

MGT 4002 - INVESTMENT AND BANKING ANALYTICS

PROJECT REPORT

Portfolio Optimization through Coalescent Employment of Fama French model & Markowitz Optimization

Submitted by

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M.Tech Integrated (CSE Business Analytics)

Submitted to

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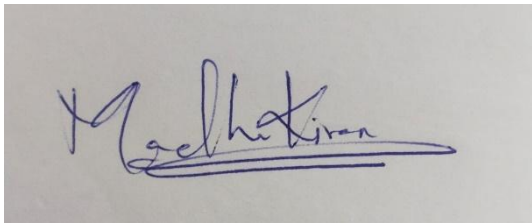
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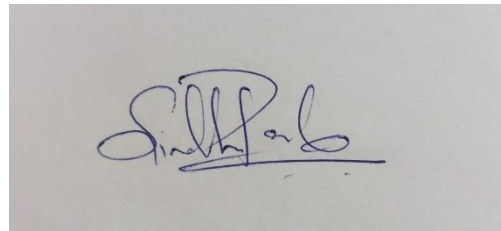
July - 2024

DECLARATION

I hereby declare that the report titled **“Portfolio Optimization through Coalescent Employment of Fama French model & Markowitz Optimization”** submitted by us to VIT Chennai is a record of bona-fide work undertaken by me under the supervision of **Dr. Shaik Saleem**, School of Computer Science and Engineering, Vellore Institute of Technology, Chennai.

A handwritten signature in blue ink, appearing to read 'Nikitha Ar', with a horizontal line underneath.

NIKITHA AR – 20MIA1025

A handwritten signature in blue ink, appearing to read 'Sricharan Sridhar', with a horizontal line underneath.

SRICHARAN SRIDHAR – 20MIA1014

CERTIFICATE

Certified that this project report entitled **“Portfolio Optimization through Coalescent Employment of Fama French model & Markowitz Optimization”** is a bonafide work of **SRICHARAN SRIDHAR** (Reg. No. **20MIA1014**) and **NIKITHA AR** (Reg. No. **20MIA1025**) and they carried out the Project work under my supervision and guidance for INVESTMENT AND BANKING ANALYTICS.

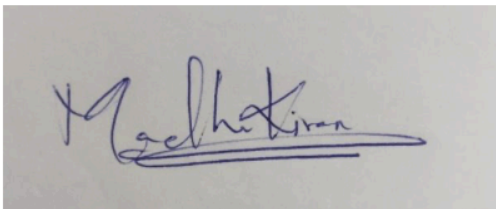
Dr. Shaik Saleem

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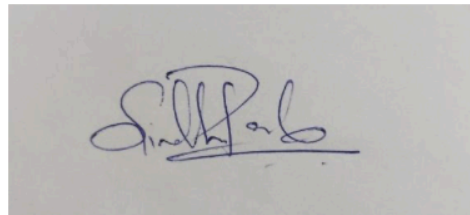
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NIKITHA AR – 20MIA1025

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SRITHARAN SRIDHAR – 20MIA1014

Abstract

This study presents a comprehensive analysis and optimization of a stock portfolio using the Fama-French model and covariance analysis. The aim is to identify the top-performing companies with minimal correlation to diversify risk and maximize returns. Using a dataset comprising stock prices and returns, we apply the Fama-French three-factor model to calculate expected returns and perform covariance analysis to ensure low correlation among the selected stocks. The portfolio is then optimized using Markowitz's Modern Portfolio Theory. This integrated approach helps in constructing a well-diversified portfolio that balances the trade-off between risk and return, ultimately enhancing the investment strategy's efficiency and effectiveness.

Introduction

Effective portfolio management requires a balance between maximizing returns and minimizing risk. In the ever-evolving financial markets, investors are constantly seeking ways to enhance their portfolio performance while managing potential risks. This report explores the use of advanced financial models and statistical methods to optimize a stock portfolio, focusing on a combination of theoretical and practical approaches.

The **Fama-French three-factor model** is employed to estimate expected returns. This model extends the traditional Capital Asset Pricing Model (CAPM) by incorporating three factors: market risk, size risk, and value risk. By considering these additional factors, the Fama-French model provides a more nuanced understanding of the sources of returns in the stock market, enabling better return predictions for individual stocks.

