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Research on the Portfolio Construction Strategies under the Background of Epidemic

Yukun Hu[1, *]

[1] School of Economics and Management, Xiamen University, Selangor, Malaysia
*Corresponding author: FIN2309361@xmu.edu.my

Abstract:

Under the outbreak of COVID-19, the U.S. stock market experienced the most serious recession in the past decade. How to optimize the investment portfolio has become an important issue that every investor should think about. In this special period, risk-free rate played an important role though it is always neglected by investors. In this research, the pillar industries are taken into consideration and Markowitz portfolio theory is used to examine the result. It shows risk-free rate can be used as an indicator during economic fluctuation. High, low, and medium risk-free rates suggest the comprehensive, stable, and speculative investment tactic. The basic production industry performed well at when high risk-free rate. While the stable investment strategy will be preferred in terms of a low risk-free rate but under the medium or normal risk-free, it puts lots of weight on the innovative industry. In conclusion, this research evaluated the risk-free rate's influence and proposed a specific investment strategy to deal with it.

Keywords: Pandemic; Risk-free rate; Markowitz portfolio theory; Investment.

1. Introduction

As the outbreak of COVID-19 took place in 2019 September, the U.S. stock market encountered one of the biggest economic recessions. The world economy entered the third decade of this century with uncertainties and challenges of the COVID-19 pandemic before it fully recovered from the lingering aftereffects of the financial crisis[1]. With the increasing unemployment rate and shutting down of corporations, investors were facing the difficult choice of restricting their portfolio to optimize the return rate and diversify the risk, also, they should consider political elements that are equivalent important and determine whether they can survive or not. In the post-pandemic era, the U.S. stock market is shuffled again which leads to another question that investors have to deal with- Conclude the experience during the pandemic period and have a better investment portfolio that can reduce the risk brought by public issues.

A previous study discovered that there was a boom dropping in 2020 in the U.S. stock market after the Wilshire 5000 Total Market index which is the benchmark of the U.S. market reached its all-time high after the 2008 financial crisis. The 2020 U.S. Stock market Crash has greatly affected the lives and livelihoods of many people throughout the country and caused permanent damage to the wealth of many investors, especially investors with little experience in risk management [2]. The COVID-19 pandemic had a significant impact on the 2020 U.S. stock market crash, as evidenced by various studies. Mazur et al. found that loser stocks exhibited extreme asymmetric volatility during the crash, correlating negatively with stock returns [3]. Li highlighted that emerging markets were the main risk receivers in the 2020 stock market crash, with volatility spillovers staying at extremely high levels. Besides the pandemic, investor expectations in the wake of COVID-19 can be predicted from their political identity as measured before COVID-19 [4]. Because public opinion can affect investors' decisions, This aligns with the findings of Stecula et al., who highlighted the correlation between populism and conservative media with conspiracy beliefs about COVID-19, emphasizing the role of partisanship in shaping individuals' perspectives during the pandemic. During the research, the paper shows how Republicans used different designs of "StockTwits" to convey information to investors and influence the stock price. This suggests that individuals may turn to unhealthy behaviors to manage anxiety during the pandemic, which could be influenced by their political beliefs and media consumption habits. However, ETF still outperformed and investors did not see their assets significantly underperform the market [5]. Pavlova and de Boyrie found that stocks with better ESG scores have been more resilient to higher financial market uncertainty, suggesting that ESG

considerations may play a role in mitigating risk during turbulent times. However, not all ETFs were affected by COVID-19 equivalently, different can magnify the influence caused by the pandemic [6]. For instance, Engelhardt et al. reported that the volatility of equity markets in high-trust countries was significantly lower than in low-trust countries during COVID-19. Investing in precious metals was another tactic used by investors to reduce the risk because metals like gold and silver were considered durable and stable during the turbulence. The 10-year US Treasury Yield forecasting model, which is useful for projecting the future of the Risk-Free Rate, is presented in this study [7]. Understanding that the 10-year constant maturity U.S. Treasury notes are essential for assessing investment opportunities and determining loan interest rates. Burak Dagkus explores the complex relationships between the yield on these securities and a few chosen exogenous variables, including the Producer Price Index for Industrial Gas Manufacturing, crude oil prices, and the JY-USD spot exchange rate, in addition to evaluating risk premiums [8]. In this research, risk-free rate will be take into consideration in order to optimize the portfolio.

