

Impact of the Outbreak on U.S. Equity Portfolios Based on Markowitz and Index Models

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Abstract. The epidemic occurred in 2020 made a great difference in the global financial markets. To explore the impact on stock market, this paper builds special portfolios under four specific constraints by using Markowitz and index model. This paper selected the stock prices of 11 stocks in different industries for 20 years and then focused on two vital indicators to analysis the change of risk and return. One is minimum variance, and the other is maximum sharp ratio. The results show that there was an increase in both minimal variance and maximum sharp ratio during this special period. Comparing with the data before, this paper argues that the outbreak has caused financial volatility and accelerated the shift in the consumer side of the equation. The fluctuation of stock price can give rise to significant speculative activity and the increase in speculative activity has led to an increase in risk and a simultaneous increase in return. This paper also found that the degree of restriction under four constraints is almost not change. The results from this paper facilitate the study of epidemic's impact on other stock and help people to build a reasonable portfolio when investing.

Keywords: Coronavirus outbreak; Markowitz and Index Model; Portfolio.

1. Introduction

The Coronavirus outbreak, a once-in-a-century black swan incident, has had a severe impact on the global economy and society. The epidemic began with a massive outbreak in March 2020 in the U.S. At the same time, there were four meltdowns in U.S. stocks. U.S. GDP plunged at a 31.7% annualized quarterly rate in the second quarter, and a soar have taken placed in the unemployment to 14.7% in April, which became the highest since the Great Depression of the 1930s. Therefore, it is very meaningful to study the impact of the epidemic on U.S. stock portfolios by utilizing the Markowitz model and the Index model in this paper.

Research based on behavioral finance has found that the factor of investor sentiment can play a huge role in explaining some anomalies that happen in the stock market. It has been concluded that the disclosure of news of air crashes can create a psychological emotion of panic for investors, causing investors to make irrational judgments and affect their judgment and trading in the stock market, thus making the stock market suffer a shock [1]. Black swan events usually cause a chain of negative reactions and even extreme changes in the market, such as the September 11 terrorist attacks. It has been studied that the impact of the September 11 terrorist attacks on U.S. real estate sector stocks, where daily stock market return volatility increased significantly, but the terrorist attacks had only a temporary financial impact on REIT returns [2]. In response to this epidemic, it has been studied that the performance of the Fama-French model in the U.S. stock market and concluded that the square of R showed a significant decrease due to the epidemic, i.e., the model explained less strongly [3]. It has been found that brand equity makes a great difference in firms' stock performance, especially during the stock market crash crased by Covid-19. And according to U.S. listed companies, firms with the best brands experience higher stock returns, lower systematic risk and lower idiosyncratic risk in the context of Covid-19 crash than other firms [4]. It has been studied that the impact of the new crown pandemic on the microstructure of the U.S. stock market, explaining liquidity and volatility dynamics through indices, analyzing 48 classified sectors of Fama-French, and showed that the growth in the number of confirmed cases and deaths from the new crown virus was significantly associated with market liquidity and volatility [5]. It has been studied that the impact of the Google Trends Composite Index with Covid-19 as a search term and thematic composite on the implied volatility of 13 major stock markets in the United States, China, Italy, France, and India, with the

strongest direct and indirect impact on Europe compared to the rest of the world, where anxiety about the contagion effect of Covid-19 led to higher risk aversion in stock markets [6]. It has been analyzed that the impact of the new crown epidemic crisis on the medical device industry, arguing that as the vulnerability of global value chains has been highlighted in this crisis [7]. It also has been analyzed that the impact of Covid-19 on stock returns in the U.S. restaurant industry in terms of financial position, corporate strategy, and ownership structure, and found that the decline was more pronounced for larger, more leveraged, cash-flowing, and more international firms [8]. Kare et al. studied the potential influence of the epidemic on tourism and concluded that the recovery of global tourism would take more than 10 months [9]. It has been studied that the impact of the epidemic on agriculture and food supply chains and concluded that a pandemic would severely influence food demand and thus food safety, with a dramatic impact on the most vulnerable populations [10]. In general, it seems that these studies mainly focus on the impact of the new crown epidemic on some industries, while the literature on the impact of the epidemic on the stock market is less and the studies are relatively scattered, lacking research on stock indices and portfolios. Therefore, this paper builds portfolios consisting of 11 stocks in several sectors through Markowitz and index models. Analyzing the minimum variance and maximum Sharpe ratio before and after the epidemic to obtain more valuable conclusions.

