Impact of Global Events on Firms in S&P 500 —An Analysis Using Technological Tools

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Abstract—This paper explores the impact of global events on global economy from both economical and natural perspectives. In this paper, we have collected the stock data of 10 firms from the S&P 500 and the impact of the Great Recession and the COVID-19 pandemic on them will be explored and analyzed. The 10 firms can be sorted into 4 fields: technology company (NVIDIA Corporation, Cisco Systems, Inc Intel Corporation), financial services (The Goldman Sachs, Group, Inc. U.S. Bancorp, The Toronto-Dominion Bank, The Allstate Corporation), consumer defensive (The Procter & Gamble Company, Colgate-Palmolive Company), and healthcare product producer (Johnson & Johnson). According to the analysis, the features of the portfolio are discussed. These results shed light on guiding further exploration focusing on portfolio design based on multi-assets in terms of hedging risks. This paper utilized several financial tools to analyze the stock price of the selected firms, for example, Markowitz model. By doing such data-based research, the behaviors of stock prices of the firms when encountering major global events have been revealed. The data processing in this research are primary based on Excel, a Microsoft software that enable us to construct data into diagrams, or process using the same method at the same time as a whole.

Keywords-Economic crisis, public health events, S&P 500 firms, online financial data, stock prices, Excel data processing

1 INTRODUCTION

In the past decades, despite the overall progress of the global economy, the world had faced many significant financial or natural challenges, e.g., The Great Depression after World War II, the Great Recession in 2007 and 2008, and the recent outbreak of COVID-19. With no exception, all of these events had brought severe shock to the global economy, as well as most the firms and companies. In Indonesia, the impact of the Great Recession forced many industries and services to stop working, which lead to 13% of negative growth in GDP [1-5].

The Great Recession, which started in 2007 due to the failure of the U.S. housing market, was considered the most devastating global economic crisis after the Great Depression. The failure in the housing market has several major causes: government management failure, private firms taking too much risk, and excessive borrowing. After the Great Recession began in America, it quickly spread to the entire world, causing a huge amount of economic loss. Phillip Swagel

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predicted that due to the 2.4 reduction in GDP, the United States will suffer problem such as unemployment and increase in cost of capital [6]. These evaluations make sense, since the results are in agreements with the data from "The Great Recession definition" where 8.7 million jobs were lost in the U.S.

The COVID-19 pandemic started in December 2019 and has lasted more than 3 years. On this occasion, the global economy has once dropped into the valley. Limitations put on cargo shipments and personnel movements have intensively harmed international trade. According to the report by WTO, international trade had fallen 5.3% in 2021 [7]. Few months after the outbreak of the pandemic in Wuhan, China, many private firms in China shut down since they cannot sustain their operation without international and domestic trading. Millions lost their job, and even more, are struggling to try to keep their companies away from shutting down. According to Ref. [8], many countries lost the access to some of the important goods after the quarantine policy implemented by Chinese government since 12.2% of the world's trades were related to China.

Prospective earnings and investment risk are two key points needed to be considered for the investment of securities and other venture capital investments. Therefore, the way and measure to evaluate the risk and earnings of portfolio investment and the path to balance these two indicators for asset allocation are urgent problems to address for market investors. With this in mind, Markowitz theory came into being in the 1950s and early 1960s. The mean-variance model is based on the following assumptions [9, 10]:

- When investors consider investment choices, it is based on the probability distribution of securities earnings in a certain position time.
- Investors estimate the risk of securities portfolio according to the variance or standard deviation of the expected earnings of securities.
- Investors' decisions are only based on the risks and benefits of securities.
- At a certain risk level, investors expect the maximum return, i.e., at a certain level of return, investors hope to minimize the risk.

Based on the above assumptions, Markowitz established the calculation method and effective boundary theory of prospective earnings and portfolio investment and established the mean-variance model of asset optimal allocation. The objectives of the model are the variance of the portfolio, which can be described as following:

$$\boldsymbol{\sigma^2 = var\left(\sum_i x_i r_i\right) = \sum_{ij} x_i x_j cov(r_i, r_j)} \quad (\mathbf{1})$$

where

$$\boldsymbol{\sum_i x_i E(r_i) \geq \mu, \sum_i x_i \leq 1, x_i \geq 0} \quad (\mathbf{2})$$

If security *i* allows short selling, the corresponding constraint $x_i \geq 0$ should be removed. Thus, x_i is the proportion of investments in security *i*, the sum of the total investment $\sum_i x_i$ is less than or equal to 1. The expectation of return r_i of the *i* stock is $E(r_i)$, and the covariance of return of the two stocks i and j is Cov (r_i, r_j). The expected return of the desired portfolio is $\sum_i x_i E(r_i) \geq \mu$. To achieve the expected return μ, the risk σ^2 can be minimized by adjusting the capital ratio x_i.

