Financial Analysis Report

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Executive Summary

The purpose of this report is to conduct a comprehensive analysis of investment portfolios using Markowitz Portfolio Theory and to construct an efficient frontier to optimize portfolio performance. The analysis is based on historical data of various stocks.

Key findings: -

- The analysis demonstrates the importance of diversification in portfolio construction. By allocating investments across different asset classes with low correlations, investors can reduce portfolio risk without sacrificing returns. Diversification allows for the creation of portfolios that lie on the efficient frontier, maximizing risk-adjusted returns.
- By applying Markowitz Portfolio Theory, we have constructed an efficient frontier that represents the optimal trade-off between risk and return for our investment portfolios. The efficient frontier highlights the portfolios that provide the highest expected returns for a given level of risk, as well as the portfolios that offer the lowest risk for a given level of return.
- Along the efficient frontier, we have identified several optimal portfolios with varying risk-return profiles. These portfolios represent the most efficient combinations of assets for achieving specific investment objectives. Investors can choose the portfolio that best aligns with their risk tolerance and return expectations.
- Efficient frontier analysis provides valuable insights into portfolio risk management. By understanding the risk-return trade-offs inherent in different portfolios, investors can make informed decisions to balance risk and return according to their investment goals and constraints.

Recommendations: -

- Based on the analysis, we recommend investors to consider allocating their portfolios along the efficient frontier to achieve optimal risk-

adjusted returns. Diversifying across asset classes and rebalancing periodically can help maintain portfolio efficiency over time.

- Investors should implement risk mitigation strategies, such as diversification, asset allocation, and periodic portfolio rebalancing, to manage portfolio risk effectively. Additionally, incorporating alternative assets with low correlations can further enhance diversification benefits.
- It is essential for investors to monitor portfolio performance regularly and adjust allocations as market conditions change. Revisiting the efficient frontier periodically allows investors to adapt their portfolios to evolving market dynamics and investment objectives.

In conclusion, the analysis highlights the importance of Markowitz Portfolio Theory in optimizing investment portfolios and constructing efficient frontiers. By applying these principles, investors can build well-diversified portfolios that balance risk and return effectively, ultimately enhancing long-term investment outcomes.

Introduction

In the fast-paced world of finance, investors grapple with the task of crafting investment portfolios that effectively balance risk and return. Harry Markowitz's Nobel Prize-winning Portfolio Theory, introduced in 1952, lays the groundwork for optimizing portfolio performance by emphasizing diversification and asset allocation.

This report seeks to apply Markowitz Portfolio Theory to analyze investment portfolios and construct efficient frontiers, which represent the ideal blends of assets for achieving specific investment objectives. By utilizing historical data and quantitative methods, we aim to pinpoint portfolios that offer the highest anticipated returns for a given level of risk, and conversely, those that minimize risk for a desired level of return.

Our analysis delves into the core tenets of diversification, risk management, and portfolio optimization inherent in Markowitz Portfolio Theory. Through the creation of efficient frontiers, our objective is to furnish investors with valuable insights into constructing portfolios, allocating assets, and implementing strategies to mitigate risk.

By grasping the principles and methodologies underpinning Markowitz Portfolio Theory, investors can make informed decisions to craft well-diversified portfolios aligned with their investment objectives and risk tolerance. The conclusions and suggestions outlined in this report aim to empower investors to navigate the complexities of financial markets and enhance their long-term investment outcomes.

Methodology

We commence the portfolio construction process by meticulously selecting a diverse range of stocks. Our method involves accessing monthly stock data spanning at least a decade, including metrics like high, low, open, close, and volume for each stock. This selection process aims to ensure a comprehensive representation of various asset classes, thereby encompassing a wide range of risk and return sources.

Estimation of Expected Returns and Volatilities:

Expected returns and volatilities of the chosen assets are estimated based on historical data. This entails computing the mean returns and standard deviations of the monthly data for each stock over the past ten years. Expected returns signify the average return investors can anticipate from each asset, while volatilities indicate the variability or risk associated with those returns.

Correlation Analysis:

Subsequently, we examine the pairwise correlations among the selected assets. Correlation analysis helps us understand how the returns of different assets move relative to one another. Lower correlations indicate diversification benefits, as assets with low correlations tend to move independently, thus reducing portfolio risk.

Portfolio Optimization:

Utilizing the estimated expected returns, volatilities, and correlations, we employ the principles of Markowitz Portfolio Theory to construct the efficient frontier. This frontier represents the collection of portfolios offering the highest expected returns for a given level of risk or the lowest risk for a given level of return. We utilize mean-variance optimization techniques to determine the optimal portfolio

weights for each asset, aiming to maximize expected returns while minimizing portfolio volatility, subject to specified constraints.

Assumptions and Limitations:

Several assumptions and limitations underlie the analysis:

• We presume that historical returns and volatilities serve as reliable indicators of future performance, which may not always hold true.

• The analysis assumes investors are risk-averse and seek to maximize utility, consistent with Markowitz Portfolio Theory principles.

• The optimization process may be sensitive to input parameters like the historical time period chosen, estimation techniques, and model assumptions.

• Transaction costs, taxes, and other frictions are not accounted for in the optimization process.

• While VaR and CVaR estimate potential losses, they do not encompass the full spectrum of risks, such as extreme market events or liquidity risks

Data Analysis

Stock	Symbol
Green Brick Partners	GRBK
Advanced Micro Devices	AMD
NVIDIA	NVDA
Cadence Design	CDNS
Lam Research	LRCX
Builder's First Source	BLDS
Monolithic Power	MPWR
Fair Issac Corp	FICO
Broadcom	AVGO

Table 1.1: - Gives the names and the symbols of the selected stocks.

The table above shows the stocks we have selected for the construction of an efficient frontier.

