The Portfolio Construction During COVID-19 Pandemics Based on Markowitz Models and Index Models

Xinsong Fan[1*, †], Jiahao Wang[2 †], Keming Yi[3†], Lijia Zhou[4†]
*Corresponding author: xfan1@wyomingseminary.org, Jiaohao.wang@ljcds.org,

yikeming_2023@stu.swfla.org, zhoulijia@shphschool.com

[1]Wyoming Seminary, Shanghai, China

[2]La Jolla Country Day School, Shanghai, China

[3]Shanghai World Foreign Language Academy, Shanghai, China,

[4]Shanghai Pinghe School, Shanghai, China

[†]These authors contributed equally

Abstract—Contemporarily, COVID-19 has a huge impact on every aspect of life, especially business and finance. It penetrates so deeply that corporates lost a significant amount of their income. To investigate the impact on the financial market, we collected twenty-year data from 10 famous tickers to investigate the performances of the portfolio based on different construction models. On account of exploring the impact of COVID-19 on industries to what extent, we compared the trend during the specific time period and the previous data and found the most optimized point based on Markowitz Model and Index Models. According to the results, small industries experienced a more negative impact from the covid-19 than the larger corporates. These results shed light on the portfolio design to optimize the investments decision.

Keywords-COVID-19; Economic Loss; Markowitz Models and Index Model; Data Analysis.

1 INTRODUCTION

Asset allocation is the implementation of an investment strategy that attempts to balance risk versus reward by adjusting the percentage of each asset in an investment portfolio according to the investor's risk tolerance, goals, and investment time frame [1-3]. Asset allocation refers to the allocation of investments to different types of assets, e.g., stocks, bonds, real estate, and cash according to the investor's individual circumstances and investment objectives in order to obtain the desired return while minimizing the risk of market failure. In brief, asset allocation is a financial concept in which investors allocate their asset portfolios in terms of the time frame of their investment plans and the risk they can tolerate. It can be applied to any portfolio with more than two stocks but is more commonly used at the asset class level. Different asset classes operate differently in the marketplace, i.e., their returns and the risks involved vary [4, 5].

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The concept of asset allocation was not born in modern times. 400 years ago, In fact, the Spaniard Cervantes, in his legendary work Don Quixote, advised, "Don't put all your eggs in one basket" [6]. No coincidence that Shakespeare's contemporaries also conveyed the idea of "diversification" in "The Merchant of Venice" [7]. Afterward, however, the theory of asset allocation has not grown much in the following 300 years. No doubt that one or two interesting examples can be cited. For example, in 1921, the Wall Street Journal suggested to investors an optimal portfolio: 25% in sound bonds, 25% in sound preferred stocks, 25% in sound common stocks, and the remaining 25% in speculative securities. In 1952, as the beginning of modern asset portfolio theory, Markowitz published his 14-page paper, the Portfolio Selection [8]. In 1959, Markowitz systematized his theory by publishing Portfolio Selection which attempts to analyze how households and firms can dispose of financial assets under conditions of uncertainty. The book was an attempt to analyze how households and firms could dispose of their financial assets in order to invest their wealth in the most appropriate way and thus reduce risk, marking the birth of modern portfolio selection theory.

Scholars have been analyzing the implementation of asset allocation for decades. Roger, one of the best-known scholars and practitioners in the field of asset allocation, published an article named about his understanding of asset allocation way back in 2000 [9]. The passages mainly focus on whether asset allocation policy explains 40 percent, 90 percent, and 100 percent of the performance. During the research, three categories were introduced to the stage, while results turned out to be matched their prediction before the experiment took place. With each fund's total returns against its policy returns and recorded the R square value for each fund in the study, results turned out that on average, about 90 percent of the variability of returns of a typical fund across time is explained by asset allocation policy. Most of a fund's ups and downs are explained by the ups and downs of the overall market. Another research was led by MFS, an American-based global investment manager founded in 1924 discussed the fluctuation range during the past 20 years for the asset allocation. With the change of the social patterns, different industries suffered from either pros or cons, presented by the sum of charts and pie charts to illustrate the overall annualized return [10, 11].

