TEXAS McCombs
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Executive Memo - Portfolio Optimization Project

To: Client XYZ
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Date: Oct 23, 2024
Subject: Portfolio Analysis and Optimization Recommendations for Risk Reduction and Return Improvement

Introduction

The purpose of this memo is to provide a detailed summary of the analysis conducted on your current investment portfolio. As your investment advisor, our objective is to offer insight into strategies that can either enhance portfolio returns or reduce associated risks, depending on your preference. After reviewing your original portfolio allocations, we have employed multiple quantitative optimization approaches to determine the best reallocation strategies. These include the Global Minimum Variance (GMV) Portfolio, Efficient Portfolio, and Optimal Risky Portfolio (ORP). The findings are summarized below, with recommendations on how to proceed based on your goals.

Summary of Current Portfolio Metrics

The current portfolio is valued at $45,000,000, distributed across various sectors as follows:

- **Materials**: $6,300,000 (14%)
- **Communication Services**: $4,950,000 (11%)
- **Energy**: $2,250,000 (5%)
- **Financials**: $6,300,000 (14%)
- **Industrials**: $4,050,000 (9%)
- **Technology**: $5,400,000 (12%)
- **Consumer Staples**: $2,250,000 (5%)
- **Real Estate**: $6,750,000 (15%)
- **Utilities**: $1,350,000 (3%)
- **Health Care**: $1,800,000 (4%)
- **Consumer Discretionary**: $3,600,000 (8%)

The portfolio's overall **expected monthly return** is 13.37%, calculated as the average monthly return over the past 120 months. The **standard deviation**, which measures risk, stands at 5.40%, while the **Sharpe Ratio** is 0.16. These metrics indicate that while the current allocation provides a reasonable return, there is room for improvement in terms of risk management and potential return enhancement.

Data Analysis and Python Implementation

To conduct the necessary analysis, we used Python and the Yahoo Finance library to download historical data for each of the sectors in the portfolio. The following steps outline the process:

1. **Data Collection**
    - We utilized the yfinance library to download monthly historical returns for each sector over the past 120 months. However, some ETFs did not have data available for the entire 120-month period. As a result, we adjusted the start date for data collection to **August 1, 2018**, and the end date to **September 1, 2024**, ensuring a consistent data set. We also removed any missing values (NAs) to ensure data quality.
    - The data was collected for each sector represented by its corresponding ETF (e.g., XLB for Materials, XLC for Communication Services, etc.). The Python code snippet below illustrates how the data was collected:
2. **Computation of Portfolio Metrics**
    - Once the historical data was collected, we computed the **expected monthly returns** and **standard deviations** for each sector. These were calculated as the average monthly return and the standard deviation of monthly returns, respectively.
    - The **correlation matrix** and **covariance matrix** were also derived from the data to understand the relationships between the different sectors. These matrices are crucial for optimizing the portfolio.
3. **Portfolio-Level Calculations**
    - Using matrix operations, we computed the overall **expected return** and **standard deviation** for the portfolio. The following Python code illustrates the calculation of these metrics:
    - The **Sharpe Ratio** was then calculated by dividing the portfolio's excess return (over the risk-free rate) by its standard deviation.

Optimization Analysis
We conducted several optimization exercises to evaluate how the portfolio could be adjusted for better outcomes. The approaches taken include:

1. **Global Minimum Variance (GMV) Portfolio**
    - The GMV portfolio aims to achieve the lowest possible risk by optimizing the allocation across the existing set of securities. By redistributing weights to minimize volatility, the GMV portfolio achieved a **reduced standard deviation of 3.48%**, compared to the original 5.40%.
    - The expected return, while slightly lower than the original, remains within an acceptable range. This suggests that by adopting the GMV allocation, we can significantly reduce risk without compromising returns drastically.
    - **Recommendation**: If your primary objective is to reduce exposure to market volatility, transitioning to the GMV allocation is advisable. This portfolio provides a conservative approach, focusing on capital preservation and stability.
2. **Efficient Portfolio (Matching Original Expected Return)**
    - We also constructed an efficient portfolio that matches your original expected return while optimizing risk. This portfolio seeks to maintain your desired level of return while reducing volatility. By adjusting the weights across the various sectors, we identified a portfolio that achieves the **same expected return of 13.37%** but with a **lower standard deviation of 3.60%**.
    - This efficient portfolio allows for better risk-adjusted performance by lowering exposure to sectors with higher volatility while maintaining investments in sectors with consistent returns.
    - **Recommendation**: Reallocating to the efficient portfolio is ideal if you prefer to maintain your current return level while simultaneously improving the portfolio's risk profile. This approach provides a balanced strategy, preserving return potential while enhancing stability.
3. **Optimal Risky Portfolio (ORP)**
    - The ORP approach identifies the portfolio that provides the highest possible **Sharpe Ratio**, thus optimizing the trade-off between risk and return. By reallocating weights, the ORP offers an increase in **expected return to 36.17%**, with a similar or slightly higher level of risk compared to the current portfolio.
    - Additionally, we analyzed constrained scenarios to understand the impact of limits on sector weights. In Scenario 1, we imposed a **lower bound of 0% and an upper bound of 15%** on sector weights. This led to a moderate reduction in risk, though it also slightly reduced the return potential. In Scenario 2, we applied **bounds of -20% and 35%**, resulting in an improvement in the Sharpe Ratio.