The results show that there are both positive and negative sides in the influence of epidemic. From the perspective of risk, the minimal variance has a dramatic increase during this special period. This can be explained by the rising of uncertainty risk which is brought by outbreak. From the perspective of both risk and return, the significant indicator sharp ratio shows an escalating trend. This means that the appearance of the epidemic has brought more speculative activities in some industries.

2. The introduction of data

This paper investigated the portfolio performance covering consumer cyclical, technology, financial services and industrials, and each stock select 20 years data monthly from 2001 to 2021. The consumer cyclical part selects Amazon (AMZN), which is one of the largest online e-commerce companies in the United States. The technology selects Apple Inc (AAPL) and Citrix Systems Inc (CTXS). Apple Inc. is an American high-tech company founded by Steve Jobs. The main products of this company are the iPod media players, Mac computer series, iPad tablets and iPhone smartphones. Citrix Systems, Inc. is a multinational company that provides server and desktop virtualization, software-as-a-service, networking, and cloud computing technology. The financial services select JPMorgan Chase & Co (JPM), Berkshire Hathaway Inc (BRK/A) and the progressive corporation (PGR). J.P. Morgan Chase & Co. is a major U.S. commercial bank formed by the merger of J.P. Morgan & Co. Berkshire Hathaway is a company that is primarily engaged in the insurance business, and the most significant of which is property and casualty insurance based on direct premiums as well as reinsurance amounts. Progressive Corporation is an insurance holding company that provides personal auto and other property casualty insurance, among other things. The industrials select United Parcel Service Inc (UPS), FedEx Corporation (FDX), J.B. Hunt Transport Services Inc (JBHT) and Landstar System Inc (LSTR). United Parcel Service Inc is a world leader in logistics, providing parcel and freight delivery, facilitation of international trade, deployment of cutting-edge technologies and other solutions aimed at enhancing the effectiveness of global business management. FedEx is a group of international couriers that offer night delivery, heavy freight, ground delivery, document copying and logistics services. J. B. hunt Transportation Company is the largest full container transportation company in the United States. Landstar System, Inc. is a non-asset-based provider of freight transportation services and supply chain solutions. It is clear that every stock has an increased trend during these 20 years.