Our research's goal is to analyze the impact of COVID-19 on asset allocation. Tremendous loss and change in the global economy mean that the situation for different asset classes is not optimistic. With a better understanding of how the circumstance difference takes place, it would be better for different asset classes to deal with the situation while stepping out from the impact brought by the pandemic. The rest part of the paper is organized as follows. The Sec. II will introduce the data origination and the analyzing method. Subsequently, the results will be demonstrated and explained accordingly with the describing of the research limitations. Eventually, a brief summary will be given in Sec. IV.

2 DATA & METHOD

The ten stocks chose to calculate are Adobe Inc., Alaska Air Group, Inc., Bank of America Corporation, Citigroup Inc., Hawaiian Holdings, Inc., International Business Machines Corporation, Southwest Airlines co., SAP SE, and Wells Fargo &Company. We found their 5-day week daily data for the past 20 years from Yahoo Finance. Fig. 1 gives the price trend of the selected underlying assets.

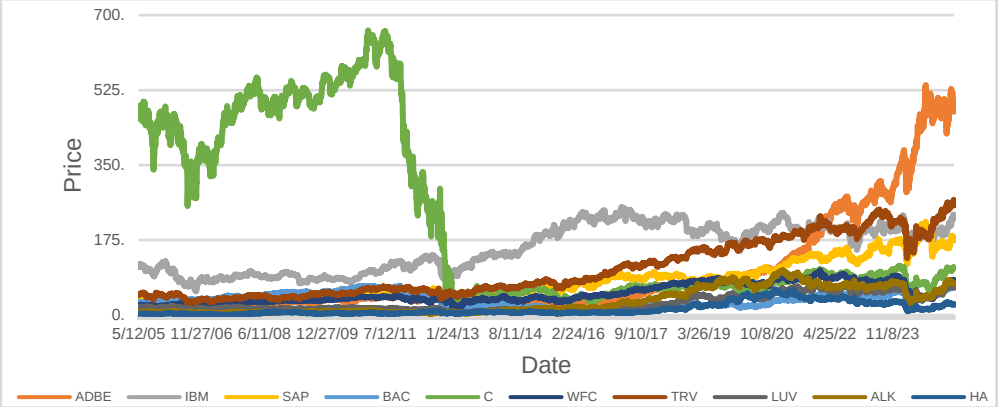

Figure 1. Historical daily total return data for ten stocks in 20 years

Basically, our aim is to use these data to plot a Permissible Portfolios Region. As a result, the single-index model, developed by William Sharpe in 1963 and is commonly used in the finance industry, is a simple asset pricing model to measure both the risk and the return of stocks:

$$R_i = \beta_i r_M + \alpha_i + residual_i (1)$$

Where R_i is the return of the instruments, β_i is the stock's beta, or responsiveness to the market return, r_M represents the market returns, α_i is the stock's alpha value, $residual_i$ denotes for the residual returns. According to this formular, the return of an asset is influenced by the market (reflected in beta), which has firm-specific excess returns (reflected in alpha), and firm-specific risks (residuals).

To achieve these components, we need first to transmit from daily data into monthly data, which used a formula "if(month(today)<>month(tomorrow),1,0)", then keep all data with the number 1. Secondly, we choose the whole column of one stock using "AVERAGE [data]*12" and "STDEV [data]*SQRT (12)" to calculate the annualized average return and annualized standard error. Thirdly, we calculate the correlation between ten stocks by using "CORREL [all data of stock 1, all data of stock 2]". This step helps us to obtain the prerequisite data for beta and alpha. The correlation table is given in Table. 1. Finally, we can calculate beta and alpha through the excel function called "slope" and "intercept". It is worthy to mention that we need to multiply the alpha by 12 since this is monthly data and we want to put it into an annualized formula.

To achieve the two models, we utilized the solver function to adjust the weighting of each stock. Setting the output at the cell of standard deviation or Sharp ratio, we successfully found the points of minimum variance and the maximum Sharpe ratio with the correct allocation of the weights. Both Markowitz Model and Index Model follow the same calculation method but achieve different data, so the two models provide two insights into the optimization of the portfolio with the maximum income while minimizing the risk.