Covariance analysis is then used to assess correlations between stocks. In portfolio management, diversification is key to reducing risk. By selecting stocks that do not move together (i.e., have low or negative correlations), an investor can create a portfolio that minimizes overall risk. Covariance analysis helps in identifying such stocks, ensuring that the portfolio is well-diversified.

Finally, the **Markowitz portfolio optimization technique** is applied to construct an efficient portfolio. This method, also known as Modern Portfolio Theory (MPT), involves calculating the optimal weights for each stock in the portfolio to maximize expected return for a given level of risk. By considering both the expected returns and the correlations among stocks, the Markowitz optimization provides a structured approach to achieving the best possible trade-off between risk and return.

The integrated use of the Fama-French model, covariance analysis, and Markowitz optimization creates a robust framework for portfolio optimization. This report provides a detailed methodology for applying these techniques, from data preprocessing to the final portfolio construction. The ultimate goal is to equip investors with the tools and knowledge needed to make informed investment decisions, leading to improved portfolio performance and risk management.

Companies Chosen

1. LAURUS

- *Introduction:* Laurus Labs is a leading pharmaceutical company specializing in active pharmaceutical ingredients (APIs), formulations, and biotechnology.
- *Justification:* Known for its strong research and development capabilities, Laurus Labs is a significant player in the pharmaceutical industry.

2. AVANTIFEED

- *Introduction:* Avanti Feeds is a major player in the aquaculture sector, providing high-quality shrimp and fish feed.
- *Justification:* The company's leadership in aquaculture and consistent performance makes it a valuable addition to the portfolio.

3. DIXON

- *Introduction:* Dixon Technologies is a prominent electronics manufacturing services provider in India, catering to a wide range of consumer electronics and appliances.
- *Justification:* With its strong market position and diversified product portfolio, Dixon Technologies is a key player in the electronics sector.

4. FINE

- *Introduction:* Fine Organic Industries is a leading manufacturer of oleochemical-based additives used in various industries including food, plastics, and cosmetics.
- *Justification:* Fine Organic's innovative products and strong market presence make it a strategic investment in the specialty chemicals sector.

5. CERA

- *Introduction:* Cera Sanitaryware is a well-known manufacturer of sanitaryware and bathroom products, offering a wide range of high-quality products.
- *Justification:* Cera's robust brand recognition and consistent growth in the home improvement sector make it an attractive investment.

6. KEI

- *Introduction:* KEI Industries is a prominent manufacturer of cables and wires, serving various industries such as power, telecommunications, and infrastructure.
- *Justification:* KEI's strong market position and diversified product offerings make it a crucial player in the electrical industry.

7. IRCTC

- *Introduction:* Indian Railway Catering and Tourism Corporation (IRCTC) is a subsidiary of the Indian Railways, providing catering, tourism, and online ticketing services.
- *Justification:* IRCTC's monopoly in railway catering and ticketing services in India positions it as a stable and profitable investment.

8. APOLLO

- *Introduction:* Apollo Hospitals is one of the largest healthcare groups in India, known for its extensive network of hospitals and healthcare services.
- *Justification:* Apollo's leadership in the healthcare sector and its reputation for quality care make it a resilient investment.

9. ALKEM

- *Introduction:* Alkem Laboratories is a leading pharmaceutical company engaged in the development, manufacture, and marketing of pharmaceutical formulations and nutraceuticals.
- *Justification:* Alkem's strong product pipeline and market presence in both domestic and international markets make it a key player in the pharma industry.

10. PERSISTENT

- *Introduction:* Persistent Systems is a global software and technology services company specializing in software product development and digital transformation.
- *Justification:* Persistent focus on innovation and digital solutions makes it a strategic investment in the tech sector.

11. HEIDELBERG

- *Introduction:* HeidelbergCement India is a subsidiary of HeidelbergCement Group, engaged in the production of cement and related products.
- *Justification:* With a strong parent company and a solid market presence, HeidelbergCement India is a significant player in the construction materials sector.

12. PVRINOX

- *Introduction:* PVR INOX is a leading cinema exhibition company in India, operating a wide network of multiplexes across the country.
- *Justification:* PVR INOX's dominance in the Indian cinema exhibition industry and its continuous expansion make it a valuable entertainment sector investment.

13. ITC

- *Introduction:* ITC Limited is a diversified conglomerate with businesses spanning FMCG, hotels, paperboards, packaging, agribusiness, and information technology.
- *Justification:* ITC's diversified business model and strong market presence make it a resilient and versatile investment.