131	TICKER 1	TICKER 2	TICKER 3	TICKER 4	TICKER 5	TICKER 6	TICKER 7	TICKER 8	TICKER 9
GRBK	383.48	71.77	55.35	38.34	66.80	104.10	57.60	43.34	48.46
AMD	71.77	254.88	113.97	50.59	69.25	74.05	66.31	57.43	53.09
NVDA	55.35	113.97	166.37	45.43	65.28	62.93	64.24	32.96	51.09
CDNS	38.34	50.59	45.43	49.40	32.49	43.30	39.97	25.67	28.08
LRCX	66.80	69.25	65.28	32.49	94.75	65.31	48.80	37.13	41.30
BLDR	104.10	74.05	62.93	43.30	65.31	245.72	45.37	44.38	44.68
MPWR	57.60	66.31	64.24	39.97	48.80	45.37	85.43	26.85	35.60
FICO	43.34	57.43	32.96	25.67	37.13	44.38	26.85	72.46	29.30
AVGO	48.46	53.09	51.09	28.08	41.30	44.68	35.60	29.30	68.02

Table 1.2: - Covariance Matrix

The table above shows the covariance matrix of the returns of the joint mean-centered data of the stocks.

131	GRBK	AMD	NVDA	CDNS	LRCX	BLDR	MPWR	FICO	AVGO
GRBK	1.00	0.23	0.22	0.28	0.35	0.34	0.32	0.26	0.30
AMD	0.23	1.00	0.55	0.45	0.45	0.30	0.45	0.42	0.40
NVDA	0.22	0.55	1.00	0.50	0.52	0.31	0.54	0.30	0.48
CDNS	0.28	0.45	0.50	1.00	0.47	0.39	0.62	0.43	0.48
LRCX	0.35	0.45	0.52	0.47	1.00	0.43	0.54	0.45	0.51
BLDR	0.34	0.30	0.31	0.39	0.43	1.00	0.31	0.33	0.35
MPWR	0.32	0.45	0.54	0.62	0.54	0.31	1.00	0.34	0.47
FICO	0.26	0.42	0.30	0.43	0.45	0.33	0.34	1.00	0.42
AVGO	0.30	0.40	0.48	0.48	0.51	0.35	0.47	0.42	1.00

Table 1.3:- Correlation Matrix

The table above shows the correlation matrix of the joint standardized data of the stocks. We can observe a very high correlation between the following companies: -

- Cadence Design systems and Monolithic Power (0.62)
- Lam Research and Monolithic Power (0.54)
- NVIDIA and Monolithic Power (0.54)
- Broadcom and Lam Research (0.51)

This suggests that they tend to move very closely with each other. This reduces the diversification benefits and high correlation also implies higher systematic risk.

We also observe a comparatively lower correlation between the following companies: -

- Advanced Micro Devices and Green Brick Partners (0.23)
- NVIDIA and Green Brick Partners (0.22)

This implies higher diversification benefits and lower systematic risks.