Table 1 The correlation table

	SPX	ADBE	IBM	SAP	BAC	C	WFC	TRV	LUV	ALK	HA
SPX	1	0.6646	0.6494	0.6494	0.6023	0.7017	0.5553	0.5976	0.5369	0.4636	0.3898
ADBE	0.6646	1	0.4552	0.5342	0.4226	0.4633	0.2975	0.4518	0.3883	0.2328	0.1797
IBM	0.6494	0.4552	1	0.5853	0.3128	0.4198	0.2669	0.3824	0.3470	0.3569	0.2462
SAP	0.6494	0.5342	0.5853	1	0.3306	0.4338	0.2979	0.3751	0.3176	0.2822	0.1436
BAC	0.6023	0.4226	0.3128	0.3306	1	0.8262	0.7606	0.3931	0.4279	0.2751	0.3375
C	0.7017	0.4633	0.4198	0.4338	0.8262	1	0.7031	0.5119	0.4277	0.3044	0.3429
WFC	0.5553	0.2975	0.2669	0.2979	0.7606	0.7031	1	0.3450	0.4059	0.3470	0.3584
TRV	0.5976	0.4518	0.3824	0.3751	0.3931	0.5119	0.3450	1	0.4069	0.3595	0.2395
LUV	0.5369	0.3883	0.3470	0.3176	0.4279	0.4277	0.4059	0.4069	1	0.5191	0.4215
ALK	0.4636	0.2328	0.3569	0.2822	0.2751	0.3044	0.3470	0.3595	0.5191	1	0.4042
HA	0.3898	0.1797	0.2462	0.1436	0.3375	0.3429	0.3584	0.2395	0.4215	0.4042	1

3 RESULTS & DISCUSSION

Based on the data collected in the previous section, we construct two models to optimize the portfolio.

3.1 Markowitz Model

In the Markowitz Model (seen from Fig. 2), those blue dots on the map represents all the possibilities if assigned different weights to each stock. The dots are all random so that they can be used for the purpose of estimating. The curve in the graph is the minimum portfolio frontier, a curve that consists of all the points that have the least variance (standard deviation) at each return rate assigned. The leftmost point of the curve is the global minimum-variance portfolio which indicates the portfolio with the smallest variance compared to the portfolio at other given return rates. The global minimum variance in our model is at the point when the expected return is 6.691% with a minimum variance of 11.746%. All the portfolios below this minimum variance will be considered as not possible or not wise to approach. All the parts of the curve above the global minimum frontier are the efficient frontier which is a relatively optimal portfolio that investors will choose. Moreover, the straight line in the Markowitz Model refers to the Capital Allocation Line (CAL), a combination of risk-free and risk assets, indicating the expected return given a certain level of risk. The slope of the CAL is a ratio between incremental return and risk. The slope of CAL in our model is 1.035. Since our goal is to optimize the

portfolio, the intersection between CAL and efficient frontier represents the most optimized point, which is when the minimum variance is 21.265% with an expected return of 22.000 %. This point provides the greatest expected portfolio while reducing the standard deviation as much as possible within the limit.

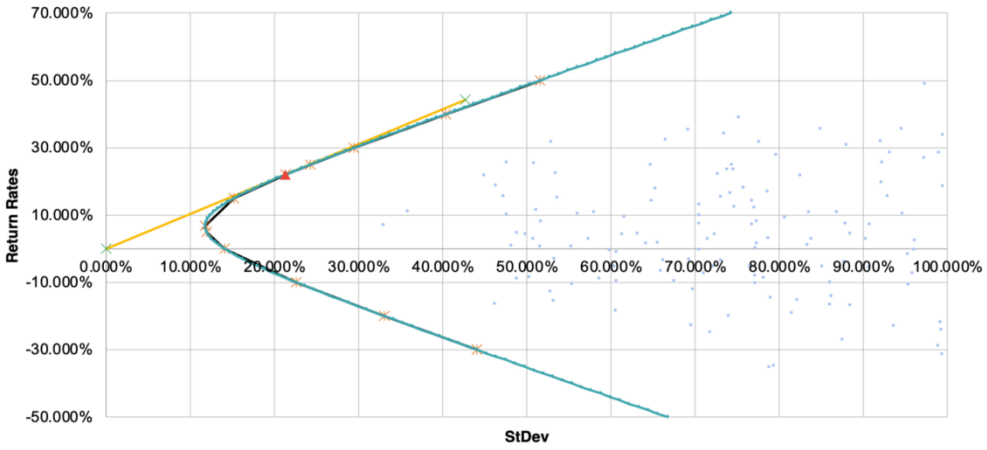

Figure 2. The results of Markowitz Model.