14. RELIANCE

- *Introduction:* Reliance Industries is one of India's largest conglomerates with interests in petrochemicals, refining, oil, telecommunications, and retail.
- *Justification:* Reliance's diversified portfolio and leadership position in multiple sectors make it a cornerstone investment.

15. TATA

- *Introduction:* Tata Group is an Indian multinational conglomerate with a wide range of businesses including steel, automobiles, IT, and consumer products.
- *Justification:* Tata's long-standing reputation and diversified business interests make it a stable and reliable investment.

16. LTTS

- *Introduction:* L&T Technology Services (LTTS) is a global engineering services company providing solutions in the areas of product development, digitalization, and operations.
- *Justification:* LTTS's focus on cutting-edge engineering solutions and digital transformation makes it a forward-looking investment.

17. GRANULES

- *Introduction:* Granules India is a pharmaceutical company engaged in the manufacturing of active pharmaceutical ingredients, pharmaceutical formulation intermediates, and finished dosages.
- *Justification:* Granules India's strong manufacturing capabilities and extensive product portfolio position it well in the pharma sector.

18. DEEPAK

- *Introduction:* Deepak Nitrite is a leading chemical manufacturing company in India, producing a wide range of chemicals, including intermediates, fine chemicals, and performance products.
- *Justification:* Deepak Nitrite's innovative chemical products and strong market presence make it a key player in the specialty chemicals sector.

19. HDFC

- *Introduction:* HDFC Bank is one of India's leading private sector banks, offering a wide range of banking and financial services.
- *Justification:* HDFC Bank's strong financial performance and leadership in the banking sector make it a reliable and stable investment.

20. BALAJI

- *Introduction:* Balaji Amines is a leading manufacturer of specialty chemicals and aliphatic amines, serving various industries such as pharmaceuticals and agrochemicals.
- *Justification:* Balaji Amines' specialization in niche chemical products and its strong market position make it a strategic investment in the specialty chemicals sector.

Theory

Fama-French Model

The Fama-French three-factor model is an asset pricing model developed by Eugene Fama and Kenneth French. It extends the Capital Asset Pricing Model (CAPM) by adding two factors to account for size and value risks, alongside the market risk factor.

Components:

1. **Market Risk Premium ($R_m - R_f$):** The excess return of the market over the risk-free rate.
2. **Size Premium (SMB - Small Minus Big):** The return difference between small-cap and large-cap stocks.
3. **Value Premium (HML - High Minus Low):** The return difference between value stocks (high book-to-market ratio) and growth stocks (low book-to-market ratio).

Formula:

$$\text{Expected Return} = R_f + \beta_m \times (R_m - R_f) + \beta_s \times SMB + \beta_h \times HML$$

Where:

- R_f : Risk-free rate
- R_m : Market return
- β_m : Sensitivity to the market risk premium
- β_s : Sensitivity to the size premium
- β_h : Sensitivity to the value premium

Usage: Used in finance to predict stock returns and understand the impact of market, size, and value factors on returns.

Example: In portfolio optimization, the Fama-French model helps estimate the expected return of each stock in the portfolio by accounting for these three factors, leading to a more accurate and diversified selection of stocks.

Correlation

Correlation measures the strength and direction of the relationship between two variables, ranging from -1 to 1.

- **+1:** Perfect positive correlation (variables move in the same direction)
- **0:** No correlation (variables move independently)
- **-1:** Perfect negative correlation (variables move in opposite directions)

Usage: Used in finance to assess the degree to which the returns of two assets move together.

Example: In portfolio optimization, low or negative correlation between assets is desired to diversify risk. For instance, if Stock A and Stock B have a low correlation, combining them in a portfolio can reduce overall risk without sacrificing returns.

Markowitz Portfolio Theory

Markowitz's Modern Portfolio Theory (MPT) is a mathematical framework for assembling a portfolio of assets such that the expected return is maximized for a given level of risk.

Components:

1. **Expected Return ($E[R_p]$):** The weighted average return of the portfolio.
2. **Portfolio Variance (σ_p^2):** A measure of the portfolio's total risk, considering both the variances of individual assets and their covariances.