These findings indicate that providing more flexibility in allocation can improve the portfolio's overall performance.

- **Recommendation**: For clients seeking to enhance returns, the ORP offers an attractive option. Depending on your risk tolerance, we can adjust the constraints on weights to either increase potential returns or mitigate risk exposure.

Capital Allocation Insights

To further illustrate the potential of these portfolios, we have provided a **Capital Allocation Diagram (CAD)** (see Exhibit 1). The diagram includes:

- **Client's Original Portfolio** (Point A), which serves as the baseline for comparison.
- **Global Minimum Variance Portfolio** (Point B), showcasing the lowest achievable risk.
- **Efficient Portfolio Matching the Original Expected Return** (Point C), highlighting a better risk-return balance.
- **Optimal Risky Portfolio** (Point D), which maximizes the Sharpe Ratio.
- The **Capital Allocation Line (CAL)**, demonstrating the risk-return tradeoff when investing in a combination of the risk-free asset and the ORP.
- The **Efficient Frontier (EF)**, representing the set of optimal portfolios that offer the highest return for each level of risk.

The CAD provides a clear visual representation of how different portfolios align with your risk-return preferences. The **Optimal Capital Allocation Line** helps illustrate how a mix of the ORP and risk-free assets can achieve an attractive combination of risk and return.

Recommendations

Based on our analysis and discussions regarding your investment objectives, we offer the following recommendations:

1. **Risk-Reduction Focus**: If your primary goal is to reduce risk, transitioning to the **Global Minimum Variance Portfolio** is the best course of action. This portfolio minimizes volatility and focuses on preserving capital, making it ideal for investors with a conservative risk profile.
2. **Return Enhancement**: For clients interested in enhancing returns while maintaining reasonable risk exposure, we recommend reallocating to the **Optimal Risky Portfolio (ORP)**. This approach provides the highest Sharpe Ratio, meaning you get the best possible return for the level of risk taken. Additionally, we can consider relaxed weight constraints to increase flexibility and optimize the return potential further.

3. **Balanced Approach**: If you prefer to maintain your current expected return while reducing risk, the **Efficient Portfolio** is an appropriate choice. This portfolio maintains the same expected return as your original allocation but achieves a better risk-adjusted performance.

Implementation Plan

- **Step 1**: Decide on your primary focus—whether it is risk reduction, return enhancement, or a balanced approach. This will determine which portfolio optimization strategy to implement.
- **Step 2**: Review the detailed sector allocation adjustments and approve the rebalancing strategy. We will provide a comprehensive breakdown of the new weights for each sector.
- **Step 3**: Begin the transition process by reallocating assets. This will be done in a phased manner to minimize market impact and transaction costs.
- **Step 4**: Monitor the new portfolio's performance and make any necessary adjustments to ensure alignment with your long-term investment goals.

