Portfolio Analysis Project: FINC 410

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As our comprehensive project in Advanced Security Analysis, we construct and analyze a portfolio consisting of five publicly traded companies. Our investment strategy revolves around blue-chip stocks that have shown consistent, long-term growth with relatively low risk. With this in mind, we assemble a portfolio composed of J.P. Morgan & Co., Microsoft Corporation, Amazon.com Inc., BlackRock, Inc., and Lululemon Athletica Inc. We examine and utilize risk vs. reward analysis, the Portfolio Theory Model, the Capital Asset Pricing Model (CAPM), and the Fama-French Three-Factor Model as modes of analysis. From these methods, we gain insight into the optimal composition of our portfolio and an in-depth analysis of our portfolio's performance. This paper presents macroeconomic conditions, the theories and algorithms that we used for our analysis and reallocation, and the performance of our portfolio.

Introduction

Portfolio management requires careful consideration of investor goals, strategy, and theoretical analysis. In this management project, our goal is to construct a portfolio that avoids extreme losses in our short-term management period of January 24, 2022 to April 23, 2022. More generally, our investment strategy relies on blue-chip stocks to generate a reasonable return while remaining risk averse. In an effort to further mitigate risk, we diversify our portfolio into five historically reliable stocks across the following sectors: technology, consumer services, financial services, and communication services. With this investment strategy in mind, we select a portfolio composed of J.P. Morgan (JPM), Microsoft (MSFT), Amazon (AMZN), BlackRock (BLK), and Lululemon (LULU).

To confirm that our stocks align with our investment strategy, we conduct a risk vs. reward analysis. We calculate the portfolio's five-year historical variances, covariances, and sample means from publicly reported data. Our risk vs. reward analysis verifies that our five stocks lie primarily within the low-risk, moderate reward category.

Knowing that our stocks align with our investment strategy, we apply the Portfolio Theory Model to construct the optimal portfolio. Then, we apply the Capital Asset Pricing Model and the Fama-French Three-Factor Model to reallocate the optimal weights for our modified portfolio. With the derivation of the Capital Allocation Line and Minimum Variance Frontier, the Portfolio Theory Model determines the optimal weights of the tangency portfolio. The tangency portfolio, suggested by Portfolio Theory analysis, reveals optimal weights of 10% in J.P. Morgan, 70% in Microsoft, 10% in Amazon, 0% in BlackRock, and 10% in Lululemon.

Following the Portfolio Theory analysis, we apply the Capital Asset Pricing Model (CAPM) and Fama-French Three-Factor Model to our portfolio to determine a reallocation

strategy. Our reallocation strategy aims to slightly increase risk in hopes of higher returns. Based on these modes of analysis, we determine the weights of our modified portfolio to be 4% in JPM, 80% in MSFT, 7% in AMZN, 2% in BLK, and 7% in LULU.

Macroeconomic Analysis and Data

Before we discuss the analysis of the risky assets in our portfolio, it is crucial to consider some current events and trends that may affect the overall economy. The systematic risk factors that are most prevalent include the continued effects of the COVID-19 pandemic on macroeconomic indicators such as interest rates, inflation, consumer spending, and the labor market. Additionally, international events, including the conflict between Russia and Ukraine, have the potential to impact the global economy.

Interest rates were initially cut in March of 2020 to stimulate the economy as COVID-19 first appeared on the scene. Since then, the Federal Reserve has been considering a sizable increase in interest rates following their meeting in March of 2022 to regain control of the expanding economy and inflation. It is anticipated that inflation will remain high for the next several months; however, Michelle Bowman, Federal Reserve governor, suggests that raising the interest rates may relieve consumer demands that pressure the economy and eventually inflation (Timiraos, 2022).

Consumer spending spiked in early 2022 as residual restrictions of the COVID-19 pandemic continued to ease, and consumers demonstrated their pent-up demand for things such as travel, dining, and entertainment (Feuer, 2022). However, the rapid increase in inflation has dampened overall consumer activities (Cambon, 2022). Consumer spending will likely remain suppressed due to increased inflation and escalating prices (Torry, 2022).

The COVID-19 pandemic has also had a profound impact on the labor market. The lingering shortage of available workers has caused labor prices to soar, leaving many jobs unfilled. This inequality between open positions and employees has forced high volumes of workers to quit their jobs to work somewhere with higher wages and better benefits. As a result, the competition between employers has intensified and caused many to rethink their hiring practices (Mena, 2022). In January of 2022, wages showed a more significant year-over-year increase than the historical average. The labor market remains strong as unemployment holds at a low and steady rate (Cambon, 2022).

Internationally, escalations in the Russia and Ukraine conflict have caused concern about the supply chain. Areas of most concern involve the significant exports from the two countries, including energy and other raw materials. Economically, it is expected that Europe will face most of the supply chain issues surrounding this conflict. However, if the situation continues to escalate, the global economy could feel the effects of the energy and metals supply chain disruption as supply chains remain crippled by the COVID-19 pandemic (Hannon, 2022).

Overview of 5 stocks

Our portfolio consists of five large, blue-chip companies: J.P. Morgan (JPM), Microsoft (MSFT), Amazon (AMZN), BlackRock (BLK), and Lululemon (LULU). Figure 1 shows the five-year historical stock prices for each company.