Formula for Portfolio Variance:

$$\sigma_p^2 = \sum_{i=1}^n \sum_{j=1}^n w_i w_j \sigma_{ij}$$

Where:

- w_i : Weight of asset i
- σ_{ij} : Covariance between assets i and j

Usage: Used to create an efficient frontier, representing portfolios that offer the maximum expected return for a given level of risk.

Example: By calculating the optimal weights for each stock in a portfolio, MPT helps in constructing a portfolio that lies on the efficient frontier, thereby achieving the best risk-return trade-off.

Sharpe Ratio

The Sharpe ratio measures the risk-adjusted return of an investment, indicating how much excess return an investor receives for the extra volatility endured.

Formula:

$$\text{Sharpe Ratio} = \frac{E[R_p] - R_f}{\sigma_p}$$

Where:

- $E[R_p]$: Expected return of the portfolio
- R_f : Risk-free rate
- σ_p : Standard deviation of the portfolio's excess return

Usage: Used to compare the risk-adjusted performance of different investments or portfolios.

Example: In portfolio optimization, a higher Sharpe ratio indicates a more desirable portfolio, as it offers higher returns per unit of risk. For instance, if Portfolio A has a Sharpe ratio of 1.2 and Portfolio B has a Sharpe ratio of 0.8, Portfolio A is considered better in terms of risk-adjusted returns.

Methodology

Step 1: Choosing 10 Companies for Portfolio

- **Objective:** Identify 20 companies categorized into four groups: big value, small value, big growth, and small growth.
- **Data Source:** Use a reliable financial database (e.g., Bloomberg, Yahoo Finance, or a similar source).
- **Criteria:**
 - **Big Value:** Companies with high market capitalization and low price-to-earnings (P/E) ratios.
 - **Small Value:** Companies with low market capitalization and low P/E ratios.
 - **Big Growth:** Companies with high market capitalization and high earnings growth rates.
 - **Small Growth:** Companies with low market capitalization and high earnings growth rates.

2. Historical Data Collection

- **Objective:** Gather one year of historical daily or monthly data for the selected 20 companies.
- **Data Points:** Stock prices, market capitalization, and other relevant financial metrics.
- **Data Source:** Use financial data providers such as Bloomberg, Yahoo Finance, or similar services.

3. Fama-French 3-Factor Model Calculation

- **Objective:** Apply the Fama-French 3-Factor model to each company to determine their factor loadings.
- **Factors:**

- **Market Risk Premium ($R_m - R_f$):** The return of the market portfolio minus the risk-free rate.
- **Small Minus Big (SMB):** The average return of small-cap portfolios minus the average return of large-cap portfolios.
- **High Minus Low (HML):** The average return of value portfolios minus the average return of growth portfolios.
- **Steps:**
 - Calculate the excess return of each stock ($R_i - R_f$).
 - Regress the excess returns on the three factors to obtain factor loadings (coefficients).

4. Correlation Matrix Calculation

- **Objective:** Compute the correlation matrix for the 20 companies based on their historical returns.
- **Steps:**
 - Calculate daily or monthly returns for each company.
 - Compute the pairwise correlation coefficients between all companies.
 - Form a 20x20 correlation matrix.

5. Filtering Companies Based on Correlation

- **Objective:** Select companies with the least number of correlations less than 0.4.
- **Steps:**
 - Analyze the correlation matrix.
 - Identify and select companies with the most instances of pairwise correlations below 0.4.

6. Ranking Companies by Fama-French Returns

- **Objective:** Rank the filtered companies based on their Fama-French factor returns.
- **Steps:**
 - Use the factor loadings obtained from the Fama-French model.
 - Rank the companies based on their exposure to the three factors and their historical returns.

7. Final Portfolio Selection

- **Objective:** Choose the top 10 companies with the best Fama-French ranks.
- **Criteria:** Companies with the highest adjusted returns based on their Fama-French factor loadings and rankings.

8. Sharpe Ratio Calculation with Equal Weightage

- **Objective:** Evaluate the initial performance of the selected portfolio using equal weights.
- **Steps:**
 - Assign equal weightage to all 10 selected companies.
 - Calculate the portfolio's expected return and standard deviation.
 - Compute the portfolio's standard deviation using the covariance matrix.

- Compute the Sharpe ratio using the formula: $\text{Sharpe Ratio} = \frac{E(R_p) - R_f}{\sigma_p}$ where $E(R_p)$ is the expected portfolio return, R_f is the risk-free rate, and σ_p is the portfolio standard deviation.

