A1: Final Coding Assignment

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Wealth Management: Investment Risk Management and Optimization in R - FIN-5207 - SFO1

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July 13th, 2024

Introduction

Our Client is an investor based in Palo Alto, California. They have a total of $95 Million USD in liquid assets. They are considered a Ultra High Net Worth client. The assets and their allocations are as follows:

1) *IXN – Tech ETF – 17.5% - Equity,*
2) *QQQ – NASDAQ 100 – 22.1% - Equity,*
3) *IEF – Treasury Bond ETF – 28.5% - Fixed Income,*
4) *VNQ – Vanguard Real Estate ETF – 8.9% - Real Estate,*
5) *GLD – SPDR Gold Shares – 23% - Commodities.*

Throughout this document, full portfolio returns and risks analysis are done. Recommendations and further adjustments are performed.

Questions and Further Analysis

1. What is the most recent 12M*, 18M, 24M (months) return for each of the securities (and for the entire portfolio)?

12 Months Average Returns for assets and Portfolio are the following:

1) *IXN = 2.76%*
2) *QQQ = 2.25%*
3) *IEF = -0.04%*
4) *VNQ = 0.39%*
5) *GLD = 1.76%*
6) *Portfolio = 1.41%*

18 Months Average Returns for assets and Portfolio are the following:

1) *IXN = 3.26 %*
2) *QQQ = 3.02%*
3) *IEF = -0.22%*
4) *VNQ = -0.08%*
5) *GLD = 1.29%*
6) *Portfolio = 1.47%*

24 Months Average Returns for assets and Portfolio are the following:

1) *IXN = 2.39 %*
2) *QQQ = 2.06%*
3) *IEF = -0.39%*
4) *VNQ = -0.32%*
5) *GLD = 1.37%*
6) *Portfolio = 1.04%*

IXN and QQQ have showed consistently higher returns compared to other assets, while IEF and VNQ have showed negative returns in most cases. GLD was stable overall with medium returns. Overall, portfolio returns are low and further balancing could be beneficial to improve returns.

2. What are the correlations between your assets? Are there any interesting correlations?

12 Months Correlations:

	monthly.returns	monthly.returns.1	monthly.returns.2	monthly.returns.3	monthly.returns.4	monthly.returns.5	portfolio_ret
monthly.returns	1.0000000	0.97887611	0.8155074	0.8594763	0.16557621	0.9359387	0.9445585
monthly.returns.1	0.9788761	1.00000000	0.8363750	0.9005231	0.08256773	0.9707531	0.9351933
monthly.returns.2	0.8155074	0.83637500	1.0000000	0.8881542	0.16934774	0.8201131	0.8890885
monthly.returns.3	0.8594763	0.90052315	0.8881542	1.0000000	0.25930949	0.9219029	0.9393934
monthly.returns.4	0.1655762	0.08256773	0.1693477	0.2593095	1.00000000	0.1786177	0.3980588
monthly.returns.5	0.9359387	0.97075310	0.8201131	0.9219029	0.17861775	1.0000000	0.9373084
portfolio_ret	0.9445585	0.93519334	0.8890885	0.9393934	0.39805878	0.9373084	1.0000000

18 Months Correlations:

	monthly.returns	monthly.returns.1	monthly.returns.2	monthly.returns.3	monthly.returns.4	monthly.returns.5	portfolio_ret
monthly.returns	1.0000000	0.9728563	0.7037587	0.6420515	0.2433389	0.8061312	0.9129489
monthly.returns.1	0.9728563	1.0000000	0.6954510	0.6818251	0.1772426	0.8540629	0.8992435
monthly.returns.2	0.7037587	0.6954510	1.0000000	0.7092118	0.4478708	0.6980779	0.8688161
monthly.returns.3	0.6420515	0.6818251	0.7092118	1.0000000	0.2267371	0.9032785	0.7674340
monthly.returns.4	0.2433389	0.1772426	0.4478708	0.2267371	1.0000000	0.2173845	0.5358467
monthly.returns.5	0.8061312	0.8540629	0.6980779	0.9032785	0.2173845	1.0000000	0.8499597
portfolio_ret	0.9129489	0.8992435	0.8688161	0.7674340	0.5358467	0.8499597	1.0000000