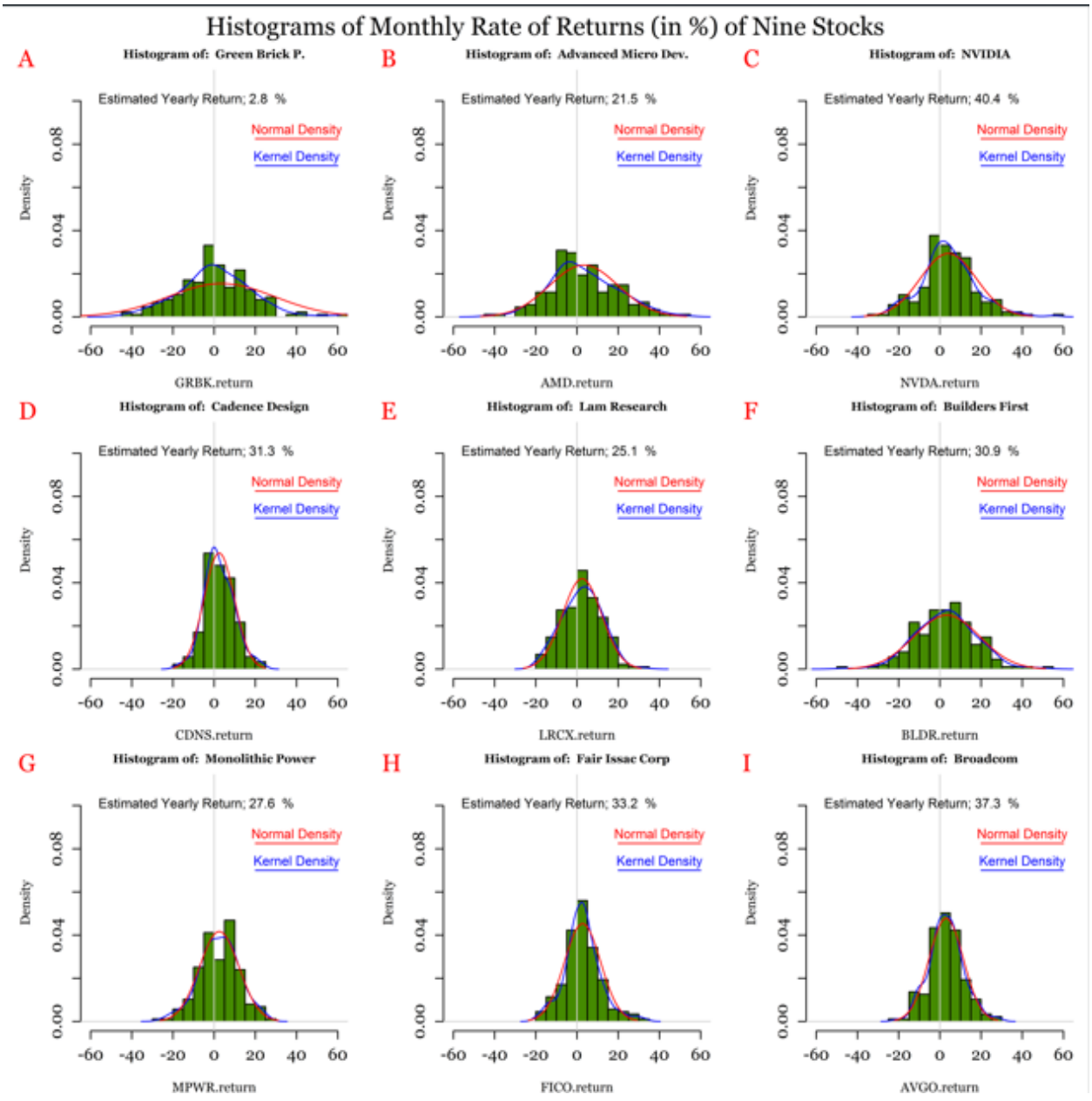

Fig 1.1: - Histogram monthly returns

The Histogram above shows the distribution of the monthly rate of returns of the 9 stocks. Here are some unique features which can be drawn from the curves: -

- Broadcom: This histogram shows a bell-shaped distribution, suggesting that the monthly returns for this stock are normally distributed around a central value.
- NVIDIA: This histogram appears to have a slightly right-skewed distribution, indicating that there are more months with returns above the mean compared to those below it.

- Green Brick Partners: This histogram has a wider spread compared to others, suggesting a higher volatility in the monthly returns for this stock.
- Cadence Design: This histogram stands out as it shows a negative skew, indicating that there are more months with returns below the mean. This could suggest a higher risk associated with this stock.

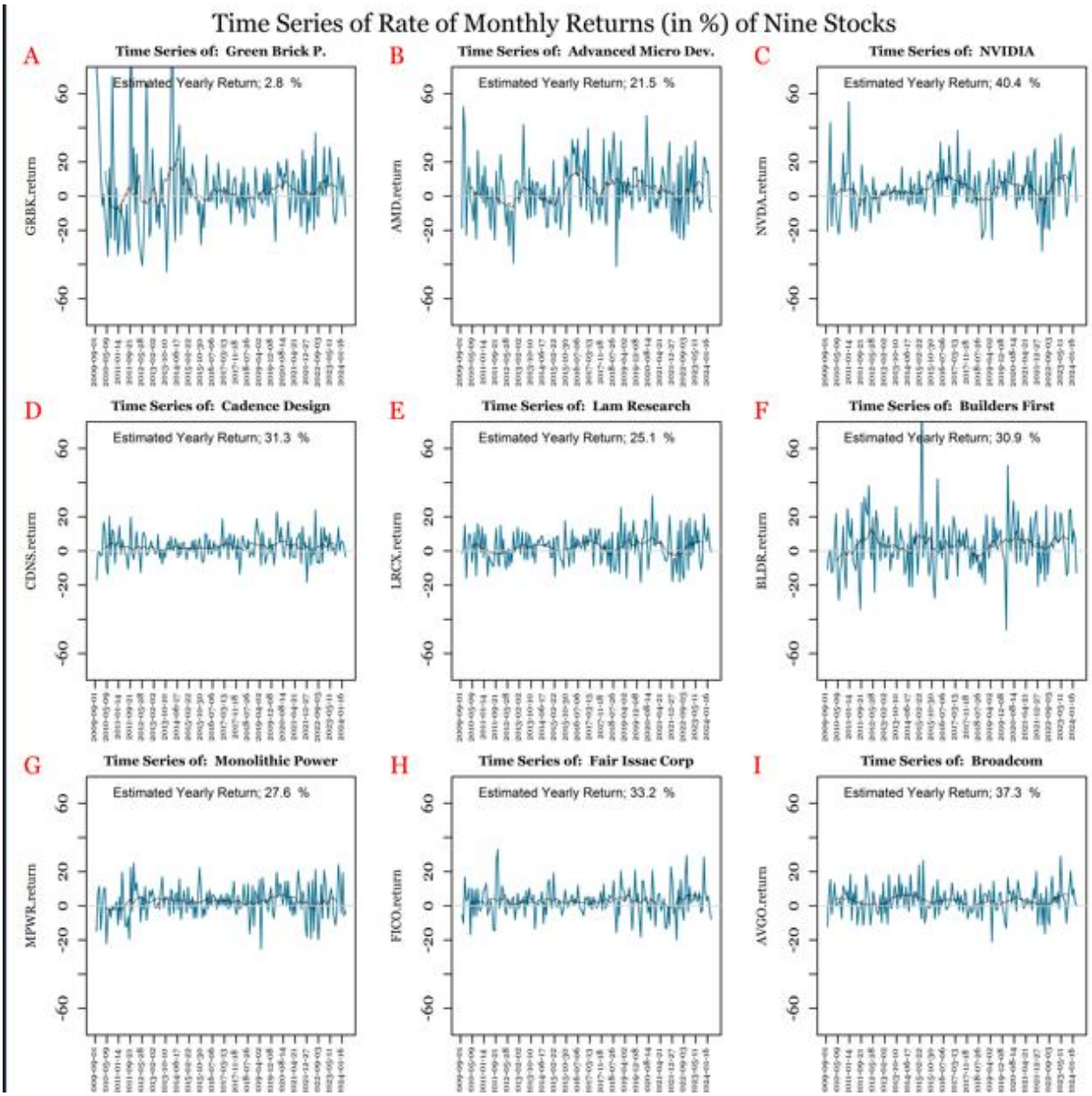

Fig 1.2: - Time series for the rate of monthly returns

- Variability: All the stocks show variability in their monthly returns, as indicated by the fluctuations in the graphs. This is a common characteristic

of stock returns and is a measure of the risk associated with investing in these stocks. Stocks like (Green Brick partners, Advanced Micro devices, Builders first) tend to vary much and stocks like(Fair Issac Corp, Cadence design) vary very less

- Trends: Some stocks show noticeable trends over time. For example, the stock represented by NVIDIA seems to have a generally upward trend, indicating a consistent increase in monthly returns over the period. On the other hand, the stock represented by Monolithic power shows a downward trend, indicating a decrease in monthly returns over time.