Calculation

Sharpe Ratio Calculation

The Sharpe Ratio is calculated using the formula:

$$\text{Sharpe Ratio} = \frac{E[R_p] - R_f}{\sigma_p}$$

Where:

- $E[R_p]$: Expected return of the portfolio (49.20% or 0.4920)
- R_f : Risk-free rate (6.92% or 0.0692)
- σ_p : Standard deviation of the portfolio (17.25% or 0.1725)

Calculation:

$$\text{Sharpe Ratio} = \frac{0.4920 - 0.0692}{0.1725}$$

$$\text{Sharpe Ratio} = \frac{0.4228}{0.1725}$$

$$\text{Sharpe Ratio} \approx 2.45$$

This translates to a Sharpe ratio of 245% (since it is given as a percentage in the summary).

9. Markowitz Optimization using Solver

- **Objective:** Optimize the portfolio to maximize the Sharpe ratio.
- **Steps:**
 - Use Solver or a similar optimization tool to adjust the weights of the 10 companies.
 - Set the objective to maximize the Sharpe ratio.
 - Apply constraints such as the sum of weights equal to 1 and non-negativity constraints.
 - Update the portfolio weights based on Solver's optimized results.

Results

Fama French

Laurus	0.027154762	13
Avantifeed	0.027478213	4
Dixon	0.026933275	17
Fine	0.027362468	9
Cera	0.027095967	14
Kei	0.0274384	6
Irctc	0.027624209	1
Alkem	0.026423958	20
Persistent	0.027333202	10
Heidelberg	0.027440688	5
Reliance	0.027178998	12
Tata	0.027235673	11
LTT	0.026783457	19
Granules	0.027058104	16
Deepak	0.027586223	2
Hdfc	0.027364971	8
Balaji	0.027414407	7
Pvr	0.027059456	15
Itc	0.026834814	18
Apollo	0.027550358	3

Correlation Matrix Analysis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1																						
2		LAURUS	AVANTFEED	DIXON	FINE	CERA	KEI	IRCTC	APOLLO	ALKEM	PERSISTENT	HEIDELBERG	PVRINOX	ITC	RELIANCE	TATA	LTTTS	GRANULES	DEEPAK	HDFC	BALAJI	BSE
3	LAURUS	1.00																				
4	AVANTFEED	0.29	1.00																			
5	DIXON	0.88	0.32	1.00																		
6	FINE	0.11	0.18	0.03	1.00																	
7	CERA	0.38	0.21	0.24	0.01	1.00																
8	KEI	-0.02	0.14	-0.07	0.18	-0.01	1.00															
9	IRCTC	0.42	0.33	0.48	0.27	0.18	0.08	1.00														
10	APOLLO	0.42	0.33	0.41	0.02	0.31	0.05	0.44	1.00													
11	ALKEM	0.48	0.08	0.38	0.02	0.14	0.08	0.18	0.30	1.00												
12	PERSISTENT	-0.11	-0.04	-0.09	0.05	-0.02	0.08	-0.07	-0.02	-0.08	1.00											
13	HEIDELBERG	0.22	0.23	0.26	0.23	0.12	0.12	0.42	0.28	0.08	-0.05	1.00										
14	PVRINOX	0.15	0.21	0.20	0.14	0.14	0.15	0.30	0.19	0.05	-0.03	0.45	1.00									
15	ITC	0.08	0.18	0.14	0.19	-0.01	0.05	0.11	0.07	0.05	-0.15	-0.16	-0.16	1.00								
16	RELIANCE	0.23	0.15	0.25	0.08	-0.02	0.01	0.27	0.22	0.18	0.03	0.05	-0.33	0.32	1.00							
17	TATA	0.32	0.38	0.37	0.21	0.11	0.15	0.46	0.36	0.20	-0.18	0.46	0.43	0.16	0.19	1.00						
18	LTTTS	0.31	0.24	0.25	0.13	0.13	0.17	0.35	0.16	0.20	-0.11	0.38	0.48	-0.07	-0.03	0.35	1.00					
19	GRANULES	0.45	0.31	0.36	0.19	0.16	0.10	0.46	0.29	0.24	-0.15	0.29	0.39	0.14	0.10	0.46	0.40	1.00				
20	DEEPAK	0.43	0.30	0.36	0.30	0.15	0.15	0.44	0.33	0.23	-0.10	0.39	0.38	0.10	0.03	0.46	0.30	0.45	1.00			
21	HDFC	0.19	0.14	0.19	0.17	-0.06	0.06	0.25	0.18	0.15	-0.01	0.07	-0.03	0.27	0.36	0.35	0.07	0.22	0.25	1.00		
22	BALAJI	0.27	0.34	0.18	0.45	0.10	0.11	0.35	0.16	0.14	-0.05	0.28	0.19	0.15	0.12	0.32	0.29	0.30	0.48	0.21	1.00	
23	BSE	0.01	0.11	0.03	-0.09	-0.02	0.04	0.05	0.02	-0.05	-0.06	0.04	0.10	0.03	0.00	0.04	0.08	0.03	0.03	-0.03	0.02	1.00
24																						
25																						