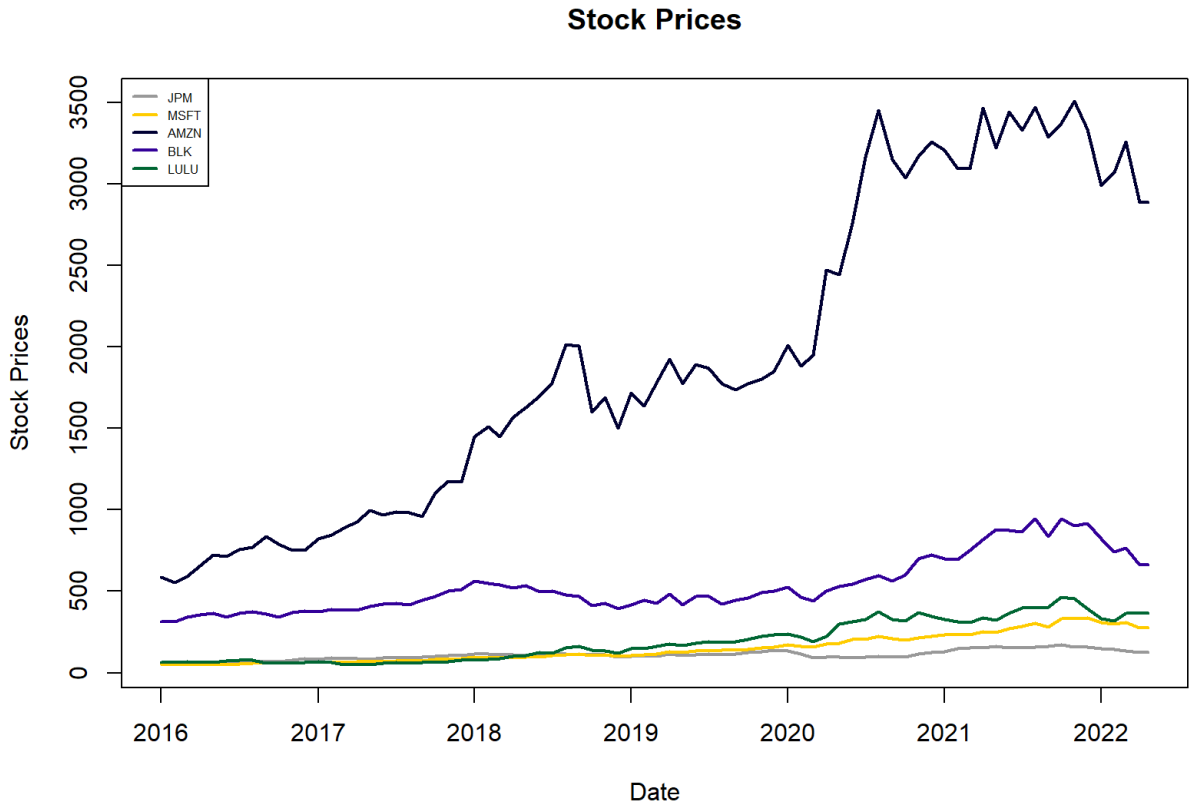

Figure 1: Stock Prices. Figure 1, constructed in RStudio, illustrates the historical stock prices from January 1, 2016 to April 23, 2022. Prices were pulled from Yahoo! Finance.

J.P. Morgan Chase & Co.

For years, J.P. Morgan Chase & Co. (JPM) has maintained a leading position in the financial sector by establishing a well-diversified capital structure. They are diversified into consumer and commercial banking, loan origination, and credit services, allowing them to maintain stability throughout various market fluctuations (Biggar, 2022). Similar to BlackRock, we believe JPM to be a well-established and diversified firm which encourages us to incorporate it in our portfolio.

Microsoft Corp.

As the technology sector continues on its high-growth trajectory, Microsoft Corp. (MSFT) has shown stability and continued growth as it aims to diversify into a gaming enterprise. Following a review by the Federal Trade Commission, MSFT plans to move forward with acquiring Activision Blizzard Inc. (ATVI), which would further enhance its growing presence in the gaming world. In addition, MSFT has made significant improvements to the Windows 11 software and continues to develop the Microsoft Teams platform as work from home remains prevalent (Bonner, 2022).

While we believe MSFT to be a good and valuable addition to our portfolio due to its broad reach in the technology sector and plans for continued growth, we acknowledge the ever-present risks. Within the technology sector, MSFT faces competition from Google and Amazon. Additionally, their exit from the mobile phone market leaves the success of Microsoft application software in the hands of Apple and Google. MSFT also bears risk from lasting supply chain disruptions on the macroeconomic scale, particularly affecting their ability to obtain microchips. (Bonner, 2022).

Amazon.com Inc.

A leader in the internet retail sector, we believe that Amazon.com Inc. (AMZN) is a solid addition to our portfolio as it has the potential to bolster stability and long-run returns. In particular, we are drawn to the consistent stream of revenue generated by the Prime program. AMZN looks to increase the Prime membership price, making way for even higher revenue in the coming year. Additionally, the continued development of Amazon Web services has allowed AMZN to expand its reach in the technology sector (Romanoff, 2022).

Amazon has faced risks associated with the lingering effects of the COVID-19 pandemic as they have been impacted by labor and supply shortages. They have attempted to combat delays and increased supply chain costs by developing their delivery network; however, these issues are still causing trouble for AMZN (Romanoff, 2022). Despite these risks, we believe that AMZN will maintain the dominant position in the marketplace and will continue to show steady returns as they adapt and diversify.

BlackRock Inc.

Being one of the largest asset management firms in the world, BlackRock Inc. (BLK) has shown that a focused, yet diversified, set of products can promote stability and long-term growth. (Biggar, 2022). One of the main concerns with BlackRock is that its size will limit its future growth. BLK will always bear the macroeconomic risk with market and interest rate fluctuations as a financial institution. With the current outlook on rising interest rates, BLK could face slight downturns in investment activities and, in turn, reduced revenue. With that being said, BLK has substantially reduced its vulnerability to market fluctuations by diversifying its products and utilizing skillful investment strategies (Warren, 2022). Overall, we recognize the risks associated with BLK, and maintain confidence in future returns due to their proven stability and diversification within the financial services sector.