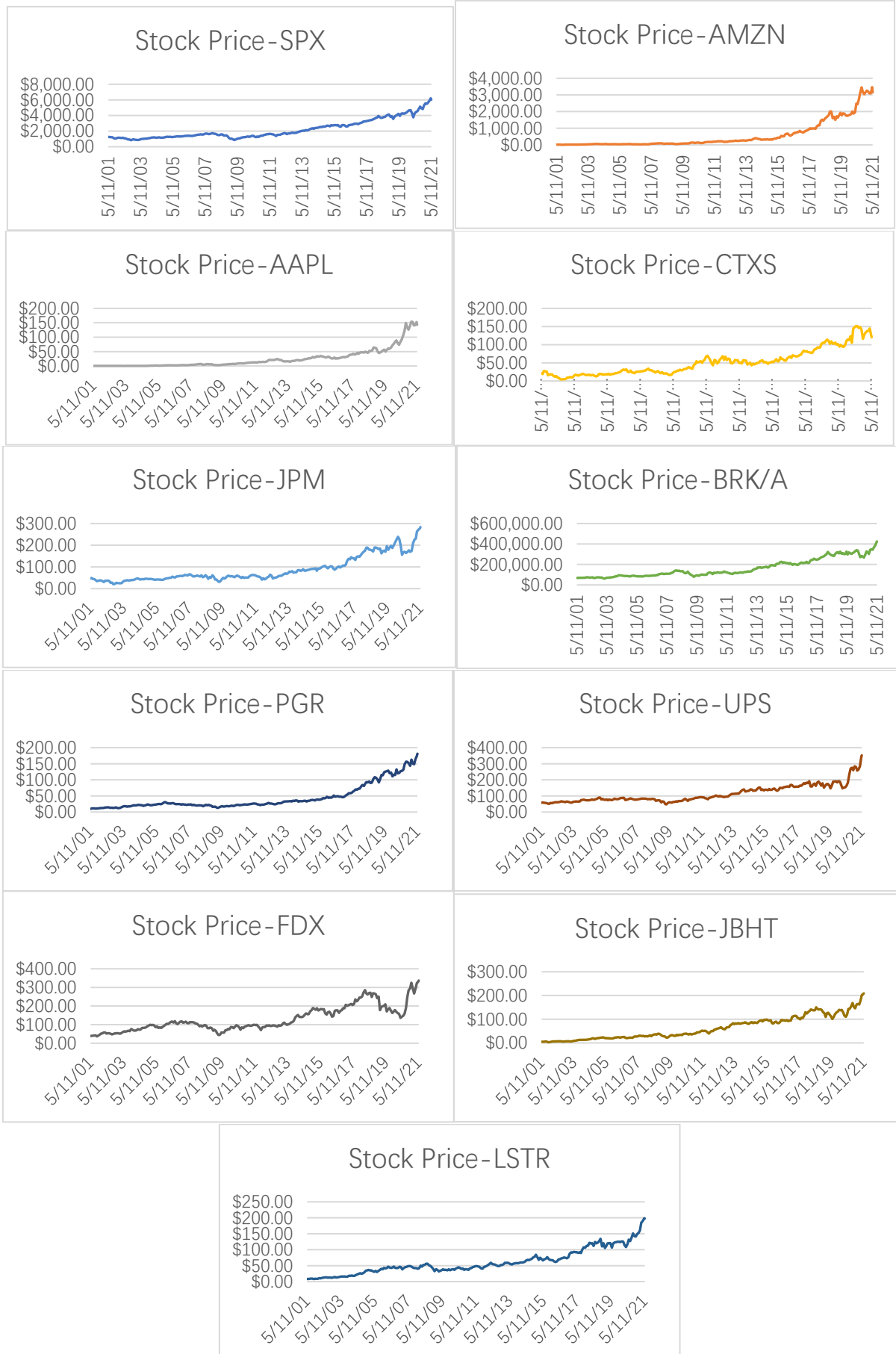


Fig. 1 Stock price for individual stocks and SPX

Source: Futuball [11]

Table 1. Correlation between 11 stocks after COVID-19

correlations	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
SPX	1.000	0.485	0.542	0.437	0.697	0.523	0.502	0.575	0.614	0.521	0.495
AMZN	0.485	1.000	0.377	0.217	0.252	0.118	0.200	0.296	0.280	0.308	0.256
AAPL	0.542	0.377	1.000	0.332	0.244	0.173	0.240	0.231	0.330	0.268	0.287
CTXS	0.437	0.217	0.332	1.000	0.324	0.181	0.271	0.264	0.331	0.290	0.252
JPM	0.697	0.252	0.244	0.324	1.000	0.452	0.393	0.361	0.440	0.442	0.375
BRK/A	0.523	0.118	0.173	0.181	0.452	1.000	0.264	0.404	0.385	0.239	0.234
PGR	0.502	0.200	0.240	0.271	0.393	0.264	1.000	0.392	0.365	0.280	0.289
UPS	0.575	0.296	0.231	0.264	0.361	0.404	0.392	1.000	0.675	0.459	0.441
FDX	0.614	0.280	0.330	0.331	0.440	0.385	0.365	0.675	1.000	0.537	0.482
JBHT	0.521	0.308	0.268	0.290	0.442	0.239	0.280	0.459	0.537	1.000	0.590
LSTR	0.495	0.256	0.287	0.252	0.375	0.234	0.289	0.441	0.482	0.590	1.000

From Table 1, the results show that each stock has a high correlation with the SPX and the correlations between stocks in the same industry are relatively high.

To explore the impact of the epidemic, this paper divided the stock price data into two parts from December 31, 2019, based on that December 31, 2019 as the time cutoff point is that the major outbreak began after January 2020 in US. In this way, data can reflect the impact of the outbreak more accurately.