24 Months Correlations:

	monthly.returns	monthly.returns.1	monthly.returns.2	monthly.returns.3	monthly.returns.4	monthly.returns.5	portfolio_ret
monthly.returns	1.0000000	0.9779776	0.7656016	0.7927886	0.3616900	0.9008990	0.9404318
monthly.returns.1	0.9779776	1.0000000	0.7617728	0.8043681	0.3188592	0.9024261	0.9321199
monthly.returns.2	0.7656016	0.7617728	1.0000000	0.7927202	0.6055395	0.7270738	0.9027312
monthly.returns.3	0.7927886	0.8043681	0.7927202	1.0000000	0.3945592	0.9188423	0.8660290
monthly.returns.4	0.3616900	0.3188592	0.6055395	0.3945592	1.0000000	0.3157986	0.6047968
monthly.returns.5	0.9008990	0.9024261	0.7270738	0.9188423	0.3157986	1.0000000	0.8872397
portfolio_ret	0.9404318	0.9321199	0.9027312	0.8660290	0.6047968	0.8872397	1.0000000

Correlations show that Asset 5 (GLD) has the lowest correlations with the other securities. It means, it is good for the diversification of portfolio for our clients. Most likely, it is a sign to keep this asset with other ones to achieve better results. Moreover, other assets are highly correlated which is interesting because they are from different asset classes and industries.

3. What is the most recent 12M sigma (risk) for each of the securities (and for the entire portfolio)?

Last year Sigma (Risks) for assets and portfolio are the following:

1) *IXN = 20.35%*
2) *QQQ = 16.8%*
3) *IEF = 8.6%*
4) *VNQ = 21.8%*
5) *GLD = 12.91%*
6) *Portfolio = 12%*

Most Risky assets are VNQ, IXN and QQQ. They should have highest returns to be worth of investments. But as we mentioned above, VNQ returns are ultra-low, so it might not be worth investing in. On the other hand, least Risky assets are IEF and GLD, which makes sense because bonds and commodities should have lower risks. Overall, Portfolio risk is around 12% which is a good risk overall. But in order to drive final conclusions we need Sharpe Ratio and further weights adjustments should be done to get best results.

4. Based on the previous 3 questions, which holdings would you sell, which holdings would you buy?

Using only previous analysis, I would drop IEF due to negative returns despite the lowest risks, and also sell VNQ for having the highest risks and 2nd lowest returns. These assets don't seem reasonable for our client. To make our decisions more concrete, let's find Sharpe Ratio and identify further path.

Sharpe ratios for assets and Portfolio are the following:

1) *IXN = 1.89*
2) *QQQ = 1.82*
3) *IEF = -0.06*
4) *VNQ = 0.22*
5) *GLD = 1.8*
6) *Portfolio = 1.52*

It suggests, that assets IXN, QQQ, and GLD should be increased in % allocation due to their highest Sharpe Ratios. While IEF and VNQ should be minimized due to lowest Sharpe Ratios. So, Buying IXN, QQQ, and GLD looks like a good decision, and Selling IEF and VNQ is going to help too.

5. How will your portfolio risk and expected returns change after rebalancing (selling and buying)?

We will start with changing weights for each asset through an algorithm that identifies the best asset allocation through maximizing and minimizing weights for each security. In our case, maximum % allocation is 0.5 which showed the best performance overall. It suggested to minimize IEF and VNQ while maximizing QQQ and splitting the rest between IXN and GLD assets.