2. Method

To find the optimized portfolio, Markowitz portfolio theory is used as an essential tool to structure and analyze the portfolio returns and find the sharper ratio-the risk-adjusted rate of return. Harry Markowitz' original theory from the 1950s derives closed-form solutions for optimal portfolio weights under the assumptions on the right. One period investment horizon Percentage returns Normally distributed Full rank covariance Constant interest rate Borrowing/lending same rate No limits on position size +/- No portfolio composition constraints Maximize Sharpe Ratio.

The rate of return can be defined as:

$$R_i = \frac{S_t}{S_{t-1}} - 1 \tag{1}$$

l R_i = The rate of return at time T

l S_t = The price of the stock at time T

l S_{t-1} = The piece of stock at time T-1

The formula for average return:

$$\bar{R} = \frac{\sum_{i=1}^{N} R_i}{N} \tag{2}$$

l N= The days of the period

A portfolio's variation or risk is more complex than just the weighted average of its constituent stocks' variances. It is also necessary to take into account the correlation, as determined by the covariance of return, between each security in the portfolio and every other security. The variance of a portfolio consisting of just two stocks can be computed using the subsequent formula.

$$co(nvex, y) = \frac{1}{N}(x_i - x)(\mu_i - \mu) \tag{3}$$

l $Cov_{(x,y)}$ = Covariance between x and y portfolio.

l x_i = Return of stock x_i.

l x = Average return of stock x_i

l μ_i = Return of stock μ_i

l μ = Average return of stock μ

The most common weight constraint applied to portfolios is to forbid short sales [6], which indicates that the weight cannot be negative, and the sum of all the weights must be one.

$$\sum W_i = 1 \tag{4}$$

$$W_i \geqslant 0 \tag{5}$$

l W_i = The weight of the stock in the portfolio

The return of a portfolio of assets is simply the weighted average of the individual securities held in the portfolio. The weight applied to each return is the fraction of the portfolio invested in that security. The formula for the calculation of expected portfolio return may be expressed as shown below [9].

$$R_P = \sum_{i=1}^{n} W_1 R_i \tag{6}$$

And portfolio variance

$$\sum = \frac{1}{N}\sum_{i=1}^{N}(x_i - \mu_I) \tag{7}$$

$$P_{variance} = W \times \sum \times n \tag{8}$$

l n= number of the stocks [8]

Industry selection: General Motors Company (GM) is chosen as the representation of the traditional manufacturing industry, and Tesla, Inc. (TSLA) is chosen as the representation of innovative manufacturing. For industrial companies: Southern Copper Corporation (SCCO) and The Mosaic Company (MOS) are taken into consideration which is in the mining industry. Exxon Mobil Corporation (XOM) and Shell plc (SHEL) are the representation of the basic manufacturing industry. For the information technology industry, Amazon.com, Inc. (AMZN) and Alphabet Inc. (GOOG) are included. For consumer product companies, PepsiCo, Inc. (PEP) and The Procter & Gamble Company (PG) are selected because they are two of the largest consumer product companies of food and daily necessities. JPMorgan Chase & Co. (JPM) is considered the representation of the financial industry, and finally, the best performance stock during the pandemic is CytoDyn Inc. (CYDY). Then, the historical data will be calculated by Markowitz portfolio theory to optimize the sharper ratio.

3. Results

3.1 Portfolio Analysis

Since risk-free stocks will be taken into consideration, according to the Markowitz portfolio theory, the sharper ratio is risk-adjusted and the goal of the research is to find the sharper ratio under different risk-free rates. To control the variance, the pandemic period historic stock date will be used, for the risk-free rate, and the highest, lowest, and normal, which is a medium risk-free rate, will be used in terms of the comparison of the shaper ratio between different risk-free rates.