Table 2. Correlation between 11 stocks after COVID-19

Correlations	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
SPX	1.000	0.607	0.766	-0.138	0.807	0.818	0.307	0.465	0.484	0.732	0.712
AMZN	0.607	1.000	0.778	0.182	0.131	0.315	0.446	0.433	0.185	0.290	0.287
AAPL	0.766	0.778	1.000	0.084	0.381	0.563	0.476	0.541	0.379	0.509	0.468
CTXS	-0.138	0.182	0.084	1.000	-0.278	-0.150	0.193	0.008	-0.290	0.123	0.001
JPM	0.807	0.131	0.381	-0.278	1.000	0.800	0.045	0.230	0.366	0.607	0.690
BRK/A	0.818	0.315	0.563	-0.150	0.800	1.000	0.287	0.600	0.639	0.640	0.677
PGR	0.307	0.446	0.476	0.193	0.045	0.287	1.000	0.356	0.176	0.194	0.153
UPS	0.465	0.433	0.541	0.008	0.230	0.600	0.356	1.000	0.641	0.528	0.418
FDX	0.484	0.185	0.379	-0.290	0.366	0.639	0.176	0.641	1.000	0.421	0.372
JBHT	0.732	0.290	0.509	0.123	0.607	0.640	0.194	0.528	0.421	1.000	0.825
LSTR	0.712	0.287	0.468	0.001	0.690	0.677	0.153	0.418	0.372	0.825	1.000

From this new correlation table after COVID-19, the results show that the Coronavirus make an effect on correlation between stocks which lead to changing in Markowitz model.

2.1 The structure of two main models

The portfolio in this paper is formed by:

$$\text{portfolio} = w_1 * SPX + w_2 * AMZN + w_3 * AAPL + w_4 * CTXS + w_5 * JPM + w_6 * BRK/A + w_7 * PGR + w_8 * UPS + w_9 * FDX + w_{10} * JBHT + w_{11} * LSTR \quad (1)$$

This thesis mainly focuses two models. The first one is Markowitz model. This theory was first proposed by the American economist Markowitz in 1952 [12]. The theory consists of two important elements, one is the mean-variance analysis method, and the other is portfolio efficient frontier model. There are two core problems of investments in securities, expected return and risk. Markowitz gave a precise definition of these, and he add mathematical and statistical methods into the study of asset portfolio selection by defining return and risk as mean and variance, pioneering the quantitative measurement of risk. Thus, the complex multidimensional problem of portfolio selection is limited to a straightforward quadratic programming problem with a clear concept., i.e., mean-variance analysis.

Markowitz argues that the investor should minimize the overall investment risk by maximizing the objective function $E(r_p) = \sum x_i r_i$ (Getting the maximum expected return) and minimizing the objective function $\sigma^2 = \sum_{i=1}^n \sum_{j=1}^n \delta_{ij}^2 x_i x_j$ (Expected minimal investment risk) to determine the weighting of each asset in the portfolio. In a portfolio investment model, the goal of portfolio construction is to build a portfolio with the highest rate of return for a given level of risk, i.e., an efficient portfolio.

The second model is index model which is proposed by William Shape in 1963 [13]. This model simply divides the risk of a single security into two components: market risk (systematic risk) and firm-specific risk. Consequently, the return of value is written in a form that includes both systematic and company-specific risk, where systematic risk can generally be represented by the yields of the major security indices.

Following are some forms of Index model. General form of the index model: $r_i = E(r_i) + \beta_i F + e_i$, F represents the Impact of macro events, e_i represents the Impact of company-specific events and β_i represents the Sensitivity of securities I to macroeconomic events. Considering the variance of individual securities $\sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma^2(e_i)$, consider the covariance of two securities $Cov(R_i, R_j) = \beta_i \beta_j \sigma_m^2$. The risks specific to both companies are not relevant, so $Cov(e_i, e_j) = 0$.

To examine the performance of the portfolio, this paper conducted the study under five restrictions. Following are introduction of those constraints.

Benchmark: This situation with no additional optimizing constraints. In this way, to demonstrate how the area of permissible portfolios in general and the efficient frontier.

Constraint 1: This extra optimization constraint is intended to emulate FINRA Regulation T, which allows broker-dealers to allow their customers to take positions that are financed 50% or more by their account equity.

$$\sum_{i=1}^{11} |w_i| \leq 2 \tag{2}$$

Constraint 2: This new optimization limitation is intended to imitate certain arbitrary "box" weight requirements that the client may provide:

$$|w_i| \leq 1, \text{ for } \forall i \tag{3}$$

Constraint 3: This extra optimization constraint is intended to mimic typical limitations in the US mutual fund industry: a US open-ended mutual fund is not permitted to have any short positions; for further information, see Section 12(a) of the Investment Company Act of 1940. (3)

$$w_i \geq 0, \text{ for } \forall i \tag{4}$$

Constraint 4: The last additional optimization is to see if adding a broad index to a portfolio has a beneficial or negative impact, (in this study is SPX).