Lululemon Athletica Inc.

Lululemon Athletica Inc. (LULU), a fitness retail firm, holds the most volatile position in our portfolio. LULU has been heavily impacted by COVID-19 related supply issues and its market being flooded with competitors offering lower prices. We still view LULU as a sound investment with these risks in mind. They have plans to continue developing their online

platform and new products. LULU, often criticized for struggling to reach beyond the U.S. market, holds onto potential growth opportunities upon expansion (Swartz, 2022).

In addition to its growth potential, we believe that Lululemon has done a great job retaining and expanding its customer base. The Lululemon ambassador program has allowed for the formation of strong relationships and draws new and existing customers to its brick-and-mortar stores. In addition, product integrity has kept customers coming back, despite a crowded market (Swartz, 2022).

Portfolio Theory Model

After selecting the five stocks comprising our portfolio, we need a way to devise our optimal allocation strategy. To do this, we turn to the Portfolio Theory Model. Derived by Harry Markowitz (1952), the Portfolio Theory Model allows investors to build portfolios with maximized returns given a specific degree of market risk. A critical aspect of the Portfolio Theory Model is the diversification effect which implies that as the number of assets increases, the asset-specific risk of the portfolio is minimized, and all that remains is the systematic risk. The Portfolio Theory Model reasons that risk-averse investors will choose to hold diversified portfolios and therefore only concern themselves with market risk. Portfolio Theory allows us to evaluate the maximized returns and minimized variance for our portfolio with the Capital Allocation Line and the Minimum Variance Frontier and, in turn, the optimal weights for each asset. Additionally, using this model to analyze our portfolio enables us to extend our analysis to the Capital Asset Pricing Model, which employs the same principles and builds off Portfolio Theory (Markowitz, 1952).

From our Capital Allocation Line (CAL), we determine the expected return and variance of our portfolio. We then observe the Sharpe ratio and the risk-free rate for the portfolio. The Sharpe ratio indicates the slope of the Capital Allocation Line and gives us a measure of the risk to reward ratio. Additionally, we see the y-intercept of the Capital Allocation Line for our portfolio is the risk-free rate.

In addition to the CAL, we derive the Minimum Variance Frontier (MVF). The MVF illustrates the various portfolio compositions that minimize variation for the risky portion of our portfolio for a specified return. To find the Minimum Variance Frontier, we compute the following:

$$min_{w_i} \sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 = 2 \sum_{i=1}^{N} \sum_{j>1}^{N} w_i w_j \sigma_{ij}, \quad (1)$$

subject to $E[r_p] = \sum_{i=1}^{N} w_i \times E(r_i)$. Once we find the Efficient Minimum Variance Frontier, we then compute the point of tangency of the Capital Allocation Line on the Minimum Variance Frontier. At the point of tangency, the portfolio contains the optimal weights of each asset in the risky portfolio which maximizes the Sharpe ratio and minimizes the variance of the risky portfolio (Markowitz, 1952).

Capital Asset Pricing Model

Following the application of Portfolio Theory, we utilize the Capital Asset Pricing Model (CAPM) to determine our assets' expected returns at the market equilibrium and the suggested prices. Initially developed by Sharpe and Lintner (1964), this model aims to expand on the Portfolio Theory Model and establish a way of evaluating asset prices. With the standard assumptions of the CAPM holding, we understand how our portfolio would perform if the

market were in equilibrium and how the asset ought to be priced. Assuming that the portfolio is well-diversified and holds no idiosyncratic risk, we use CAPM to value the risk taken on in association with market volatility. The initial step is to utilize the Security Market Line (SML), which the following formula details:

$$E[r_i] = r_f + \beta_{i,M}(E[r_M] - r_f). \quad (2)$$

In (2), r_f indicates the risk-free rate, $(E[r_M] - r_f)$ specifies the market risk premium, and $\beta_{i,M}$ describes the systematic risk associated with the asset i. To determine the beta of each asset, we use the following formula:

$$\beta_{i,M} = \frac{\sigma_{i,M}}{\sigma_M^2}. \quad (3)$$

The numerator of (3), $\sigma_{i,M}$, indicates the sensitivity of the asset i to the market. The denominator, σ_M^2, shows the total risk associated with the market. Once evaluated, the SML allows us to assess the fair price of each asset and if the asset is underpriced or overpriced. After finding the fair return and actual return for each asset, we determine each asset's alpha (α) using the formula

$$\alpha = actual\ return - fair\ return. \quad (4)$$

An asset is considered underpriced if the asset's actual price exceeds the price found from the SML. Alternatively, an asset is overpriced if the actual cost is lower than the price predicted by the SML. Both instances indicate that the stock is in disequilibrium. The alpha coefficient found in (4) gives an idea of the asset's performance. An underpriced asset shows a positive alpha due

to the surplus of returns for the shared market risk and predicted returns. Therefore, an investment strategy of maximizing positive alphas bolsters excess returns and proves to be ideal. This, however, is not always possible or realistic as the systematic risk involved does not always work out favorably for the investor (Sharpe, 1964).