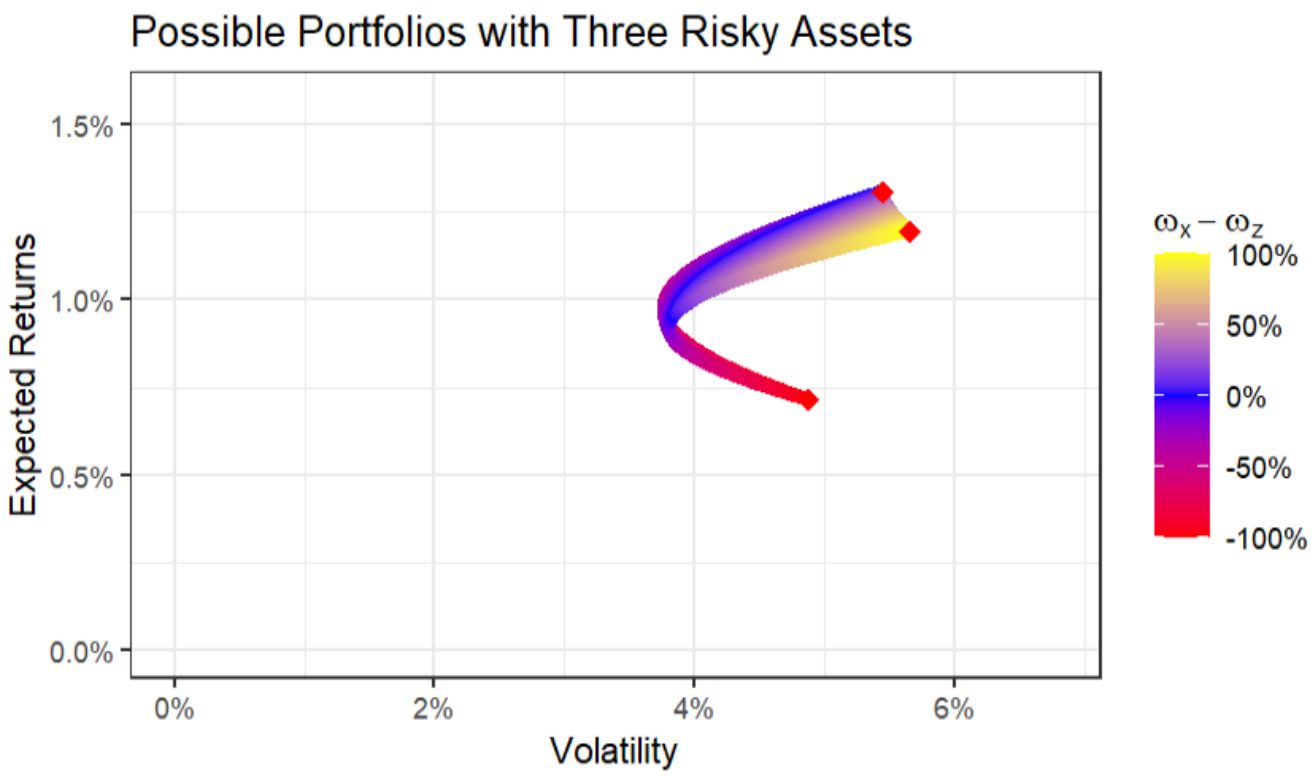
Further, running algorithm with only 3 assets, it showed the following asset allocation percentages: IXN - 0.03828932, QQQ - 0.50000000, GLD - 0.46171068. And after successfully implementing the weights and rerunning the code with the new weights it gave the following outcomes:

1) *Expected Returns: From 1.39% to 2.04%. (Which is better by 47%)*
2) *Risks (Sigma): From 12% to 11.37%. (Which is slightly better)*
3) *Sharpe Ratio: From 1.5 to 2.413 (Which is a significant boost by 61%)*

These adjustments led to less assets in the portfolio while having good diversification and higher Sharpe Ratio, which means More Returns per Risk Unit.

6. Can you build an efficient frontier for this portfolio (select 3 assets with similar high Sharpe)? What can you say based on the efficient frontier?

The efficient frontier shows the benefits of diversification, which will be helpful for investors to have higher returns per unit of risk. We can see a "Christmas Effect" where two assets improve returns while the other one decreases the risks. Moreover, investors should define their Risk Tolerance in order to define the weight of investments to each asset. Then they can follow their goals and bring greater results.



Further Analysis and Insights (done with chosen 3 assets)

The following Tracking Errors for the past 12 months show how closely to VONE (benchmark here) they perform.