$$w_1 = 0 \tag{5}$$

3. Results

This section shows the results obtained by the portfolio under different scenarios. To begin with, the risk is the only factor considered. As shown in Table 3 to Table 6, this paper builds the portfolio which has the minimum variance in two models under four constraints. Comparing with the situation of no constraint, what is noteworthy is that constraints 1 and 2 have almost no effect on the minimum variance in two models. This result reflects the fact that those two constraints are weakly restricted. And the results shows that the minimum variance under constraints 3 and 4 are bigger than the results without constraints.

Markowitz-minimum Variance

Table 3. Weights of minimum variance portfolio under Marowitz model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Benchmark	0.722	-0.023	-0.038	-0.010	-0.185	0.362	0.139	0.034	-0.103	-0.005	0.108
Constraint 1	0.722	-0.023	-0.038	-0.010	-0.185	0.362	0.139	0.034	-0.103	-0.005	0.108
Constraint 2	0.722	-0.023	-0.038	-0.010	-0.185	0.362	0.139	0.034	-0.103	-0.005	0.108
Constraint 3	0.385	0.000	0.000	0.000	0.000	0.385	0.142	0.007	0.000	0.000	0.081
Constraint 4	0.000	0.025	0.042	0.008	-0.071	0.563	0.235	0.114	-0.081	0.006	0.158

Table 4. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Benchmark	7.15%	12.24%	0.584
Constraint 1	7.15%	12.24%	0.584
Constraint 2	7.15%	12.24%	0.584
Constraint 3	10.04%	13.09%	0.767
Constraint 4	13.20%	13.39%	0.986

Index-minimum Variance

Table 5. Weights of minimum variance portfolio under Index model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Benchmark	0.658	-0.041	-0.047	-0.024	-0.129	0.345	0.134	0.086	-0.036	-0.017	0.072
Constraint 1	0.658	-0.041	-0.047	-0.024	-0.129	0.345	0.134	0.086	-0.036	-0.017	0.072
Constraint 2	0.658	-0.041	-0.047	-0.024	-0.129	0.345	0.134	0.086	-0.036	-0.017	0.072
Constraint 3	0.305	0.000	0.000	0.000	0.000	0.377	0.146	0.093	0.000	0.000	0.079
Constraint 4	0.000	-0.016	-0.008	-0.001	-0.050	0.480	0.216	0.178	0.035	0.028	0.138

Table 6. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Benchmark	6.46%	12.43%	0.520
Constraint 1	6.46%	12.43%	0.520
Constraint 2	6.46%	12.43%	0.520
Constraint 3	10.24%	12.99%	0.788
Constraint 4	11.47%	13.21%	0.869

In addition to considering risk, return also been investigated as another factor. In this paper, Sharpe ratio as an important indicator that considers both risk and return. According to analyzing Sharp ratio and the results from Table 7 to Table 10, there are several conclusions about the difference between four constraints. First, the constraint 3 is the most restrictive. To be more specific, banning short selling makes a difference on maximum Sharp ratio. It reduces maximum Sharp ratio and maximum risk-taking. Investing in this constraint is suitable for the risk averse, not for the risk seeking. Second, the constraint 4 which means you can't invest in SPX also has a great restriction power. As we all know, SPX is a market-value-weighted index which is indicator to measure the performance of the stock market. People can use it to track average returns and comparing performance of managers. Because it is a stock index which is broadly based on many firms, so it can make a huge difference to our portfolios. These results indicate that invest in SPX has a positive influence on portfolio. It can make the maximum Sharp ratio become bigger and the minimal variance become smaller. Third, the constraint 1 is less restrictive than the constraint 3, but also has a great limited ability. The intrinsic mean of constraint 1 is the restriction of maintenance margin. We know that the percentage margin is calculated by dividing the account's net worth, or "equity value," by the market value of the securities., which is fifty percent under the constraint 1. The investor can borrow part of the purchase

price of the stock from the broker and securities purchased on margin are used as collateral from the loan. It can get great yield and risk. That's why this constraint can get bigger maximum sharp ratio and risk than the constraint 3 which is no short selling.