- Volatility: The width of the fluctuations in the graphs can give an idea about the volatility of the stocks. Stocks with wider fluctuations, such as the one represented by Green Brick Partners, are more volatile and therefore considered riskier.

Efficient Frontier Analysis

The below mentioned are a few constraints that were considered before building the efficient frontier: -

- The stocks chosen are from the ones mentioned in Table 1.1
- The desired amount of funds to be invested is $100,000.
- The risk appetite of the investor is 70%.
- The investor is considering investing these funds for a period of 1 year.
- No shorting of stocks

STOCKS	SELECT?	FUND F.W	ABS(WEIGHT)	AMOUNT		
GRBK	1	0.024285	0.024284609	1699.922603		
AMD	0	0	0	0		
NVDA	1	0.269351	0.269350819	18854.55734		
CDNS	1	0.131922	0.131922432	9234.570253		
LRCX	0	0	0	0		
BLDR	1	0.021683	0.021682655	1517.785882		
MPWR	1	0.013046	0.013045569	913.1898104		
FICO	1	0.227231	0.227230772	15906.15406		
AVGO	1	0.312483	0.312483144	21873.82006		
		1	1	70000		

Table 1.4: - Stock Portfolio (1 year)

Insights: -

- Based on Markowitz Portfolio Theory we recommend the investor to invest 70,000$ in all the stocks selected except Advanced Micro Devices and Broadcom in the respective proportions as mentioned in Table 1.4.
- The rest 30,000$ will be invested in a risk-free fund with an average expected return of **0.38%** based on the US government Treasury Data**.**
- The investor can expect a monthly return estimate of **2.64%** with a standard deviation of **5.09%**.
- The investor can expect a yearly return estimate of **36.73%**

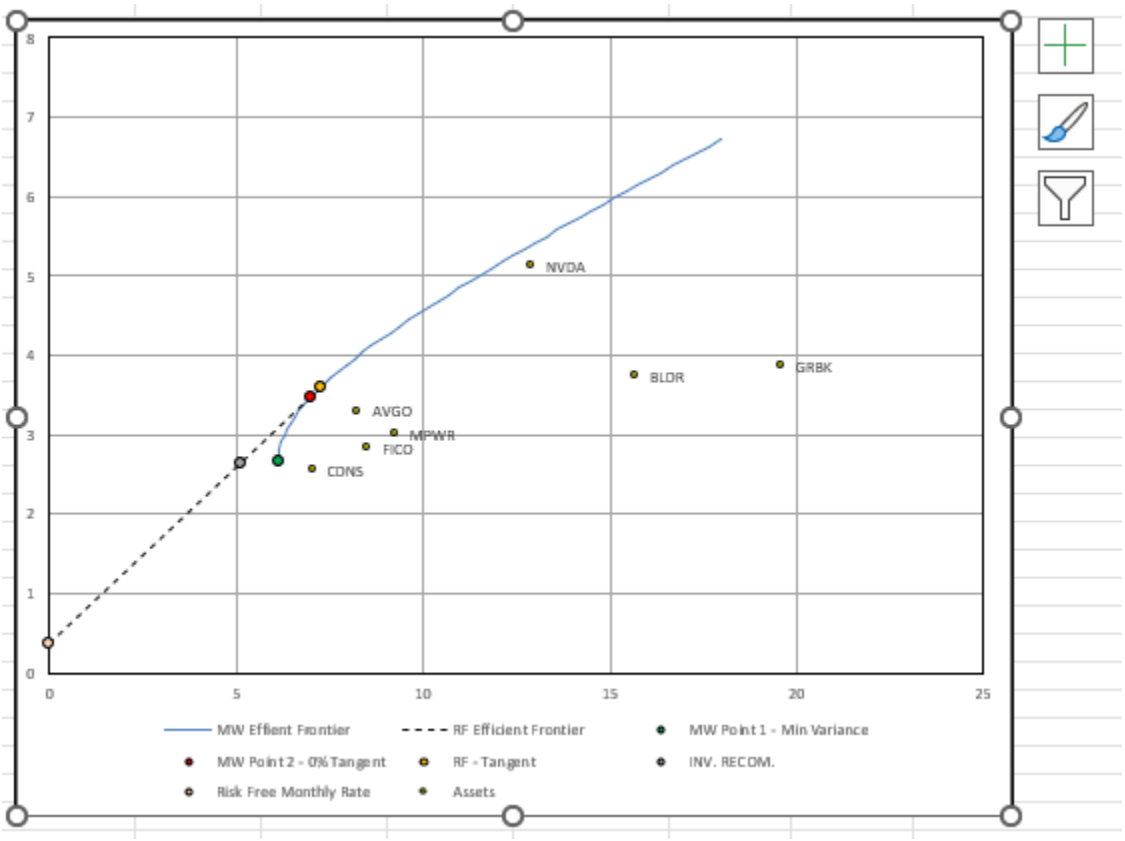

Fig 1.3: - Efficient Frontier Analysis (1 year)

Insights: -

- Fig 1.3 shows the graph of the efficient frontier, The curved line connecting the data points represents the efficient frontier. This frontier shows the optimal combination of assets or portfolios that provide the highest expected return for a given level of risk, or conversely, the lowest risk for a given level of expected return.
- As you move along the efficient frontier from left to right, the level of risk (standard deviation) increases, but so does the expected return. This illustrates the fundamental trade-off between risk and return in investment decisions.
- The tangent line from the risk-free rate (represented by the horizontal axis) touches the efficient frontier at a point labeled "INV. RECOM." This point

represents the optimal portfolio that maximizes the risk-return trade-off for a given risk tolerance and return expectation.