The mean-variance model laid the foundation of modern portfolio variance investments, but the amount calculation model is so large that the actual operation effect is not good, hence William's sharp single index model is established. It greatly simplifies the calculation burden of the portfolio selection model and asset pricing. “Common factors", which a representative of the index yield as general macroeconomic factors, are introduced [11].

The rest part of the paper is organized as follows. The Sec. II will discuss about methodology. The Sec. III will explain the results and discussion. Eventually, a brief summary is given in Sec. IV.

2 METHODOLOGY

The raw data includes the daily stock price of ten stocks, the index S&P 500, and risk-free (U.S federal funds effective rate) from 2001/5/11 to 2021/5/12. The raw data come from Yahoo! Finance. Ten-year period stock price changes can be seen in the graph below. The price trends of the companies are given in Fig. 1.

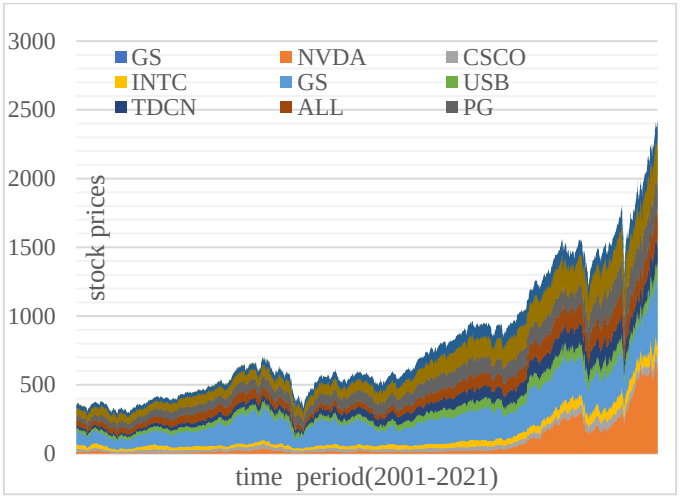

Figure 1. The price trends of the companies

To find out the targeted portfolios and frontiers in both Markowitz and Index models, data needs to be converted into the annualized average return, standard deviation. Their Sharpe ratio and correlation coefficients between stocks may also need to be calculated using the tool in Excel. Besides, links between two individual stock companies, correlation coefficients for all ten stocks, and indexes with each other are calculated by using the stock prices. This may involve some errors. The annualized average return for ten stocks and the stock index, annualized standard deviations, their corresponding Sharpe ratio, and the correlation can be seen. These are necessary data for calculating min-variance and optimal portfolios using Markowitz’s model.

$$E(R_P) = \sum_i w_i \, E(R_i) \tag{3}$$

According to the given formular from the Markowitz model, portfolio expected return can be calculated, which is the sum of all induvial stock expected return multiplying its weight.

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_{ij} \tag{4}$$

Portfolio return variance can also be obtained by multiplying the weight of one stock and the weight of the other stock and their covariance. However, there is a mathematical application of the regression line for the index model, which is shown below.

$$R_i = \alpha_i + \beta_i R_M + e_i \tag{5}$$

Here, R_i is the expected return for individual stock. β_i is defined to be the sensitivity of individual stocks to the market return; $\alpha_i$is the abnormal return without macroeconomic factors. The R_M is the expected return of the market index. For this essay, the benchmark here is set to be the data for S&P 500 index. The e_i is the residual return that is assumed normally distributed with mean zero and standard deviation.

In addition, it is assumed that the abnormity of individual stocks is uncorrelated with each other, which simplifies the calculation step. The following two formulae for the index model are implemented to find out the portfolio expected return and its variance

$$\boldsymbol{\sigma_p^2 = \beta_p^2 \sigma_M^2 + \sigma^2(e_p)} \tag{6}$$

Being proficient in the theory, Excel and relevant tools are utilized to process the data and obtain desired results. A solver is used to find the maximum Sharpe ratio portfolio and global minimum variance portfolio by changing the inputs, which are the weights of different stocks in the portfolio. A solver table is introduced to track points in minimum variance frontier, efficient frontier, and inefficient frontier respectively. It is done with a frequency of 0.05%.

The final results can be illustrated through two graphs for different models. One constant is also used, which limits the index weight to zero. Each graph is for the Markowitz mean-variance model, the other one is for the index Model. Comparisons and analyses can be made to spot the differences and similarities.

