Preliminary Analysis

The analysis begins by performing a Monte Carlo simulation along with convex optimization to identify candidate portfolios lying on the efficient frontier. Out of 5 portfolios explored (See appendix), 3 portfolios were selected as candidates. For ease of analysis, the risk-free rate is taken as 0, and the 5 years of data used ranges from 1st January 2017 to 1st January 2022. Sharpe Ratio is used to calculate risk-adjusted return (RAR). See the appendix for each portfolio's underlying stock composition and weightage.

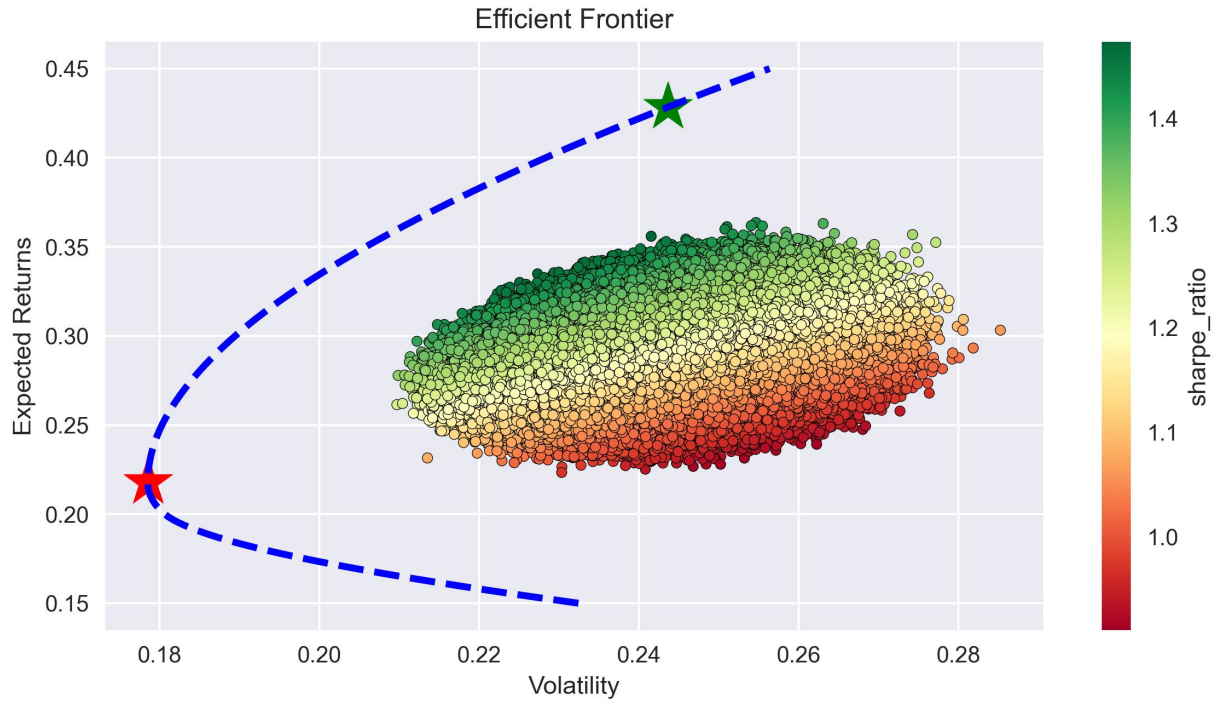


Image 1: Efficient Frontier. The green star represents the point of the highest Sharpe Ratio. The red star represents the point of lowest volatility.

Portfolio 1: Highest Risk-Adjusted Return

The portfolio that gives the highest RAR is represented by the green star in Image 1. This portfolio solely focuses on finding combinations and weightage that would give the highest possible Sharpe Ratio.

Portfolio 2: Minimum Volatility

The portfolio that gives the lowest volatility is represented by the red star in image 1. This portfolio focuses on finding combinations and weightage that would give the lowest possible volatility for the given set of stocks.

Portfolio 3: Least Market Sensitive (Beta)

This portfolio requires a pre-selection of underlying stocks based on their market sensitivity before finding the efficient frontier of the stocks. Criteria of beta (*B)* where -1<*B*<1 is used to get a list of stocks that is theoretically less volatile than the S&P 500.