- The graph includes a risk-free asset, likely represented by a government bond or similar low-risk investment. The risk-free rate serves as the starting point for constructing the capital allocation line (tangent line).

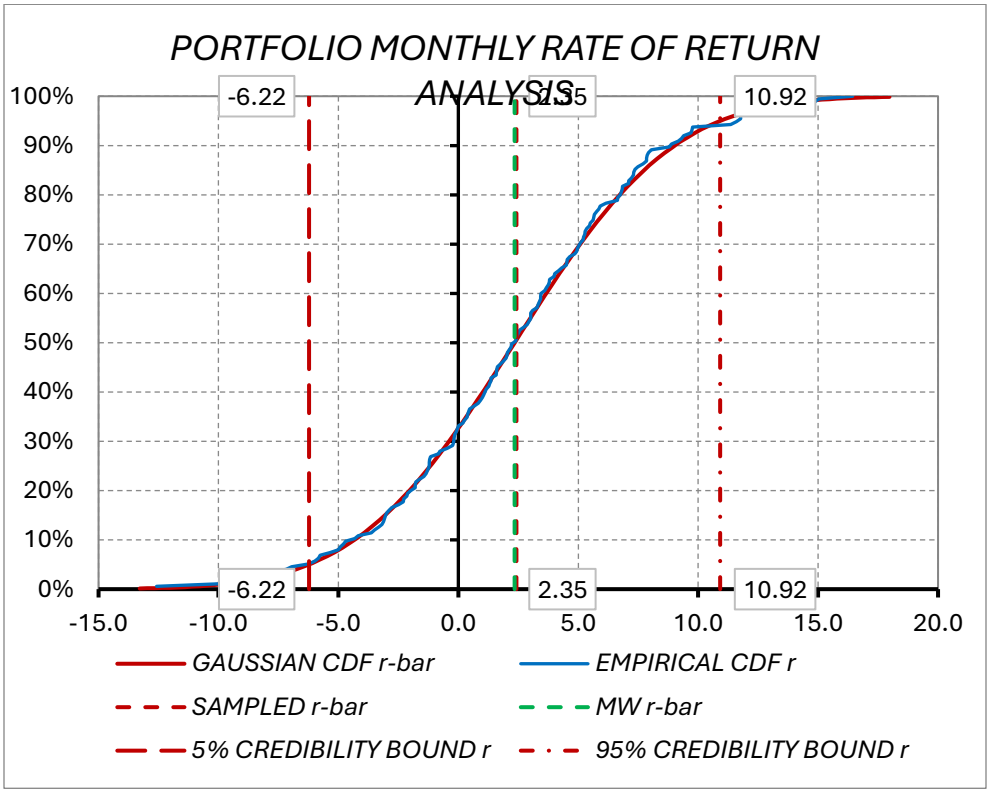

Fig 1.4: - Monthly rate of return analysis (1 year)

The figure above depicts the histogram of the monthly rate of return fitted to a gaussian distribution. The following can be concluded from the above figure: -

- On average the investor can expect a return of **2.35%** monthly rate of return.
- We are **90%** sure that the monthly rate of return will be between **-6.22%** to **10.92%**.