1) *QQQ has TE of 4.24% which is insignificant and means that this asset is consistent with mimicking the market.*
2) *IXN has TE of 8.2% which is medium and means that assets mostly follow the market trend with slight deviations.*
3) *GLD has the highest TE of 18% which means it deviates the most, probably because it has a direct focus on Gold only.*

This code is flexible as a different Benchmark asset can be set based on the investor's risk tolerance and investment objectives.

The CAPM Model is another crucial tool to estimate expected returns and evaluate market risks, which helps our investors to make more informed decisions regarding assets.

1) *IXN has R-squared of 0.86 which means that it's returns can be mostly explained by market (VONE). Furthermore, it has a Beta of 1.27 and it means that for every unit of VONE increase, IXN will increase by 1.27 units. In other words, IXN is riskier than the market.*

```
> summary(IXN_reg)

Call:
lm(formula = monthly.returns ~ monthly.returns.5, data = last_12_months)

Residuals:
      Min        1Q    Median        3Q       Max
-0.024094 -0.013171 -0.004158  0.010277  0.043031

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.005719   0.006781   0.843    0.419
monthly.returns.5 1.271800   0.151327   8.404 7.63e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02169 on 10 degrees of freedom
Multiple R-squared:  0.876,     Adjusted R-squared:  0.8636
F-statistic: 70.63 on 1 and 10 DF,  p-value: 7.626e-06
```

2) *QQQ has similar results. R-Squared is 0.94 which states a statistical significance and that returns can be mostly explained by market trends. Moreover, Beta is 1.09 which means that for every unit increase in VONE, QQQ will increase by 1.09. In other terms, this asset is slightly riskier than the market.*

```
> summary(QQQ_reg)

Call:
lm(formula = monthly.returns.1 ~ monthly.returns.5, data = last_12_months)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0232622 -0.0019700  0.0001928  0.0021330  0.0280750

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.003770   0.003815   0.988    0.346
monthly.returns.5 1.088432   0.085123  12.787  1.6e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0122 on 10 degrees of freedom
Multiple R-squared:  0.9424,    Adjusted R-squared:  0.9366
F-statistic: 163.5 on 1 and 10 DF,  p-value: 1.605e-07
```

3) *GLD has a -0.06 R-Squared which states randomness of movements compared to the market. Moreover, Beta is 0.15 which means that for every 1 unit increase in market value - GLD will increase by 0.15 units. Or that it is much less risky compared to VONE.*

```
> summary(GLD_reg)

Call:
lm(formula = monthly.returns.4 ~ monthly.returns.5, data = last_12_months)

Residuals:
      Min        1Q    Median        3Q       Max
-0.054845 -0.021766 -0.007592  0.019018  0.067383

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.01493    0.01202   1.242    0.243
monthly.returns.5  0.15400    0.26827   0.574    0.579

Residual standard error: 0.03846 on 10 degrees of freedom
Multiple R-squared:  0.0319,    Adjusted R-squared:  -0.06491
F-statistic: 0.3296 on 1 and 10 DF,  p-value: 0.5786
```

All these details help to evaluate chosen assets compared to market. In the future, it helps to understand assets sensitivity to the market.

Finally, as a result of running Fama French Model and Linear Regression - neither of the assets price direction was predicted correctly. Most of the predictions were wrong, which means that we cannot use it for potential forecasting or future assessments regarding our current assets.

Conclusion

Current client portfolio requires rebalancing and optimization. Main points are:

1) *Sell IEF and VNQ due to their low Return to Risk ratio (Sharpe Ratio), and Buy more IXN, QQQ, and GLD. They showed consistency and better diversification together.*
2) *Rebalancing % allocations to each asset should bring 47% more returns for about the same risks with only 3 assets. And the Efficient Frontier confirmed diversification importance.*

3) *CAPM model indicated IXN and QQQ market sensitivity while having slightly higher risks. And GLD has much lower relation to the market and much lower risks.*

Finally, once we understand our client's risk tolerance and future goals, we can modify current optimization based on the efficient frontier and weighting model we created.