard deviation

The table (Table 10) below illustrates the Sharpe Ratio in the maximum Sharpe ratio portfolio under the benchmark and four constraints.

Table 10 Performance of maximum Sharpe ratio portfolio under Markowitz Model

Before COVID-19			Since COVID-19		
Return	StDev	Sharpe	Return	StDev	Sharpe
31.945	19.253	1.6592	53.527	16.803	3.1854
%	%	6	%	%	7
24.863	15.440	1.6103	53.527	16.803	3.1854
%	%	4	%	%	7
31.945	19.253	1.6592	53.527	16.803	3.1854
%	%	6	%	%	7
21.895	15.499	1.4126	52.073	16.559	3.1447
%	%	5	%	%	8
26.502	16.502	1.6059	53.023	16.691	3.1768
%	%	3	%	%	1

Note: StDev stands for standard deviation

Index Model

The table (Table 11) below illustrates the Sharpe Ratio in the minimum variance portfolio under the benchmark and four constraints before and since the COVID-19 pandemic in the U.S.

Table 11. Performance of minimum variance portfolio under Index Model

Before COVID-19			Since COVID-19		
Return	StDev	Sharpe	Return	StDev	Sharpe
9.043	9.523	0.9496	28.618	11.832	2.4186
%	%	3	%	%	24
24.863	15.244	1.6310	28.618	11.832	2.4186
%	%	4	%	%	24
9.043	9.523	0.9496	28.618	11.832	2.4186
%	%	3	%	%	24
9.979	9.954	1.0024	32.931	12.769	2.5788
%	%	6	%	%	84
10.392	9.797	1.0607	28.328	11.845	2.3915
%	%	9	%	%	01

Note: StDev stands for standard deviation

The table (Table 12) below illustrates the Sharpe Ratio in the maximum Sharpe ratio portfolio under the benchmark and four constraints.

Table 12. Performance of maximum Sharpe ratio portfolio under Index Model

Before COVID-19			Since COVID-19		
Return	StDev	Sharpe	Return	StDev	Sharpe
29.640	17.240	1.7192	68.321	18.282	3.7370
%	%	5	%	%	5
24.863	15.244	1.6310	68.321	18.282	3.7370
%	%	4	%	%	5
29.640	17.240	1.7192	68.321	18.282	3.7370
%	%	5	%	%	5
22.747	14.922	1.5244	63.583	17.640	3.6044
%	%	5	%	%	27
26.188	15.552	1.6839	67.174	18.240	3.6826
%	%	1	%	%	82

Note: StDev stands for standard deviation

As can be seen from the above data, the minimum variance portfolios can be maximized with different constraints before and since the COVID-19 outbreak under both Markowitz and Index models. Before the COVID-19 outbreak in American, the Sharpe ratio is maximized under Constraint 1, allowing short positions in the portfolio. However, since the COVID-19 outbreak in American, the portfolio can achieve the highest Sharpe ratio under Constraint 3, which is not allowing any positions. In conclusion, under a minimum variance portfolio, the results from two periods illustrate that the portfolios can be maximized without any positions under uncertain circumstances, especially the COVID-19 pandemic.

By understanding the impacts of the pandemic in the American stock market, investors can optimize their portfolios by considering the COVID-19 as a factor.

5. CONCLUSION

We have experienced the COVID-19 pandemic for over a year, and people are learning how to thrive in this pandemic by now. It may continuously influence our lifestyles and the overall economic market. This paper employs the adjusted 10-year (January 2011 to May 2021) total return of the S&P 500 index and 10 company stocks to analyze the portfolio performance under various circumstances. In addition, the most significant finding is that different constraints lead to various performances in the portfolio with the involvement of COVID-19. This paper separates the 10-year data to before and since March 2020, when there was a significant market fluctuation in the U.S. Before March 2020 (before COVID-19 involvement), the

minimum variance portfolio can receive the best performance when permitting broker-dealers to allow their customers to have positions under both of Markowitz Model and Index Model. However, after March 2020 (since COVID-19 involvement), the minimum variance portfolio can have the best performance when any short positions are prohibited under both Markowitz Model and Index Model. Thus, the investors should modify their portfolio strategies responding to the COVID-19 outbreak in the U.S. Besides, to control and limit the risk in the financial market under the uncertainty of the COVID-19 pandemic, it might not be a good idea to take the risk to go short position in their investment. Instead, investors should not do short selling if they want to achieve a better and safer portfolio performance. However, the data of adjusted total return since the COVID-19 outbreak is limited since it only covers a few months. Therefore, the analysis for best portfolio performance with the involvement of the COVID-19 pandemic is limited. In addition, the state is facing a rebound of the pandemic due to the Delta variant, so the American stock market may experience another financial inconstancy in the upcoming months, which may reconstruct portfolio management strategy for investors.

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