3 RESULTS & DISCUSSION

As illustrated in Fig. 2, stock PG has the highest Sharpe ratio, NVDA has the highest standard deviation all over the period that shows its highest volatility among 10 stocks. Fig. 3 presents the 10-stock minimum variance frontier, efficient frontier, inefficient frontier, capital allocation line, optimal portfolio, and global-minimum variance portfolio built in the Markowitz model that contains both restraint-free and zero-index weight versions. Fig. 4. establishes similar frontiers and suitable portfolios, but it is built based on the index model. The grey line indicates the Sharpe ratio of individual stock, orange line refers to the annualized standard deviation of the stock, and the blue line shows the annualized average return. The TABLE 1 indicates the correlation coefficients between ten stocks and the index with each other. Curiously, the data are symmetrical about the diagonal line, which is the correlation between the stock with itself.

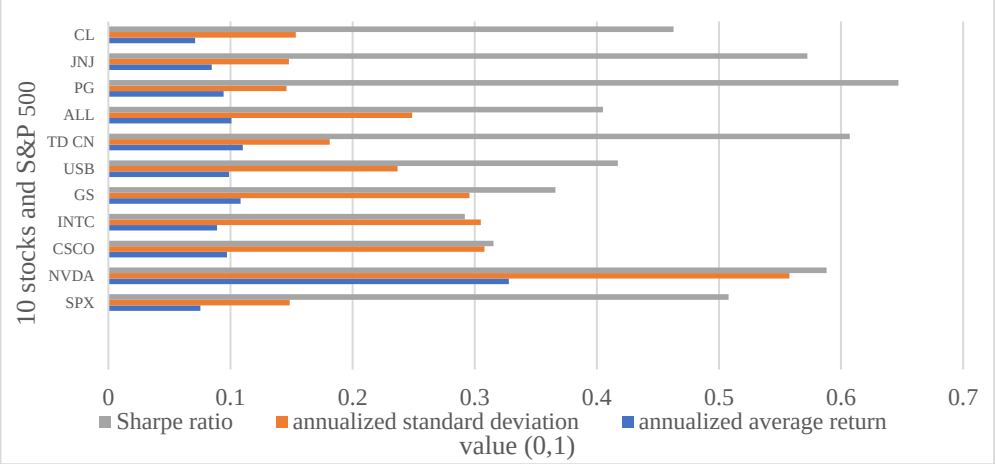

Figure 2. Average return. standard deviation and Sharpe ratio

Table 1 Correlation coefficients

correlation	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1.000	0.527	0.637	0.578	0.708	0.609	0.645	0.630	0.412	0.542	0.440
NVDA	0.527	1.000	0.487	0.524	0.343	0.160	0.338	0.157	0.060	0.165	0.069
CSCO	0.637	0.487	1.000	0.614	0.487	0.328	0.410	0.297	0.220	0.239	0.165
INTC	0.578	0.524	0.614	1.000	0.411	0.280	0.412	0.286	0.136	0.325	0.110
GS	0.708	0.343	0.487	0.411	1.000	0.472	0.494	0.417	0.173	0.296	0.203
USB	0.609	0.160	0.328	0.280	0.472	1.000	0.539	0.540	0.336	0.234	0.218
TD CN	0.645	0.338	0.410	0.412	0.494	0.539	1.000	0.417	0.231	0.273	0.212
ALL	0.630	0.157	0.297	0.286	0.417	0.540	0.417	1.000	0.346	0.452	0.407
PG	0.412	0.060	0.220	0.136	0.173	0.336	0.231	0.346	1.000	0.494	0.483
JNJ	0.542	0.165	0.239	0.325	0.296	0.234	0.273	0.452	0.494	1.000	0.527
CL	0.440	0.069	0.165	0.110	0.203	0.218	0.212	0.407	0.483	0.527	1.000

Firstly, it is noticeable that the minimum variance frontier is the same as the combination of the efficient frontier and inefficient frontier, for two models with different constraints.

Secondly, no matter in which models, interestingly the curves with index weight zero constraints always have a flatter frontier. It is obvious and intuitive because it is put a constraint based on the free-constraint version. The result is that the range of possible portfolios shrinks.

There are some defects in the data processing and analysis. The residual data are the individual firm's specific risk. Since it is hard to be collected, the simple solution for obtaining the residual return data is to use excess return data minus the beta times stock index excess return minus alpha.

This can be not accurate at all. Moreover, the number of outliers in the final result graphs is Signiant. These may come from systematic errors during the calculation of the solver table. Further improvements are required.