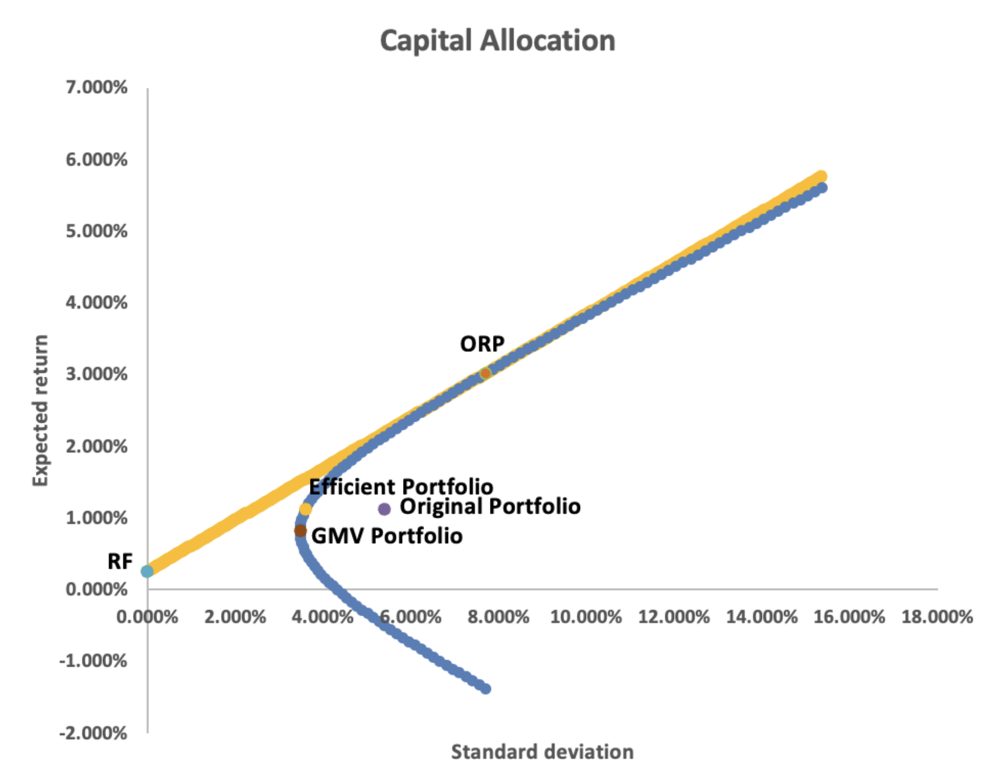
Conclusion

The analyses and recommendations provided are designed to align your portfolio with your financial objectives, whether through risk reduction, return improvement, or a balanced strategy. Each of the proposed portfolios offers unique benefits tailored to specific risk-return preferences. We are confident that these recommendations will help optimize your portfolio's performance and bring it in line with your investment goals.

Please let us know which direction you would like to pursue. We are available to discuss these options in more detail and answer any questions you may have. Your feedback is important, and we are committed to providing a tailored solution that meets your needs.

Exhibits

- **Exhibit 1**: Capital Allocation Diagram (CAD)



- **Exhibit 2**: Portfolio Metrics Summary Table

Portfolio Name	XLB	XLC	XLE	XLF	XLI	XLK	XLP	XLRE	XLU	XLV	XLY	Expected Return	Annualized Return	Annualized Volatity	Sharpe Ratio
ORIGPORT	0.14	0.11	0.05	0.14	0.09	0.12	0.05	0.15	0.03	0.04	0.08	1.11%	14.22%	5.40%	0.16
GMVPORT	-0.30	0.21	-0.03	0.16	-0.35	-0.17	0.76	-0.31	0.24	0.48	0.30	0.81%	10.19%	3.48%	0.16
EFPORT	-0.26	0.04	-0.02	0.22	-0.39	0.20	0.63	-0.32	0.32	0.45	0.13	1.11%	14.22%	3.60%	0.24
ORP	-0.04	-1.02	0.04	0.58	-0.58	2.55	-0.21	-0.43	0.82	0.25	-0.95	3.01%	42.81%	7.71%	0.36
Constrain ORP S1	0.00	0.15	0.00	0.04	0.15	0.15	0.15	0.00	0.15	0.15	0.06	1.14%	14.57%	16.12%	0.19
Constrain ORP S2	-0.20	0.09	0.00	0.10	-0.15	0.35	0.35	-0.20	0.35	0.35	-0.03	1.27%	16.35%	13.41%	0.26

- **Exhibit 3:** ChatGPT Reference used for query_user_input() and display_portfolio_info() functions

i want to write a program that will query the user about their portfolio: what securities, the original weights, the risk-free rate, and potential bounds for the weights

```
def query_user_input():
    # Query the user for securities
    securities = input("Enter the securities in your portfolio (comma-separated, e.g.
    securities = [s.strip() for s in securities]  # Remove leading/trailing spaces

    # Query the user for original weights
    weights = input("Enter the weights for each security (comma-separated, e.g., 0.14
    weights = [float(w.strip()) for w in weights]
```

- **Exhibit 4:** ChatGPT reference used for retrieving the data using finance

i want to find the average monthly return and standard deviation over the past 120 months for etfs using yfinance, can you help me get the data

```
# Download 10 years (120 months) of data from Yahoo Finance
etf_data = yf.download(sector_etfs, start='2014-01-01', end='2024-01-01', interval='1mo')[

# Calculate monthly returns for each ETF
monthly_returns = etf_data.pct_change().dropna()
```

- **Exhibit 5:** ChatGPT reference used for matrix A construction

in portfolio theory, how would i construct the matrix A in Ax=b using cov_matrix

```
# Construct the augmented matrix A (2 * covariance matrix)
A = np.block([
    [2 * cov_matrix, ones.reshape(-1, 1)],
    [ones.reshape(1, -1), 0]
])
```

Next Steps
Please review the above recommendations and let us know your preference. We are prepared to provide additional analysis or further refine the portfolio allocations based on your input. Once a decision is made, we will proceed with implementing the chosen strategy and ensure a seamless transition to the optimized portfolio.

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"We attest that this assignment has been completed in accordance with the academic integrity protocols and honor codes of the McCombs School of Business and the University of Texas. We relied on no unauthorized resources (including material submitted or produced by other students—past or present, individuals not listed in this document, internet message boards, solution manuals, or other forms of outside assistance). Any assistance from AI tools (e.g., ChatGPT) has been appropriately cited. This work product is the sole result of our efforts and is being submitted as such.

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