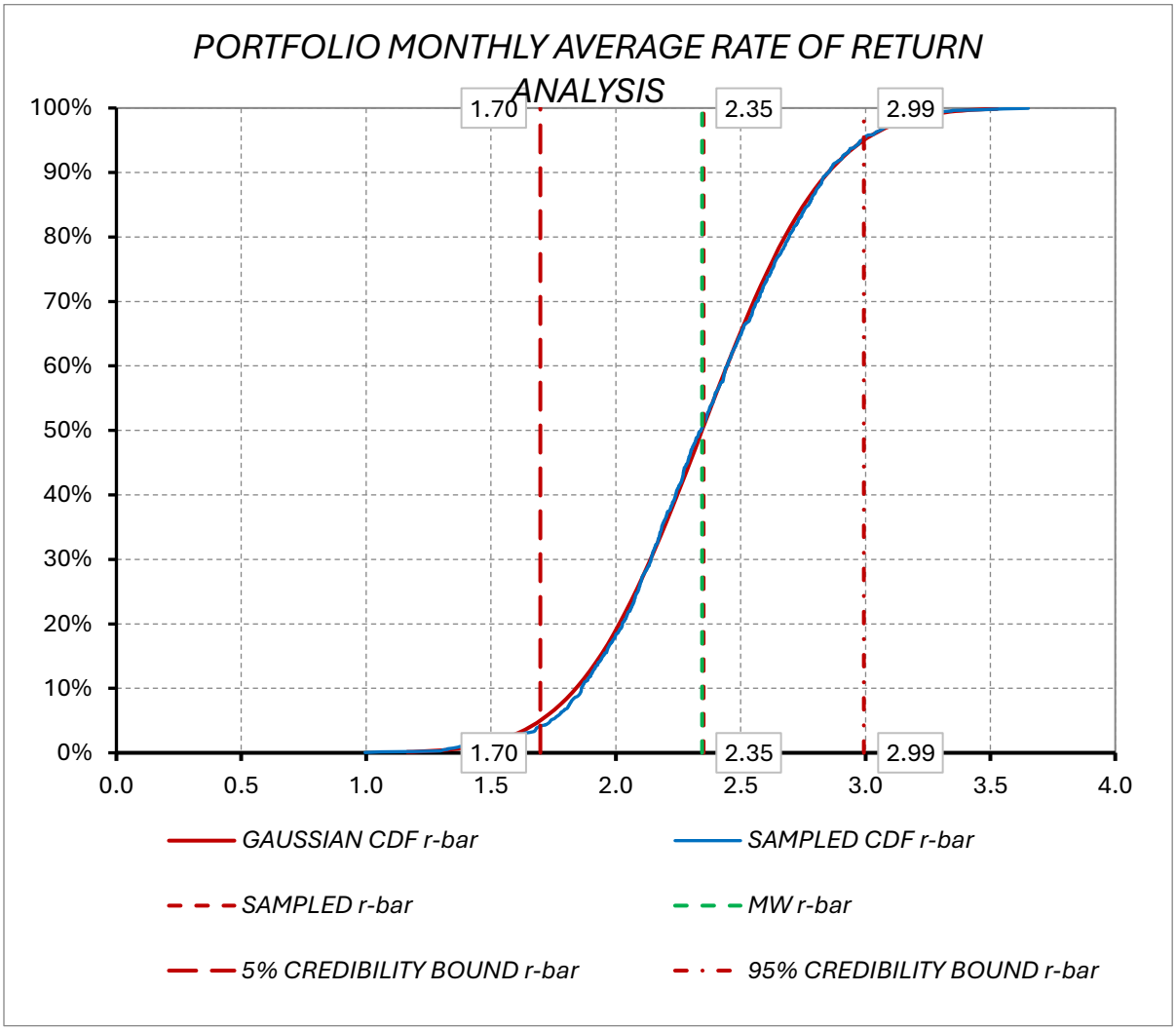

Fig 1.5: - Monthly average rate of return (20 years)

The figure above depicts the distribution of the averages of rate of return of the portfolio. We are **90%** certain that the average monthly rate of return will lie in between **1.7** and **2.99.** The mean of the monthly rate of return is **2.35%.**

Under the same constraints as previously mentioned, we will now consider investing for a duration of 20 years.

STOCKS	SELECT?	FUND F WEIGHT	ABS(WEIGHT)	AMOUNT		
GRBK	1	0.023216518	0.023216518	1625.156264		
AMD	0	0	0	0		
NVDA	1	0.259372437	0.259372437	18156.07056		
CDNS	1	0.142918448	0.142918448	10004.29139		
LRCX	0	0	0	0		
BLDR	1	0.020316831	0.020316831	1422.1782		
MPWR	1	0.015176989	0.015176989	1062.389214		
FICO	1	0.228022252	0.228022252	15961.55763		
AVGO	1	0.310976525	0.310976525	21768.35674		
		1	1	70000		

Table 1.5: - Stock Portfolio (20 years)

Insights: -

- Based on Markowitz Portfolio Theory we recommend the investor to invest 70,000$ in all the stocks selected except Advanced Micro Devices and Lam Research in the respective proportions as mentioned in Table 1.5.
- The rest 30,000$ will be invested in a risk-free fund with an average expected return of **0.31%** based on the US government treasury data**.**
- The investor can expect a monthly return estimate of **2.6%** and a with a standard deviation of **5.05%**.
- The investor can expect a yearly return estimate of **36.07%.**

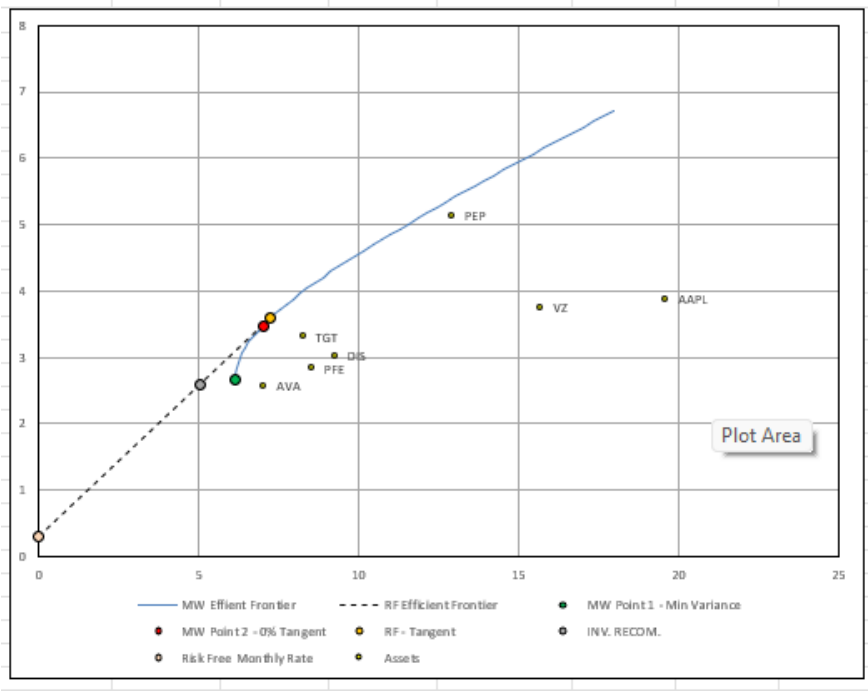

Fig 1.6: - Efficient Frontier Analysis (20 years)