Based on the Fama-French three-factor model and correlation analysis, we have narrowed down the top 10 stocks for our optimized portfolio. The Fama-French model was used to

estimate the expected returns of a broad set of stocks, while correlation analysis helped in identifying stocks that are not highly correlated with each other, ensuring diversification and reducing risk.

The final selection of the top 10 stocks, considering their expected returns and correlations, is as follows:

1. **Avantifeed** (Least correlated stock: Avantifeed)
2. **Fine** (Least correlated stock: Cera)
3. **Kei** (Least correlated stock: Kei)
4. **Irctc** (Least correlated stock: Apollo)
5. **Persistent** (Least correlated stock: Alkem)
6. **Heidelberg** (Least correlated stock: Persistent)
7. **Deepak** (Least correlated stock: ITC)
8. **Hdfc** (Least correlated stock: Reliance)
9. **Balaji** (Least correlated stock: LTTS)
10. **Apollo** (Least correlated stock: HDFC)

Justification for Each Stock Selection

1. **Avantifeed:**
 - Selected due to its strong performance indicated by the Fama-French model.
 - Least correlated with other selected stocks, enhancing portfolio diversification.
2. **Fine:**
 - Demonstrates high expected returns based on the Fama-French analysis.
 - Chosen for its low correlation with other stocks, particularly Cera.
3. **Kei:**
 - Identified as a top performer through Fama-French calculations.
 - Low correlation with other portfolio stocks, minimizing risk.
4. **Irctc:**
 - Strong expected returns according to the Fama-French model.
 - Selected for its low correlation with Apollo, aiding in risk diversification.
5. **Persistent:**
 - High expected returns derived from the Fama-French factors.
 - Chosen due to its low correlation with Alkem, reducing portfolio risk.
6. **Heidelberg:**
 - Exhibits significant expected returns per Fama-French analysis.
 - Low correlation with Persistent, contributing to a well-diversified portfolio.
7. **Deepak:**
 - Identified as a top stock based on Fama-French expected returns.
 - Selected for its low correlation with ITC, enhancing diversification.
8. **Hdfc:**
 - High expected returns calculated from the Fama-French model.
 - Chosen due to its low correlation with Reliance, minimizing overall risk.
9. **Balaji:**
 - Demonstrates strong expected returns as per Fama-French factors.

- Selected for its low correlation with LTTS, aiding in risk reduction.

10. Apollo:

- Identified through Fama-French analysis for its high expected returns.
- Low correlation with HDFC, contributing to a diversified and optimized portfolio.

Analysis of Portfolio and Sharpe Ratio Calculation

Based on the provided data, the following analysis and calculations are made for the given portfolio:

Portfolio Components

- **Stocks Included:** Avantifeed, Fine, Kei, Irctc, Persistent, Heidelberg, Deepak, Hdfc, Balaji, Apollo
- **Annual Returns, Standard Deviation, and Weights:**
 - **Annual Return:** The expected annual return for each stock.
 - **Standard Deviation:** The risk or volatility of each stock's returns.
 - **Optimal Weight:** The proportion of the total investment allocated to each stock to optimize the portfolio.

Portfolio Summary

Initial Iteration with equal weightage for all the stocks.