Comparing the results of Markowitz and Index model respectively, it shows that the portfolio in index model performance better. Under each constraint, index model shows smaller minimal variance and bigger maximum sharp ratio. The intrinsic difference between these two models is that Index model attempts to consider the correlation between securities from the perspective of analyzing the related factors that have a common influence on the returns of various securities, rather than from the perspective of the covariance of securities as Markowitz model does. As for Markowitz model, errors may occur in the estimation of correlation between each asset in the portfolio, which may lead to meaningless results, and Markowitz model can only use historical data to select the optimal portfolio but cannot provide the prediction method of security. Two models considerate about different risk factors. Those are the reasons which can explain the better performance in Index model.

Markowitz- maximum Sharp ratio

Table 7. Weights of maximum Sharp ratio portfolio under Marowitz model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Benchmark	-0.483	0.164	0.300	-0.001	-0.001	0.413	0.330	0.000	-0.015	0.125	0.167
Constraint 1	-1.000	0.223	0.398	-0.012	-0.005	0.625	0.460	-0.031	-0.106	0.209	0.239
Constraint 2	0.722	-0.023	-0.038	-0.010	-0.185	0.362	0.139	0.034	-0.103	-0.005	0.108
Constraint 3	0.000	0.130	0.252	0.000	0.000	0.193	0.227	0.000	0.000	0.088	0.110
Constraint 4	0.000	0.147	0.267	-0.034	-0.155	0.363	0.320	-0.122	-0.132	0.178	0.168

Table 8. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Benchmark	49.61%	32.25%	1.539
Constraint 1	26.42%	18.69%	1.413
Constraint 2	33.18%	22.11%	1.501
Constraint 3	22.09%	17.62%	1.254
Constraint 4	23.89%	18.02%	1.326

Index-maximum Sharp ratio

Table 9. Weights of maximum Sharp ratio portfolio under Index model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Benchmark	-3.298	0.430	0.700	0.110	0.088	0.585	0.723	0.279	0.249	0.503	0.629
Constraint 1	-0.473	0.178	0.305	0.005	-0.027	0.224	0.315	0.012	0.001	0.192	0.267
Constraint 2	-1.000	0.218	0.366	0.031	-0.088	0.333	0.400	0.095	0.056	0.250	0.338
Constraint 3	0.000	0.155	0.271	0.000	0.000	0.033	0.214	0.000	0.000	0.140	0.188
Constraint 4	0.000	0.186	0.317	-0.005	-0.212	0.117	0.277	-0.053	-0.054	0.186	0.242

Table 10. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Benchmark	60.91%	38.16%	1.596
Constraint 1	28.57%	19.98%	1.430
Constraint 2	34.07%	22.40%	1.521
Constraint 3	24.45%	19.16%	1.277
Constraint 4	26.95%	20.24%	1.331

What's more, to explore the impact of the epidemic, this paper divided the stock price data into two parts, building portfolios with minimum variance and maximum sharp ratio respectively. Firstly, focusing on the only factor, minimum variance. The results in Table 11 to Table 14 of two models show that after the Coronavirus outbreak, there was an increase in minimal variance. In other words,

the emergence of the epidemic has increased the risk of investment. According to the survey, most industries were hit hard by the outbreak, and people have also reduced their consumption due to the protective restrictions. Therefore, it is a very reasonable phenomenon.

Markowitz-minimum Variance

Table 11. Weights of minimum variance portfolio under Marowitz model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Before											
Benchmark	0.608	-0.027	-0.023	-0.033	-0.304	0.433	0.161	0.078	-0.061	0.053	0.117
Constraint 1	0.608	-0.027	-0.023	-0.033	-0.304	0.433	0.161	0.078	-0.061	0.053	0.117
Constraint 2	0.608	-0.027	-0.023	-0.033	-0.304	0.433	0.161	0.078	-0.061	0.053	0.117
Constraint 3	0.405	0.000	0.000	0.000	0.000	0.394	0.099	0.035	0.000	0.000	0.067
Constraint 4	0.000	0.015	0.043	-0.006	-0.286	0.615	0.265	0.171	-0.037	0.068	0.151
After											
Benchmark	1.866	-0.340	-0.354	0.227	-0.431	-0.231	0.185	0.145	0.037	-0.616	0.513
Constraint 1	0.655	0.000	-0.246	0.197	-0.028	0.000	0.251	0.002	0.091	-0.225	0.303
Constraint 2	1.000	-0.094	-0.299	0.205	-0.177	-0.067	0.234	0.055	0.084	-0.423	0.481
Constraint 3	0.233	0.000	0.000	0.169	0.024	0.000	0.257	0.000	0.076	0.000	0.242
Constraint 4	0.000	0.191	-0.236	0.180	0.116	0.122	0.290	-0.049	0.140	-0.199	0.445