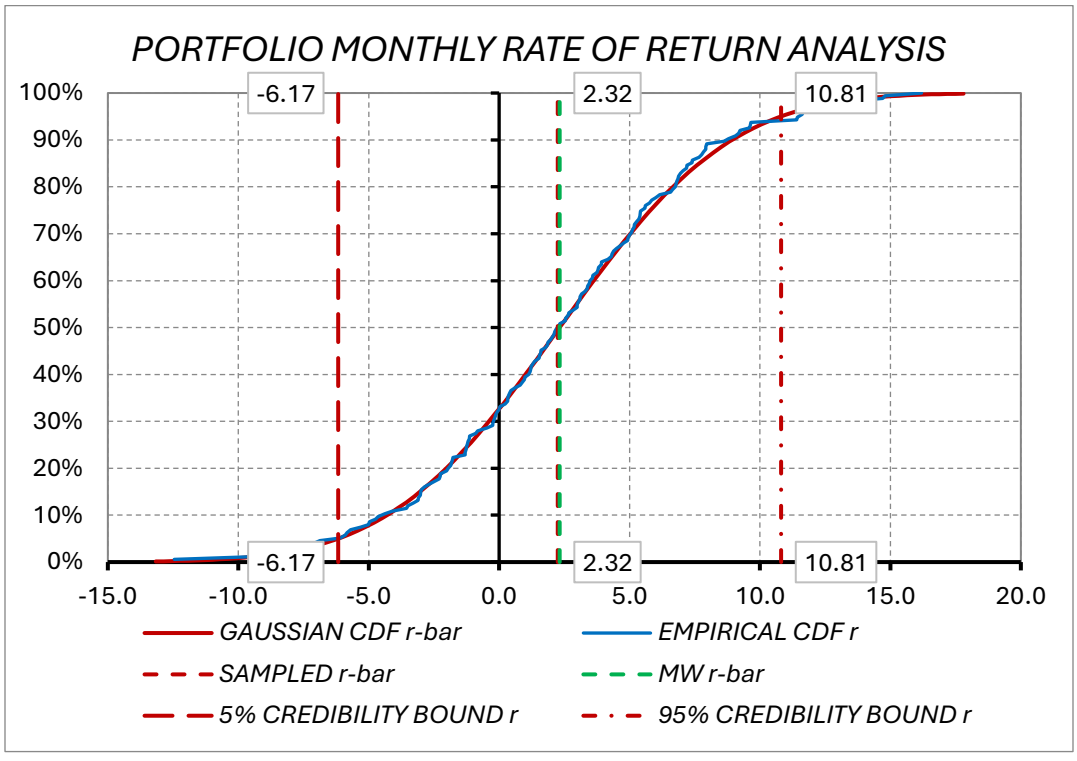

Fig 1.7: - Monthly rate of return analysis (20 years)

The figure above depicts the histogram of the monthly rate of return fitted to a gaussian distribution. The following can be concluded from the above figure: -

- On average the investor can expect a return of **2.32%** monthly rate of return.
- We are **90%** sure that the monthly rate of return will be between **-6.17%** to **10.81%**.

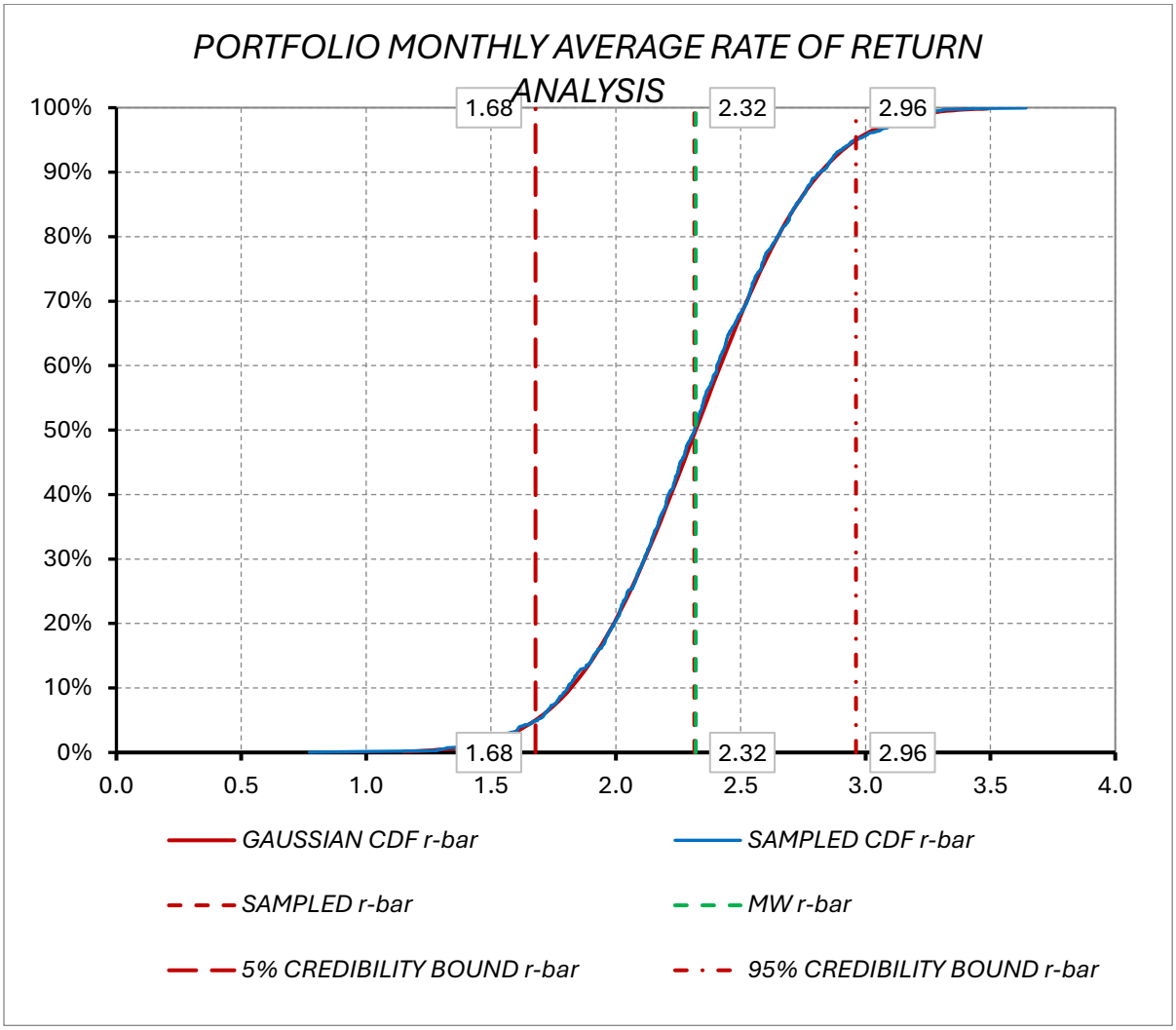

Fig 1.8: - Monthly average rate of return (20 years)