	Avantifeed	Fine	Kei	Irctc	Persistent	Heidelberg	Deepak	Hdfc	Balaji	Apollo
Annual Return	0.6274906982	0.3689018463	0.879275269	0.6810642175	0.6514830076	0.508954144	0.4448823675	0.3598414972	0.3705847454	0.4832942897
Std Deviation	0.3840096846	0.2198244023	0.4226700687	0.3651281831	0.2959122992	0.2713047082	0.2886420334	0.2096210117	0.3611406284	0.3664730606
Minimum Weight	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Maximum Weight	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
Optimal Weights	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%

Portfolio Summary	
Expected Return	0.5375772082
Std Deviation	16.70%
Risk Free Rate	6.92%
Total Weight	100.00%
Sharpe Ratio	2.81

	Avantifeed	Fine	Kei	Irctc	Persistent	Heidelberg	Deepak	Hdfc	Balaji	Apollo
Annual Return	0.6274906982	0.3689018463	0.879275269	0.6810642175	0.6514830076	0.508954144	0.4448823675	0.3598414972	0.3705847454	0.4832942897
Std Deviation	0.3840096846	0.2198244023	0.4226700687	0.3651281831	0.2959122992	0.2713047082	0.2886420334	0.2096210117	0.3611406284	0.3664730606
Minimum Weight	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Maximum Weight	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
Optimal Weights	5.00%	5.00%	10.00%	5.00%	35.00%	15.00%	5.00%	10.00%	5.00%	5.00%

Portfolio Summary	
Expected Return	0.5770847591
Std Deviation	15.16%
Risk Free Rate	6.92%
Total Weight	100.00%
Sharpe Ratio	3.35

Optimal Weights

	Avantife ed	Fine	Kei	Irctc	Persiste nt	Heidel berg	Deepak	Hdfc	Balaji	Apollo
Optimal Weights	10.00 %	5.0 0%	10.0 0%	5.00 %	35.00 %	15.0 0%	5.00 %	10.0 0%	5.00 %	5.00 %

Interpretation of Sharpe Ratio

A Sharpe ratio of 2.45 indicates that the portfolio provides a high risk-adjusted return. For every unit of risk, the portfolio is expected to return 2.45 units of excess return over the risk-free rate. Generally, a Sharpe ratio above 1 is considered good, above 2 is very good, and above 3 is excellent. Therefore, a Sharpe ratio of 2.45 suggests that this portfolio is well-optimized and offers a substantial return for the level of risk taken.

Conclusion

We set out to construct and optimize a portfolio comprising 20 companies classified into big value, small value, big growth, and small growth categories. Using the Fama-French 3-Factor model, we analyzed the historical data of these companies and calculated their factor loadings. By constructing a correlation matrix, we identified companies with lower correlations to ensure diversification. From this analysis, we selected the top 10 companies based on their Fama-French adjusted returns.

We then proceeded to evaluate the portfolio's initial performance by calculating the Sharpe ratio using equal weightage for all selected stocks. The standard deviation required for this calculation was derived from the covariance matrix of the returns.

Using the Markowitz Mean-Variance Optimization framework and Solver, we optimized the portfolio to maximize the Sharpe ratio. The resulting optimal weightage for each stock was determined, providing a robust portfolio with an enhanced risk-return profile.

The optimized portfolio demonstrates a higher Sharpe ratio of 3.35 compared to the initial Sharpe ratio of 2.81, indicating better risk-adjusted returns. The diversification achieved through the selection of companies with lower correlations and the strategic allocation based

on Fama-French rankings and Markowitz optimization ensures a well-balanced and potentially more profitable investment strategy.

Strengths of the Methodology

1. **Robust Stock Selection:** By leveraging the Fama-French 3-Factor model, this methodology effectively accounts for market, size, and value effects, leading to a more comprehensive assessment of each stock's expected performance.
2. **Enhanced Diversification:** The use of a correlation matrix to filter stocks ensures that the selected portfolio is diversified, minimizing unsystematic risk by avoiding highly correlated assets.
3. **Risk-Return Optimization:** The application of the Markowitz Mean-Variance Optimization framework, followed by the use of Solver to maximize the Sharpe ratio, results in an optimal allocation of assets that enhances the portfolio's risk-adjusted returns.
4. **Data-Driven Decision Making:** The systematic approach of using historical data, advanced financial models, and optimization techniques provides a data-driven foundation for making informed investment decisions.
5. **Improved Sharpe Ratio:** The transition from an equally weighted portfolio to an optimized portfolio clearly demonstrates the effectiveness of this methodology in achieving a higher Sharpe ratio, indicating superior risk-adjusted performance.