In the following regression model,

$$r_i - r_f = \alpha_i + \beta_i(r_M - r_f) + \varepsilon_i, \tag{5}$$

we see that for an asset i, the alpha (α_i) represents the intercept, and the beta coefficient (β_i) represents the slope. In (5), β_i also represents the Ordinary Least Squares (OLS) regression coefficient which is estimated by (3). Because (3) is an accurate estimator for β_i, we see that there is a correspondence between CAPM and the OLS regression. Therefore, the alpha coefficient in (5) corresponds to the alpha found in (4) (Sharpe, 1964).

To decompose the variance of the returns for an asset i, we look at (5) and take the variance of each side, resulting in the equation:

$$\sigma_i^2 = var(r_i - r_f) = var(\alpha_i + \beta_i(r_M - r_f) + \varepsilon_i). \tag{6}$$

(6) is then simplified to

$$\sigma_i^2 = \beta_i^2\sigma_M^2 + \sigma_\epsilon^2, \tag{7}$$

where $\beta_i^2\sigma_M^2$ is the term holding the systematic risk of the market and σ_ϵ^2 contains the unsystematic risk of the firm. Following this decomposition, we use the various parts of (7) to obtain the R^2 statistic for the OLS regression. The R^2 statistic shows the proportion of the overall risk of the asset that is systematic or market risk (Sharpe, 1964).

Fama-French Three-Factor Model

As an extension of the Asset Pricing Model, mentioned above, Fama and French (1992) developed and published the Fama-French Three-Factor Model. To further breakdown and understand risk, the Fama-French Model adjusts to incorporate additional factors pertaining to firm size and book-to-market equity into the CAPM regression. The Fama-French Model recognizes that, in general, smaller firms tend to outperform larger firms and the overall market. The risk associated with firm size is quantified in the Three-Factor model as the Small Minus Big factor. The Fama-French model also recognizes that high book-to-market firms tend to outperform firms with lower ratios. The High Minus Low factor gives insight into the risk associated with book-to-market values and indicates a growth or value stock.

The following is the Fama-French regression equation:

$$r = r_f + \beta_{Market}(r_m - r_f) + \beta_{SMB}(SMB) + \beta_{HML}(HML) + \varepsilon. \quad (8)$$

In (8), r is the expected rate of return, r_f is the risk-free rate. Additionally, β_{Market}, β_{SMB}, and β_{HML} indicate the sensitivity of r to $(r_m - r_f)$ or the market risk premium, Small Minus Big (SMB), and High Minus Low (HML), respectively. Once regressed, the factor coefficients are interpreted as follows: β_{Market} is the sensitivity of the asset to changes in the market risk premium, β_{SMB} is the asset's sensitivity to the risk associated with firm size, and β_{HML} is the asset's sensitivity to the risks of their book-to-market value (Fama & French, 1993).

Risk vs. Reward Analysis

For our risk vs. reward analysis, our group pulled the historical close prices from January 1, 2016 to January 25,2022 into RStudio from Yahoo! Finance. We then calculate the variance and sample means for each stock, as summarized in Table 1. Our goal of this analysis is to establish the amount of risk and reward present in our portfolio consisting of J.P. Morgan, Microsoft, Amazon, BlackRock, and Lululemon.

Table 1.

	JPM	MSFT	AMZN	BLK	LULU	Mean
JPM	44.4450	12.7361	11.3350	28.5194	21.2005	1.5315
MSFT	12.7361	30.0682	26.3611	21.8514	21.5555	2.4826
AMZN	11.3350	26.3611	60.2109	25.7616	27.0714	2.6185
BLK	28.5194	21.8514	25.7616	42.8682	25.1252	1.4945
LULU	21.2005	21.5555	27.0714	25.1252	112.2579	2.8350

Table 1: Risk vs. Reward Analysis. Summarizes the results of analysis of data pulled from Yahoo! Finance run in RStudio. The results show the covariances and variances of each stock.

To perform our risk vs. reward analysis for the stocks in our portfolio, we utilize the covariances, variances, and sample means found in Table 1. Using sample mean as a measure of expected returns and variance as a measure of risk, we model the spread of risk vs. reward in Figure 2.