In the first simulation, all of the precious metal future and precious metal ETFs and some representative industries' stocks from(1/1 2020-31/12 2022) were taken into consideration. This period starts with pre-pandemic time to the end of the pandemic when the U.S. risk-free rate fluctuated, and the precious metal's futures, ETF, and representative industries' stocks historical data are all taken from this period to control the variance.

From Table 1, it's easy to find among the manufacturing, innovation-oriented industry (TSLA) has the highest average return but relatively, its fluctuation and volatility are bigger than traditional industry compared with GM. In terms of the mining industry, the data is close and can indicate that the risk and public valuation toward the mining industry is almost the same and the burden falls evenly in these industries. For basic manufacturing, generally, there is an extreme condition that can be observed, the performance of SHEL was better than XOM without a doubt. IT industries and the financial industry deliver a stable signal during the pandemic, like GOOG which has a relatively smaller standard deviation and has a relatively higher average return. JPM which is the representation of the financial industry is a little volatile than the IT industry.

Table 1. Basic Information of the Future, ETF, and Stocks

	TIME	MAX	MIN	AVE	STDEV
GOLD FUTURE	3Y	5.24%	-5.63%	-0.17%	0.011
SILVER FUTURE	3Y	13%	-8.51%	-0.16%	0.023
GOLD ETF	3Y	5.67%	-4.62%	0.18%	0.010
SILVER ETF	3Y	15%	-8.37%	-0.12%	0.021
MRNA	3Y	27.8%	-17.9%	0.307%	0.054
GM	3Y	19.9%	-17.3%	0.036%	0.030
TSLA	3Y	19.8%	-21.0%	0.296%	0.454
SCCO	3Y	12.9%	-15.6%	0.101%	0.265
MOX	3Y	17.2%	-27.5%	0.172%	0.037
XOM	3Y	12.9%	-38.9%	0.128%	0.029
SHEL	3Y	17.2%	-17.1%	0.050%	0.028
AMZN	3Y	13.5%	-14.0%	0.140%	0.024
GOOG	3Y	9.40%	-11.1%	0.580%	0.021
JPM	3Y	18.0%	-14.9%	0.337%	0.023
PEP	3Y	12.9%	-11.4%	0.620%	0.015
PG	3Y	12.0%	-8.73%	0.480%	0.015
CYCD	3Y	90.5%	-35.2%	0.18%	0.089

What is most surprising is that the consumer production industry has the best performance during this period. Finally, the medical industry plays a black-house role, it's the most speculative choice at the specific time. There is a shocking discovery that all of the precious metal futures and ETFs' average returns were negative except gold's ETF. Based on this result, investment during the pandemic period may not be a wise decision.

3.2 Portfolio Optimization

At the beginning of the pandemic, the US risk-free rate was 1.85% in 2020 January (Table 2 and Table 3).

Table 2. Optimized Portfolio When Risk Free=1.85%

	TIME	WEIGHT	MIN	AVE	STDEV
GOLD FUTURE	3Y	0	-5.63%	-0.17%	0.011
SILVER FUture	3Y	0	-8.51%	-0.16%	0.023
GOLD ETF	3Y	0	-4.62%	0.18%	0.010
SILVER Ftf	3Y	0	-8.37%	-0.12%	0.021
MRNA	3Y	0	-17.9%	0.307%	0.054
GM	3Y	0	-17.3%	0.036%	0.030
TSLA	3Y	0.999	-21.0%	0.296%	0.454
SCCO	3Y	0	-15.6%	0.101%	0.265
MOX	3Y	0	-27.5%	0.172%	0.037
XOM	3Y	0	-38.9%	0.128%	0.029
SHEL	3Y	0	-17.1%	0.050%	0.028
AMZN	3Y	0	-14.0%	0.140%	0.024
GOOG	3Y	0	-11.1%	0.580%	0.021
JPM	3Y	0	-14.9%	0.337%	0.023
PEP	3Y	0.	-11.4%	0.620%	0.015
PG	3Y	0	-8.73%	0.480%	0.015
CYCD	3Y	0	-35.2%	0.18%	0.089