3.2 Index Model

With a similar format to the Markowitz Model, the Index Model also provides its most optimized point as illustrated in Fig. 3. The global minimum variance at this point is when the variance at 11.947% with an expected return of 5.580%. The intersection of the curve and line, the most optimized point, has a minimum variance of 22.196 with an expected return of 20.000%

3.3 Limitation

The random portfolio given different weights will lead to the change of the data during constructing the model. Thus, it might create an error bound in the model. Aside from the data from corporates, one is unable to gain the stats from various sources to derive a more comprehensive view. The Markowitz Model and Index Model use a similar approach to construct the most optimized portfolio might be too arbitrary and not be able to cover all the factors that contribute to the optimization.

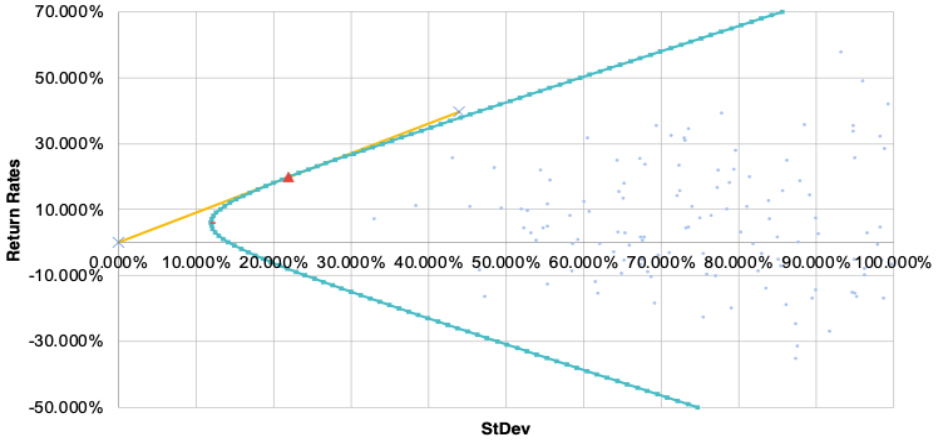

Figure 3. The results of Index Model.

4 CONCLUSION

In summary, this paper mainly investigates the impact of COVID-19 on different industries according to the performances of constructing portfolio. The outbreak of COVID-19 obviously has had a severe impact on countries' social and economic activities. In the short term, the impact of the epidemic on asset allocation is huge. In absolute terms, equities will be the most favored asset class, but from a risk-adjusted perspective, this is a short-term trend. In terms of equity markets, our research indicates that U.S. large-cap stocks will remain more stable. Small-cap stocks will receive a more negative impact, as some small businesses will experience a sharp decline in revenue and turnover due to the epidemic. They are vulnerable to long-term demand shocks, so for now they face relatively high risk. Before the epidemic spread around the world, the S&P 500 stocks had reached a peak, but after the epidemic continued to ferment, the S&P is a big drop in trend. The airline industry stock is one of the most negatively affected stocks by the epidemic among the stocks we calculated. Compared to the airline industry, computer software and investment banking were less affected. Employees of these companies were able to work and held meetings online. The products they sold and the services they provided were mainly conducted online. At the beginning of the outbreak of the epidemic, all types of assets fell to varying degrees, except for the dollar index, which rose. The dollar index has a significant negative correlation with the price movements of broad asset classes, which has a lot to do with the policies enacted by the Federal Reserve. The 3-month U.S. Treasury yield was negative at the beginning of the outbreak, and the Fed quickly lowered the federal funds rate to around zero in response to the impact of the outbreak.

In the future, we will continue to monitor policy changes, stock growth trends and inflationary pressures closely, and observe the impact of these factors on stock markets. The discovered results for the effects of epidemic on stock change trend and asset allocation is closely related to social issues and have considerable research value. Governments and human beings can provide help more effectively after they find out which of industries are mostly affected, i.e., help those industries to progress normally and assist the workers to maintain stable wages.

Overall, these results offer a relatively objective and financial guideline for the various impact that COVID-19 have on asset allocation.

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