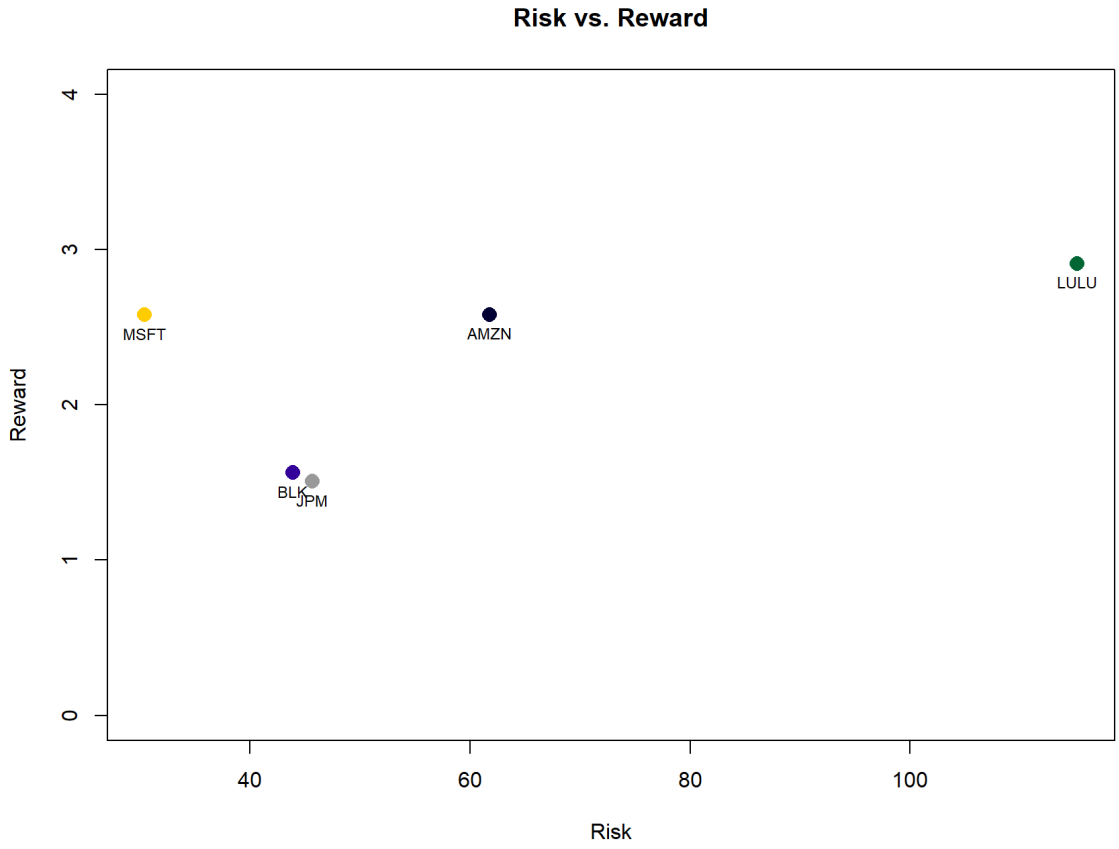

Figure 2: Risk vs. Reward Analysis. Figure 2 reflects the variances and returns found in Table 1.

The initial risk vs. reward analysis displayed in Figure 2 gives us an idea of which stocks are riskier and provide higher expected returns. This analysis establishes that LULU holds much of the risk in our portfolio. The remaining stocks hold relatively low risk and good returns, such as MSFT, which shows excellent positioning with low risk and relatively high expected returns.

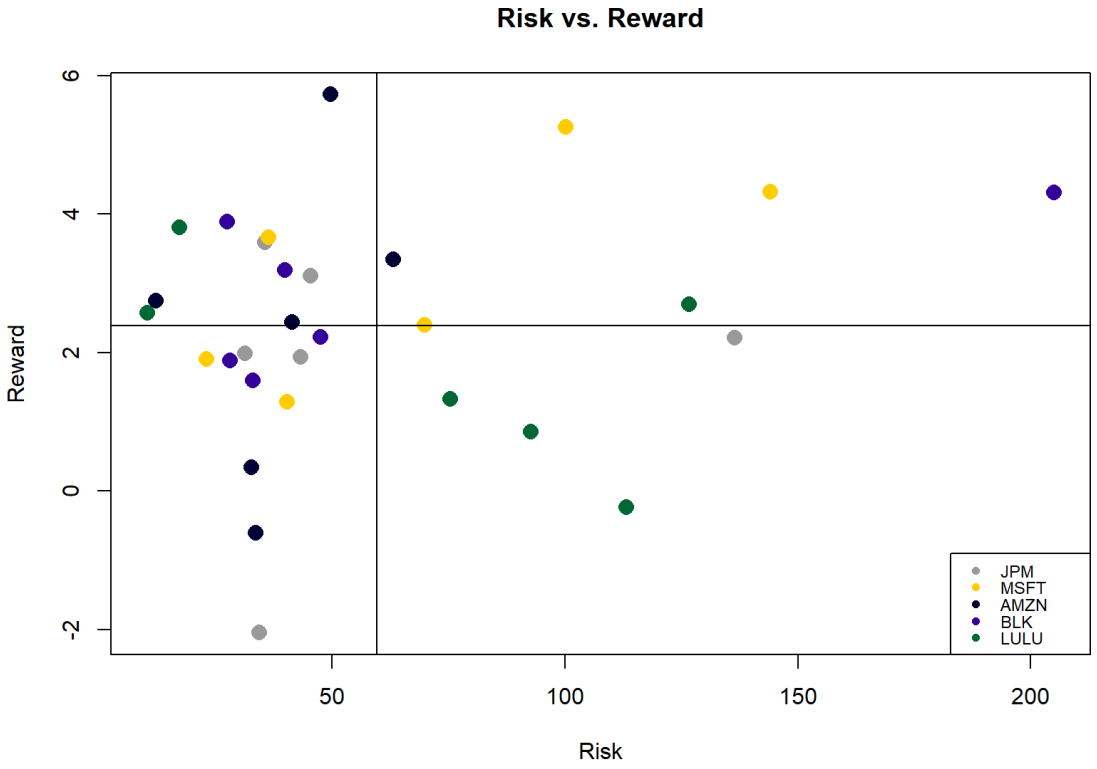

Figure 3: Historical Risk vs. Reward Analysis. Figure 3 illustrates RStudio analysis of each stock's yearly returns and variances for the years 2016 to 2021 pulled from Yahoo! Finance. To better understand the plotted data, we added a vertical line representing the average variance and a horizontal line representing the average sample mean.

From our historical risk vs. reward analysis, we see that from 2016 to 2021, our portfolio is made up of stocks that fall primarily within the low-risk, above-average reward category. Historically, MSFT and LULU have shown the highest levels of risk with respect to the rest of our portfolio; however, they also offer high returns. AMZN, BLK, and JPM have demonstrated below-average risk with average to above-average returns.