Table 12. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Before			
Benchmark	7.08%	10.60%	0.668
Constraint 1	7.08%	10.60%	0.668
Constraint 2	7.08%	10.60%	0.668
Constraint 3	8.55%	12.41%	0.689
Constraint 4	12.08%	11.64%	1.039
After			
Benchmark	9.43%	12.29%	0.767
Constraint 1	19.25%	13.68%	1.407
Constraint 2	17.15%	12.89%	1.331
Constraint 3	27.30%	16.13%	1.692
Constraint 4	26.08%	14.87%	1.754

Index-minimum Variance

Table 13. Weights of minimum variance portfolio under Index model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Before											
Benchmark	0.571	-0.039	-0.036	-0.047	-0.110	0.313	0.088	0.352	-0.204	-0.060	0.172
Constraint 1	0.571	-0.039	-0.036	-0.047	-0.110	0.313	0.088	0.352	-0.204	-0.060	0.172
Constraint 2	0.571	-0.039	-0.036	-0.047	-0.110	0.313	0.088	0.352	-0.204	-0.060	0.172
Constraint 3	0.000	0.000	0.000	0.000	0.000	0.352	0.095	0.370	0.000	0.000	0.182
Constraint 4	0.000	-0.030	-0.022	-0.037	-0.081	0.358	0.120	0.517	-0.065	-0.003	0.244
After											
Benchmark	0.295	0.036	-0.109	0.169	-0.121	0.139	0.262	0.045	0.028	0.015	0.239
Constraint 1	0.295	0.036	-0.109	0.169	-0.121	0.139	0.262	0.045	0.028	0.015	0.239
Constraint 2	0.295	0.036	-0.109	0.169	-0.121	0.139	0.262	0.045	0.028	0.015	0.239
Constraint 3	0.014	0.038	0.000	0.179	0.000	0.147	0.277	0.048	0.030	0.016	0.252
Constraint 4	0.000	0.056	-0.076	0.170	-0.075	0.213	0.277	0.057	0.040	0.052	0.287

Table 14. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Before			
Benchmark	4.85%	11.03%	0.440
Constraint 1	4.85%	11.03%	0.440
Constraint 2	4.85%	11.03%	0.440
Constraint 3	9.70%	11.82%	0.821
Constraint 4	8.14%	11.31%	0.719
After			
Benchmark	33.03%	14.85%	2.225
Constraint 1	33.03%	14.85%	2.225
Constraint 2	33.03%	14.85%	2.225
Constraint 3	37.19%	15.25%	2.438
Constraint 4	36.25%	14.99%	2.418

After that, considering about the impact on both risk and return. A rise occurred in maximum sharp ratio after the outbreak. It is startling that the incremental return per incremental risk is bigger during this special period. One explanation is black swan incidents cause the financial volatility which means the fluctuation of asset price. The other explanation is that the epidemic has accelerated the shift of the consumer side from traditional industries to the new economy. In this way, technology stocks rebound up.

Comparing these two models, the figure indicates that at almost same standard deviation, the maximum sharp ratio is bigger in Index model. Explore the reasons behind the difference, this paper found that the Coronavirus made an effect on correlation between stocks which lead to changing in Markowitz model. However, the anomalies in several sectors following the epidemic are difficult to explain effectively by the models and may be related to several important events in the U.S. and globally in 2020 such as federal reserve quantitative easing, Brexit, black riots, antitrust investigations, and the U.S. presidential election.