Table 3. Information of the Portfolio 1

PORTFOLIO RETURN	1.96%
PORTFOLIO VARIANCE	0.13%
PORTFOLIO STANDARD DEVIAITON	3.54%
RISK-FREE RATE	1.85%
SHARPER RATIO	3.00%

From Table 4, almost all of the weight falls on TELA who have the best performance during the pandemic, and the risk-adjusted rate of return is 3.00%.

Table 4. Optimized Portfolio When Risk Free=0.504%

	TIME	WEIGHT	MIN	AVE	STDEV
GOLD	3Y	0	-5.63%	-0.17%	0.011
SILVER	3Y	0	-8.51%	-0.16%	0.023
GOLD ETF	3Y	0	-4.62%	0.18%	0.010
SILVER ETF	3Y	0	-8.37%	-0.12%	0.021
MRNA	3Y	0	-17.9%	0.307%	0.054
GM	3Y	0.028	-17.3%	0.036%	0.030
TSLA	3Y	0.48	-21.0%	0.296%	0.0454
SCCO	3Y	0.48	-15.6%	0.101%	0.0265
MOX	3Y	0	-27.5%	0.172%	0.037

XOM	3Y	0	-38.9%	0.128%	0.029
SHEL	3Y	0	-17.1%	0.050%	0.028
AMZN	3Y	0	-14.0%	0.140%	0.024
GOOG	3Y	0	-11.1%	0.580%	0.021
JPM	3Y	0	-14.9%	0.337%	0.023
PEP	3Y	0	-11.4%	0.620%	0.015
PG	3Y	0	-8.73%	0.480%	0.015
CYCD	3Y	0	-35.2%	0.18%	0.089

When the risk-free reached the historic low, which is 0.504%, the portfolio theory shows the result below (Table 5).

Table 5. Information of the Portfolio 2

PORTFOLIO RETURN	2.29%
PORTFOLIO VARIANCE	35.64%
PORTFOLIO STANDARD DEVIAITON	59.7%
RISK-FREE RATE	0.504%
SHARPER RATIO	3.00%

The risk-adjusted return but there is an obvious change between TSLA and SCCO, 90% of the weight falls on these two companies (Table 6).

Table 6. Optimized Portfolio When Risk Free=4.26%

	TIME	WEIGHT	MIN	AVE	STDEV
GOLD	3Y	0	-5.63%	-0.17%	0.011
SILVER	3Y	0	-8.51%	-0.16%	0.023
GOLD ETF	3Y	0	-4.62%	0.18%	0.010
SILVER ETF	3Y	0	-8.37%	-0.12%	0.021
MRNA	3Y	0.220	-17.9%	0.307%	0.054
GM	3Y	0.09	-17.3%	0.036%	0.030
TSLA	3Y	0	-21.0%	0.296%	0.0454
SCCO	3Y	0	-15.6%	0.101%	0.0265
MOX	3Y	0	-27.5%	0.172%	0.037
XOM	3Y	0.328	-38.9%	0.128%	0.029
SHEL	3Y	0	-17.1%	0.050%	0.028
AMZN	3Y	0.077	-14.0%	0.140%	0.024
GOOG	3Y	0	-11.1%	0.580%	0.021
JPM	3Y	0.168	-14.9%	0.337%	0.023
PEP	3Y	0.001	-11.4%	0.620%	0.015
PG	3Y	0.112	-8.73%	0.480%	0.015
CYCD	3Y	0	-35.2%	0.18%	0.089

Table 7. Information of the Portfolio 3

PORTFOLIO RETURN	9.12%
PORTFOLIO VARIANCE	262.72%
PORTFOLIO STANDARD DEVIAITON	162.09%
RISK-FREE RATE	4.26%
SHARPER RATIO	3.00%

In October 2022, the US risk-free rate reached a historic high in the pandemic which is 4.26%, but the portfolio theory gives the same risk-adjusted return, although the portfolio structure changes a lot. MRNA is a medical company with relatively low risk and XOM dominates the portfolio and has half of the weight. A financial industry like JPM is also favored by the portfolio theory, following the consumer production industry and IT industry (Table 7).