Data Analysis

For our Portfolio Theory analysis, we use Algorithm 1 in RStudio, which pulls historical stock price data for each of our stocks from Yahoo! Finance. The retrieved data is inputted into

Algorithm 1 which evaluates the variances, covariances, expected return, CAL, and MVF. We utilize the historical monthly close prices from January 1, 2016, to January 1, 2022. To start, we conduct a simulation of the historical returns to establish predicted returns and variance for various portfolios. The simulation, summarized in Algorithm 1, involves summarizing the expected returns and standard deviations of the 10,626 potential portfolio allocations and plotting them as the Minimum Variance Frontier. Additionally, we find the optimized Sharpe ratio of our portfolio and plot the resulting Capital Allocation Line.

Algorithm 1.

Input: Close Prices: x = (x_1, x_2, x_3, x_4, x_5)(monthly, January 1, 2016 to January 25, 2022), Weights Matrix: wdata, Number of loops run: ind, Risk-free rate: r.

1. $returns \leftarrow (x - lag(x))/lag(x)\ [-1,] * 100$
2. $er \leftarrow colMeans(returns)$
3. $vm \leftarrow var(returns)$
4. $rp \leftarrow wdata * er$
5. $vp \leftarrow calculate\ variance\ for\ each\ generated\ portfolio$
6. sp $\leftarrow \sqrt{vp}$
7. mvf $\leftarrow matrix(c(sp, rp), length(sp), 2)$
8. $rf \leftarrow r/12$
9. $sharpe \leftarrow (mvf[,2] - rf)/mvf[,1]$
10. $wdata[sharpe == max(sharpe)]$

Output: Minimum Variance Frontier, Maximized Sharpe Ratio, Optimal Weights

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Algorithm 1 allows us to input the historical stock prices to evaluate the Minimum Variance Frontier, the Capital Allocation Line, and Maximized Sharpe Ratio. Upon generating the Minimum Variance Frontier matrix and the Sharpe ratio, we are able to calculate the optimal weights in line 10 of Algorithm 1. We find the optimal weights for our portfolio to be: 10% in JPM, 70% in MSFT, 10% in AMZN, 0% in BLK, and 10% in LULU. This optimal allocation point is illustrated in Figure 4.

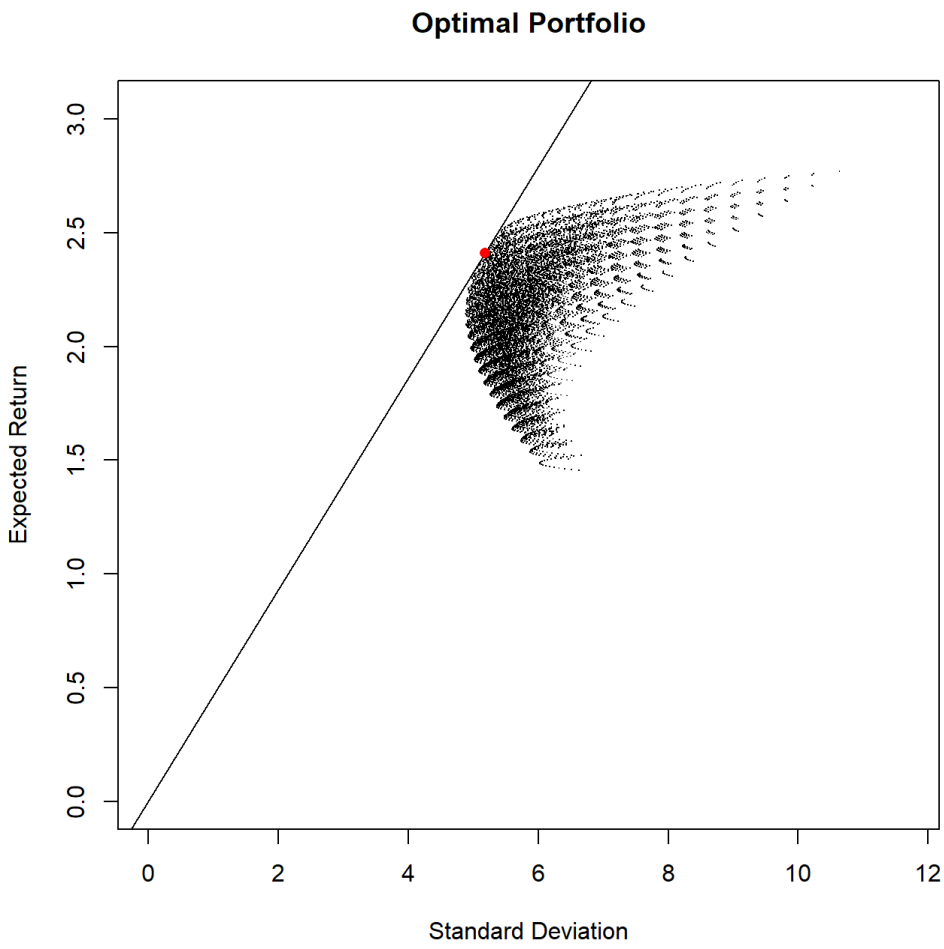

Figure 4: Optimal Portfolio Analysis. Figure 4 illustrates the Minimum Variance Frontier and the Capital Allocation Line. The point of tangency, representing the optimal portfolio, is highlighted in red. Reflects the optimal portfolio allocation as of January 1, 2022.

Capital Asset Pricing Model Analysis

Table 2 summarizes the values of α and β for each of our five stocks. The results come from our CAPM regression which utilizes the monthly data from January 1, 2016 to January 24, 2022 for each stock as well as the S&P 500. This data is retrieved from Yahoo! Finance by RStudio.

Table 2.

	JPM	MSFT	AMZN	BLK	LULU
Alpha (α)	0.1154	1.4183	1.2041	0.0366	1.3039
Beta (β)	1.1129	0.9044	1.1021	1.2357	1.3096

Table 2: Summary of CAPM Analysis showing the alpha and beta values associated with each stock. This RStudio analysis is run using data from January 1, 2016 to January 24, 2022 pulled from Yahoo! Finance.