The figure above depicts the distribution of the averages of rate of return of the portfolio. We are **90%** certain that the average monthly rate of return will lie in between **1.68** and **2.96.** The mean of the average monthly rate of return is **2.32%.**

Risk Aversion

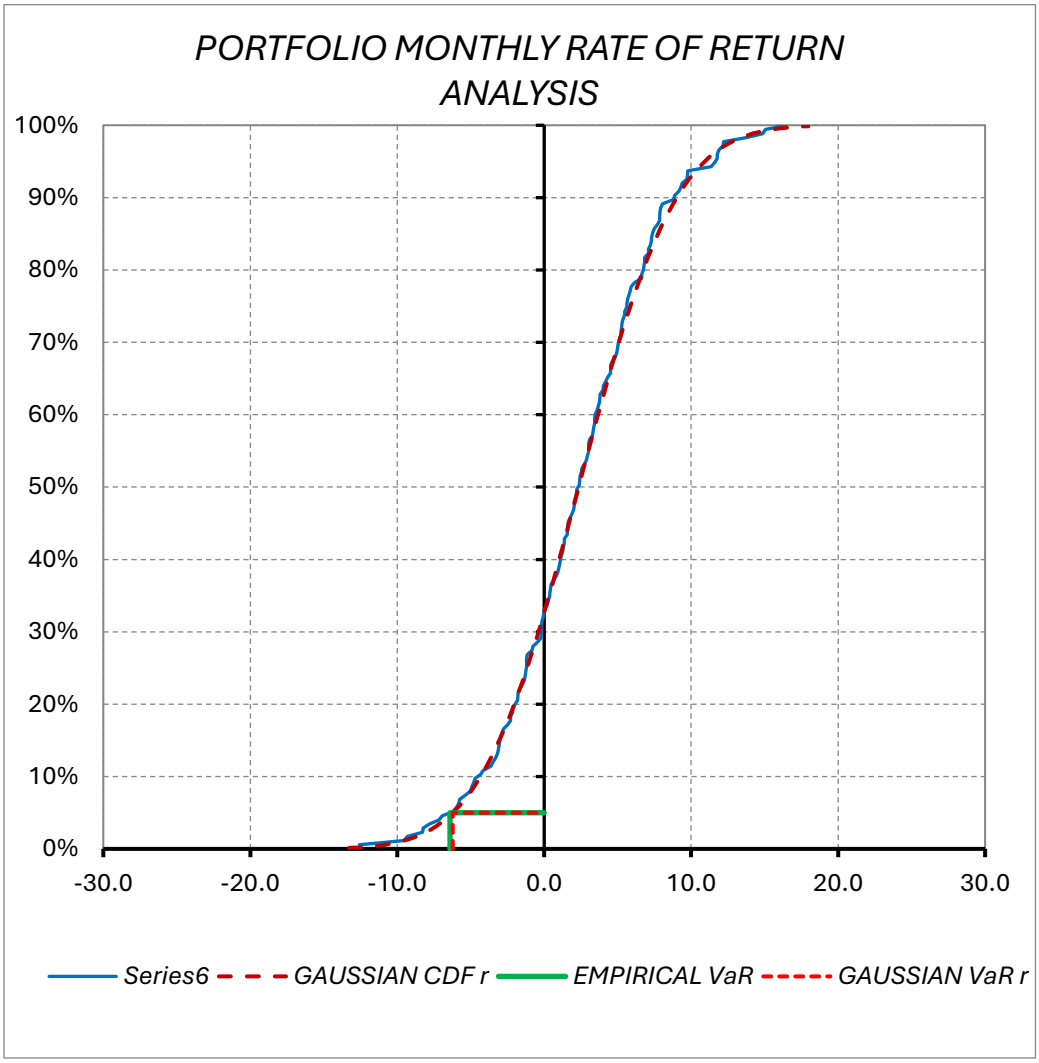

Fig 1.9: - Gaussian CDF vs Empirical VaR

- The Empirical CDF and Gaussian CDF are quite similar but not identical, indicating that the returns data is close to, but not perfectly, normally distributed.
- The portfolio has a Sharpe ratio of **37%** indicates a good risk-adjusted performance.

- The Value at risk and conditional value at risk calculated for the empirical and Gaussian fit are mostly similar.
- Overall, the investor is recommended to keep an amount of **$8600** as cash in reserves to cover **95%** of his losses on an investment of **$100,000** on a monthly basis.
- On a yearly basis, the investor is recommended to keep an amount of **$21000** as cash in reserves to cover up to **95%** of his losses.
- We also recommend the investor to get in touch with us monthly to recalculate the cash in reserves based on the returns of the portfolio.

Conclusion

In essence, the application of Markowitz Portfolio Theory has illuminated the process of creating effective portfolios and balancing risk and return in investment management. Our study has yielded several significant findings and implications for portfolio creation, risk management, and investment decision-making.

Firstly, the construction of the efficient frontier has enabled us to identify portfolios that offer the highest potential returns for a specified level of risk, and vice versa. By diversifying across a broad spectrum of assets and optimizing portfolio allocations, investors can achieve higher returns adjusted for risk and enhance their portfolio's efficiency.

Secondly, our examination of historical asset returns, correlations, and risk metrics has highlighted the vital role of diversification in mitigating portfolio risk. Assets with low correlations offer diversification benefits, reducing portfolio volatility and boosting overall stability.

Furthermore, the incorporation of Treasury interest rate data has enriched our analysis by considering the risk-free rate of return and its influence on portfolio optimization. Variations in interest rates can impact asset prices and the overall performance of a portfolio, highlighting the interdependence of financial markets.

As financial markets evolve, the principles of Markowitz Portfolio Theory continue to be relevant in shaping strategies for portfolio construction and risk management. By adapting to changing market conditions and incorporating new insights, investors can navigate uncertainties and capitalize on opportunities to attain financial success.

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