In conclusion, when the risk-free rate is low, it indicates the investor thinks and invests more speculatively, like focusing on innovation or emerging industries. When the risk-free rate is high and the potential risk in the whole market is low, the portfolio theory advises investors to focus on the basic or empirical industry.

4. Discussion

4.1 Description

As mentioned above, the manufacturing industry keeps a proportion of the weight no matter how the risk-free rate changes. When the risk-free rate=1.85%, almost all of the weight falls on TSLA, and when the risk-free rate=0.504% which is a historic low during a pandemic, the weight falls on TSLA and SCCO almost evenly and GM also has some of the weight. When risk-free rate=4.26%, GM still has a little weight while TSLA's weight falls to zero and some financial industry and consumer production industries take some of the weight. It indicates that when risk risk-free rate is extremely low, according to the portfolio theory, it will choose some basic industries that are relatively traditional like mining and manufacturing, also they are the traditional fields in such industries. When the risk-free rate is at a normal level, it encourages investors to choose their portfolio speculatively, focusing on the innovative industry with high returns and high volatility. But when risk-free rate returns out to be extremely high, the portfolio theory guides investors to invest evenly while most of the weight still falls on basic manufacturing industries.

Grabowski demonstrated the definition of the risk-free rate as the return available on the security, which the market regards as free of the risk of default. There are three main components that the risk-free rate reflects: (1) the rental rate which is a real return from the fund you lend over a period of investment, (2) the inflation, which means the expected rate of inflation over the term of the risk-free investment, and (3) the maturity risk or reinvestment, which is the risk that investors can invest their funds during the period of holding government bonds. All the securities will give the yields to maturity equipped with these three economic factors for any given maturity length [10]. In this case, the inflation-sensitive industry, which is the basic manufacturing industry, will be affected most due to the fluctuation of the risk-free rate. Because there is a gross supply chain behind them, such as raw material, and human resources, every sector will be affected by risk-free rate changes caused by inflation fluctuation.

4.2 Suggestion

This research suggests that when investors trade in extreme or volatile situations like pandemics, besides focusing on external information, a risk-free rate can be another important resource for reference. A risk-free rate indicates the government's assessment of the risk and its judgment. When risk-free is low, or general risk is high, it suggests that basic production or traditional production industry would be the best. And for a high risk-free rate, means the overall risk is low, it suggests investing more evenly in the industry. The medium risk-free rate, suggests investors invest speculatively, especially in the highly innovated field.

5. Conclusion

In regular situations, a risk-free rate would not be considered because of its stability, but in extreme situations like a pandemic, it shows its influence and is used as an indicator. Markowitz portfolio theory suggests that under different risk-free rates, the optimized portfolio can change a lot. Innovation is regarded as the core of firms favored by the investment and is fashioned out of the portfolio. The medium risk rate also represents the normal situation, and prefers industries that master the high-end technology, while the high risk-free rate suggests investing in a more comprehensive way to distribute the whole risk burden to different industries, while for the low risk-free rate, convention investment such as basic production industry will

be considered in the first place.

According to the analysis, when the risk-free rate is medium, Markowitz portfolio theory recommends adjusting the trend of the whole investing environment in the pandemic period, it's a speculative way with medium risk and high return. For extremely low and high risk-free rates, it would be a relatively conventional way. The research reminds the investor that, as a composition of the economics the risk-free rate is playing a significant role though it is always ignored.

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