From these results, we see that CAPM analysis suggests that all of the assets are underpriced, which can be visualized by their positive α values. These assets return positive α values due to their actual returns being higher than the predicted returns, given market risk. Additionally, the β values for JPM, MSFT, and AMZN indicate low sensitivity to market volatility and, therefore, lower risk. The relatively low βs of JPM, MSFT, and AMZN makes them attractive for our low-risk investment strategy. BLK and LULU, however, show slightly higher risk associated with market fluctuations.

The Capital Asset Pricing Model is well-regarded and maintains its reputation as a reliable financial model. While CAPM is considered a relatively basic model, it returns straightforward and applicable information regarding each of our stocks' performance and risk levels. With just one risk factor, CAPM leaves room for closer analysis. To supplement our results from CAPM and further understand the risk involved in our portfolio, we utilize the Fama-French Three-Factor Model.

Fama-French Three-Factor Model Analysis

Fama and French (1992) dig deeper into the market-risk factor from CAPM, adding more specific risk factors associated with firm size and value. The results of the Fama-French analysis

of our portfolio are summarized in Table 3. The stock data from January 1, 2016 to January 24, 2022 is pulled from Yahoo! Finance and the factor data is pulled from a provided matrix. Once in RStudio, we conduct the regression.

Table 3.

	JPM	MSFT	AMZN	BLK	LULU
Alpha (α)	0.2327	1.1108	0.7102	-0.1450	0.9793
β_{Market}	0.9827	0.9733	1.2172	1.2039	1.2705
β_{SMB}	0.1789	-0.4031	-0.3951	-0.0739	0.3757
β_{HML}	0.8142	-0.3947	-0.7655	0.0738	-0.5623

Table 3: Summary of Fama-French Three-Factor Analysis showing the alpha and beta values associated with each stock. This RStudio analysis is run using data from January 1, 2016 to January 24, 2022 pulled from Yahoo! Finance.

Recalling that α values are an indication of stock performance, we prefer to maximize the positive α values within our portfolio. As seen in Table 3, the α values remained positive for all except BLK, which suggests that we should consider dropping this asset from the portfolio.

The β_{Market} of JPM and MSFT indicate relative stability as they fall below 1. AMZN, BLK, and LULU, however, show higher β_{Market} around 1.2 , indicating heightened sensitivity of their returns to market volatility. These β_{Market} values show that our portfolio returns are somewhat reliant on market fluctuations, however the presence of low β_{Market} values for JPM and MSFT mitigates some of the risk.

We also see a balance across our portfolio with the three large firms showing negative β_{SMB} values, and two smaller firms showing low positive β_{SMB}values. Indicating relatively large firm sizes, these β_{SMB} values reflect our investment strategy of holding large firms in our

portfolio. Specifically, MSFT and AMZN take on high levels of risk relating to firm size. This risk is captured by MSFT and AMZN's β_{SMB} values of -0.4031 and -0.3951, respectively.

Regarding book-to-market values, our two financial institutions, JPM and BLK, reflect positive β_{HML} values whereas MSFT, AMZN, and LULU show negative β_{HML} values. Positive β_{HML} values indicate high book-to-market ratios which tend to outperform firms with low book-to-market ratios. In effect, the HML factor serves as a measure of value. In general, a positive β_{HML} identifies a value stock and a negative value identifies a growth stock. Our portfolio contains two value stocks, JPM and BLK, and three strong growth stocks, MSFT, AMZN, LULU, which further diversifies and mitigates the risks associated with book-to-market values. The diversified nature of our Fama-French β values suggests an added measure of stability as fluctuating market factors do not necessarily pose identical threats to all assets.

While we believe the Fama-French Three-Factor model to be a reliable tool in our portfolio analysis, the model itself does have limitations that might prevent us from seeing the complete picture. The risk factors in the Three-Factor model might not capture newer forms of risk, for example, the evolution of modern technology. While imperfect, we choose to utilize the Three-Factor model for a more detailed risk analysis.

Performance Tracking

In addition to the Portfolio Theory Model, applying the Capital Asset Pricing Model and the Fama-French Model allows us to further understand the risks associated with our portfolio through the resulting α and β values. These models are crucial to our reallocation plan because their results indicate the vulnerability of our firms to various risks. CAPM and the Three-Factor

model allow us to gauge the level of risk each company takes on in association with market volatility, firm size, and book-to-market value. Our reallocated portfolio reflects the results of the CAPM and Three-Factor Model as we aimed to maximize the higher α values and maintain a diverse selection of β values.

The first decision of our reallocation plan is determining that BLK should remain in the portfolio. Portfolio Theory and Fama-French analysis suggest BLK could be dropped from our portfolio due to a zero-weight and negative α value. However, we believe it to be a reliable part of our portfolio. The results from CAPM indicate a small, but positive, α for BLK, which gives theoretical justification for BLK to remain in our portfolio. Therefore, we choose to modify our optimal portfolio to include BLK, despite the suggestions of Portfolio Theory and Fama-French. The sheer size and internal diversification of BLK make it an attractive asset for our portfolio. In a recent letter to shareholders, Lary Fink, the CEO of BlackRock, addresses the importance of economic stability and shares plans for BlackRock to diversify further into the cryptocurrency market (Fink, 2022). Additionally, BLK adds a level of diversification to our portfolio with its CAPM and Fama-French βs opposing and balancing our four other assets. Overall, we believe BLK to be a sound and justified addition to our portfolio.