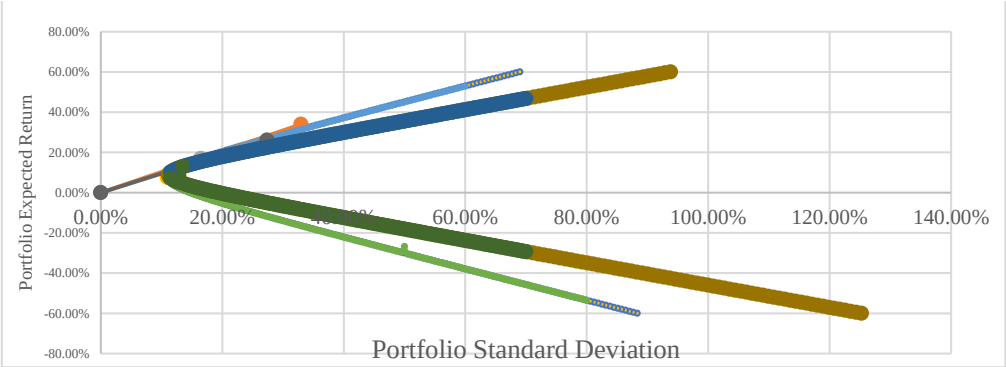

Figure 3. Different frontiers and capital allocation line for Markowitz model with two constraints

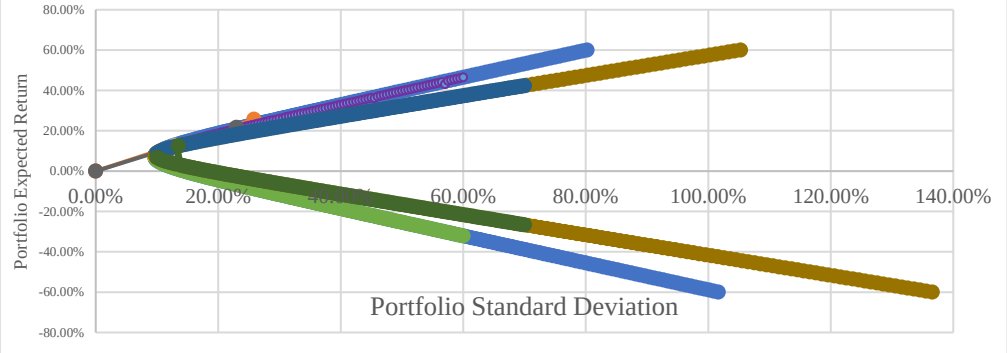

Figure 4. Different frontiers and capital allocation line for Index model with two constraints

Finally, compare the Markowitz full-covariance model with the index model, generally, there is no apparent difference in their efficient frontiers. However, the index model's points in inefficient frontier all have a higher standard deviation. This perhaps is the consequence of neglecting the correlation between two individual stocks in the market in the assumption. The Markowitz model is more accurate and would not underestimate the volatility. Nonetheless, the Markowitz model requires much more data, as it takes the correlations of all individual stocks chosen in the portfolio with each other into account to build up a more established model.

For the analysis, the single-index model assumes that only one macro factor contributes to equity return risk, which can be expressed as the yield of a market index, such as the S&P 500. According to the assumption of this model, the return of any stock can be decomposed into the expectation of the residual return of individual shares (represented here by a factor α specifically referred to by a company), the return of macro events that affect the market, and the unpredictable composition of micro-events that only affect the company.

4 CONCLUSION

In summary, this paper investigates the impacts of global events on firms in S&P 500 based on portfolio construction. According to the analysis, the stock prices of these 10 firms from the S&P 500 did drop during the Great Recession and COVID-19 pandemic. The 10 firms' stock prices share a similar pattern of fluctuation, which is generally increasing, and sharp decrease during a global crisis, then recovering quickly in 2-3 months. This had proven that even firms or corporations as massive as these 10 would be influenced. The behavior patterns analyzed in this essay could be applied to other firms in S&P 500 to try to minimize loss when another crisis arrives. Certainly, global events similar to the Great Recession and the COVID-19 pandemic are not predictable, which adds some random elements to our behavior patterns. Based on the analysis, a pattern of reaction for the 10 companies are analyzed, during, and after disastrous economic or natural events. In the future, we might be focus on the impact of such event on private, small firms run by individuals, since the analysis of S&P 500 firms doesn't represent the whole picture of the world's situation. Overall, these results offer a guideline for how leading firms in different fields in the United States cope with global events, and try to apply those strategies to other countries' firms. On this basis, global economics could be more stable, thus decrease the negative impact brought by the economic crisis.

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