Markowitz- maximum sharp ratio

Table 15. Weights of maximum sharp ratio portfolio under Marowitz model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Before											
Benchmark	-1.484	0.266	0.451	0.043	-0.318	0.892	0.650	0.013	-0.126	0.344	0.269
Constraint 1	-0.228	0.125	0.233	0.000	-0.224	0.487	0.332	0.000	-0.048	0.173	0.150
Constraint 2	-1.000	0.210	0.361	0.024	-0.321	0.772	0.547	-0.003	-0.123	0.296	0.237
Constraint 3	0.000	0.126	0.258	0.000	0.000	0.236	0.202	0.000	0.000	0.097	0.080
Constraint 4	0.000	0.120	0.217	-0.019	-0.339	0.496	0.357	-0.102	-0.142	0.236	0.176
After											
Benchmark	-5.244	1.594	0.556	-0.058	2.199	-1.307	0.765	-0.183	0.945	0.518	1.214
Constraint 1	-0.329	0.034	0.118	0.063	-0.001	-0.003	0.353	-0.064	0.247	-0.104	0.684
Constraint 2	-1.000	0.426	0.081	0.093	0.694	-1.000	0.442	0.071	0.476	-0.224	0.940
Constraint 3	0.000	0.138	0.000	0.050	0.000	0.000	0.268	0.000	0.173	0.000	0.371
Constraint 4	0.000	0.143	0.006	0.124	0.405	-1.158	0.384	0.170	0.412	-0.439	0.954

Table 16. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Before			
Benchmark	38.26%	24.64%	1.553
Constraint 1	22.17%	15.53%	1.428
Constraint 2	32.16%	20.81%	1.545
Constraint 3	20.86%	17.10%	1.220
Constraint 4	21.94%	15.68%	1.399
After			
Benchmark	122.91%	44.40%	2.768
Constraint 1	41.29%	18.75%	2.202
Constraint 2	62.44%	23.62%	2.644
Constraint 3	36.08%	17.68%	2.041
Constraint 4	52.52%	21.10%	2.489

Index- maximum sharp ratio

Table 17. Weights of maximum sharp ratio portfolio under Index model

	SPX	AMZN	AAPL	CTXS	JPM	BRK/A	PGR	UPS	FDX	JBHT	LSTR
Before											
Benchmark	0.571	-0.039	-0.036	-0.047	-0.110	0.313	0.088	0.352	-0.204	-0.060	0.172
Constraint 1	0.571	-0.039	-0.036	-0.047	-0.110	0.313	0.088	0.352	-0.204	-0.060	0.172
Constraint 2	0.571	-0.039	-0.036	-0.047	-0.110	0.313	0.088	0.352	-0.204	-0.060	0.172
Constraint 3	0.000	0.000	0.000	0.000	0.000	0.352	0.095	0.370	0.000	0.000	0.182
Constraint 4	0.000	-0.030	-0.022	-0.037	-0.081	0.358	0.120	0.517	-0.065	-0.003	0.244
After											
Benchmark	0.295	0.036	-0.109	0.169	-0.121	0.139	0.262	0.045	0.028	0.015	0.239
Constraint 1	0.295	0.036	-0.109	0.169	-0.121	0.139	0.262	0.045	0.028	0.015	0.239
Constraint 2	0.295	0.036	-0.109	0.169	-0.121	0.139	0.262	0.045	0.028	0.015	0.239
Constraint 3	0.014	0.038	0.000	0.179	0.000	0.147	0.277	0.048	0.030	0.016	0.252
Constraint 4	0.000	0.056	-0.076	0.170	-0.075	0.213	0.277	0.057	0.040	0.052	0.287

Table 18. Return, Standard deviation, Sharp ratio

	Return	Standard deviation	Sharpe ratio
Before			
Benchmark	4.85%	11.03%	0.440
Constraint 1	4.85%	11.03%	0.440
Constraint 2	4.85%	11.03%	0.440
Constraint 3	9.70%	11.82%	0.821
Constraint 4	8.14%	11.31%	0.719
After			
Benchmark	33.03%	14.85%	2.225
Constraint 1	33.03%	14.85%	2.225
Constraint 2	33.03%	14.85%	2.225
Constraint 3	37.19%	15.25%	2.438
Constraint 4	36.25%	14.99%	2.418

4. Conclusion

The Coronavirus outbreak is a black swan incident which has had a severe impact on the global economy and society. So, it is meaningful to research the influence on US stock by using Markowitz

and Index model. The paper has presented the portfolio with minimum variance and maximum sharp ratio before and after the epidemic. Our findings qualitatively agree that the outbreak has caused financial volatility and accelerated the shift in the consumer side of the equation. Besides the outbreak do not change the degree of restriction under four constraints. In the future, by selecting more representative stocks in different industries, this study can facilitate people to build a portfolio which has better return and smaller risk during this special period.

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