In order to incorporate 2% BLK into our portfolio, we look to our CAPM and Fama-French results for guidance on reallocation. From these analyses, we determine that MSFT consistently shows the highest α value and low volatility, indicating it should remain the highest weight. To counteract the increased volatility from the addition of BLK, we increase MSFT from 70% to 80%. Additionally, we reduce the weight of JPM within our portfolio from 10% to 4%

due to its smaller α value. Then, we reallocate the remaining 14% across AMZN and LULU, taking both from 10% to 7% of the portfolio.

The optimal weights for our portfolio, indicated by Portfolio Theory, are 10% in JPM, 70% in MSFT, 10% in AMZN, 0% in BLK, and 10% in LULU. The historical performance of this optimal portfolio is shown by the gray line in Figure 5. Comparatively, the black line shows the historical performance of the S&P 500 which serves as a baseline. The yellow line represents a variation of our portfolio with modified weights of 4% in JPM, 80% in MSFT, 7% in AMZN, 2% in BLK, and 7% in LULU.

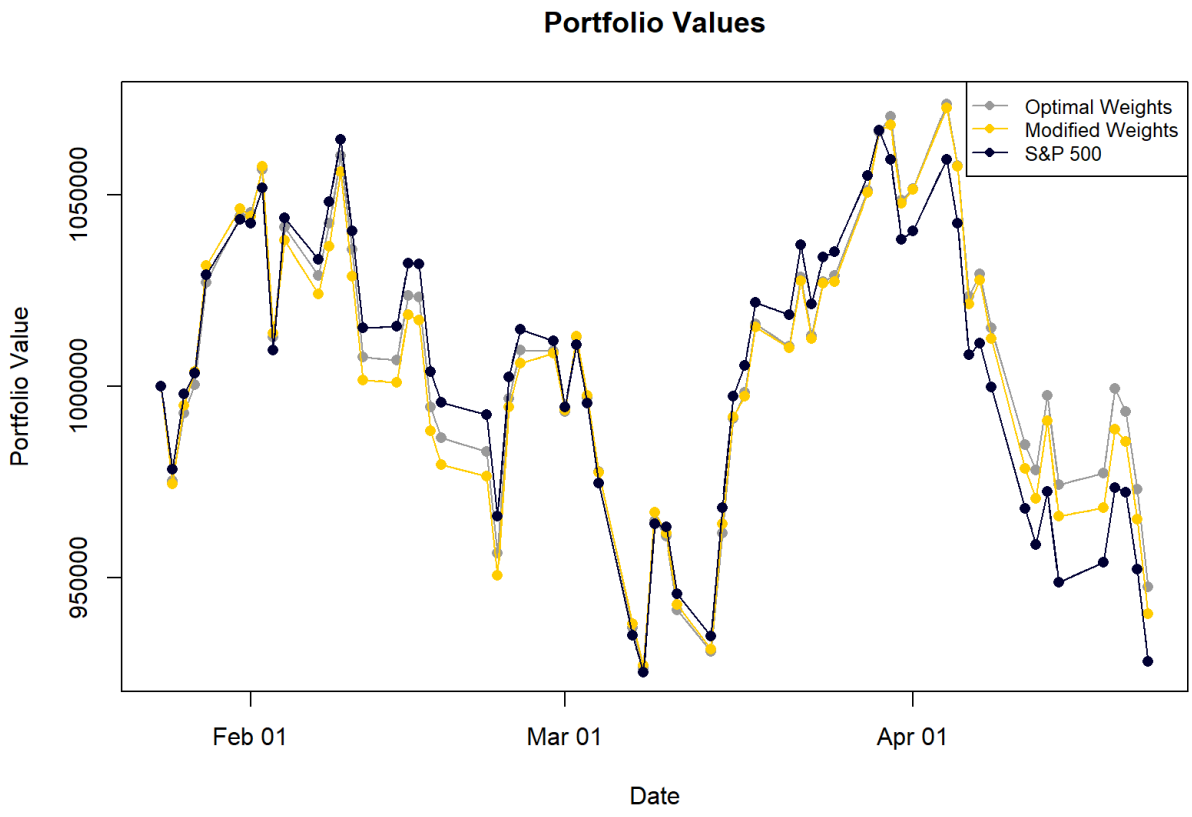

Figure 5: Portfolio Values. Figure 5 illustrates the comparison of historical values of each of the following: our portfolio using the optimal weights, our portfolio using the modified weights, and the S&P 500. The historical data from January 23, 2022 to April 24, 2022 is pulled into RStudio from Yahoo! Finance.

In Figure 5, we see the comparison of our optimal portfolio, modified portfolio, and S&P 500 baseline. Generally, we see our modified and optimal portfolios moving together, tracking the S&P 500. With that being said, there are also times when our modified portfolio is under- and over-performing our optimal portfolio and S&P 500. These phenomena are likely due to the additional volatility from BLK and increased stability from the additional 10% of MSFT.

Conclusion

In conclusion, our portfolio is consistent with our investment strategy of maintaining a diversified portfolio with large and historically reliable companies. Our optimal portfolio, developed using Portfolio Theory, consists of 10% in JPM, 70% in MSFT, 10% in AMZN, 0% in BLK, and 10% in LULU. The risks that we find associated with our companies do not deter us from any of our selections, leading us to maintain BLK's position in our modified portfolio. The weights of our modified portfolio are 4% in JPM, 80% in MSFT, 7% in AMZN, 2% in BLK, and 7% in LULU. The historical performance of our modified portfolio shows its potential to outperform our optimal portfolio as well as the S&P 500 baseline.

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