8 stocks pass the criteria with the following beta values:

AMT	: 0.7848220360656563	HOLX	: 0.8725979811116742
ARE	: 0.8485958831223445	JBHT	: 0.8884150292997143
EBAY	: 0.742415191791729	NKE	: 0.9717447681956605
FR	: 0.9508543674996175	WM	: 0.7257978579671293

Passing them through Monte Carlo portfolio optimization yields:

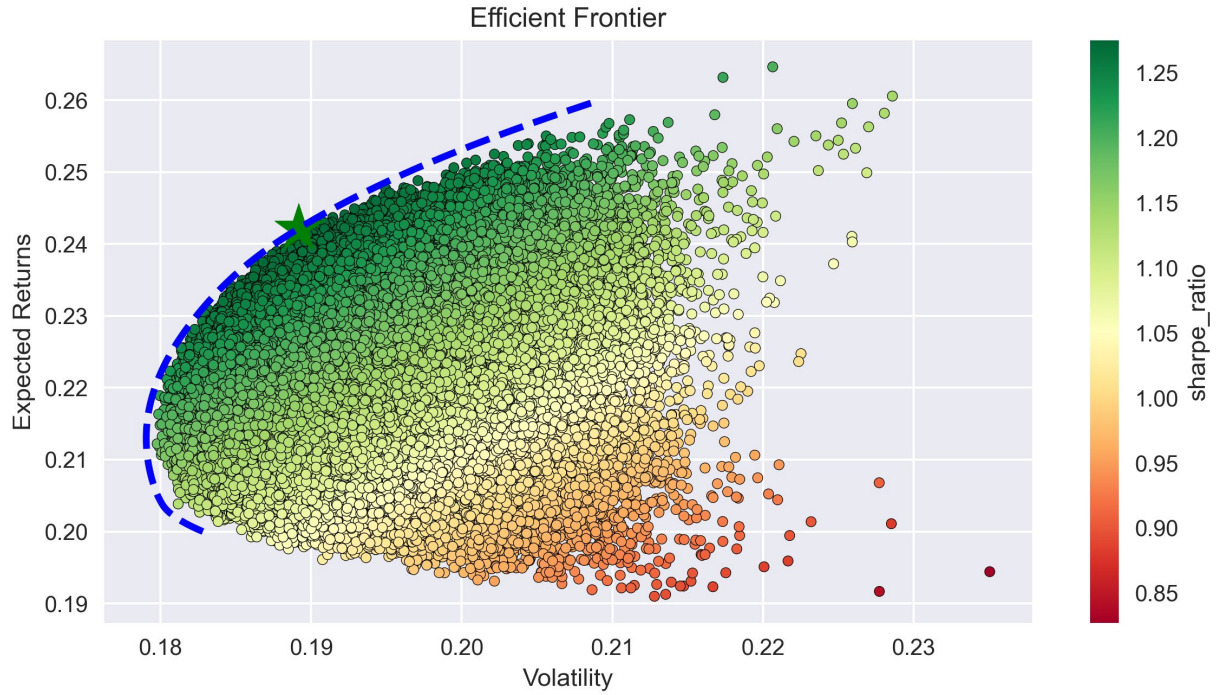


Image 2: Low Beta Efficient Frontier. The green star represents the point of the highest Sharpe Ratio

The Monte Carlo simulation provides the highest RAR possible based on the pre-selected stocks.

The "Best" Portfolio

Statistic	Portfolio 1	Portfolio 2	Portfolio 3
Sharpe Ratio	1.76	1.22	1.28
Annualized Return	48.9%	22.4%	25.1%
Volatility	0.2436	0.1786	0.1892
Excess Kurtosis	11.59	15.21	14.67
Beta	1.0902	0.7954	0.8126
Correlation	0.8608	0.8569	0.8264

Table 1: Summarized statistics of the 3 portfolios

General Risk

Portfolio 2 is the least volatile followed by portfolios 3 and 1. Interestingly, the kurtosis value ranks in reverse order of volatility. This suggests that, although Portfolio 2 is the least volatile, extreme price movement is most likely to occur for Portfolio 2 followed by 3 and 1. It is good to note that all 3 portfolios are highly leptokurtic which is expected of stock price movements.

Market Risk

All 3 portfolios show similar correlations against the market. Interestingly, Portfolio 2 shows a comparable beta value against Portfolio 3, which is built specifically to be the least market-sensitive portfolio. Thus, portfolios 2 and 3 have similar market risks while Portfolio 1 has the highest market risk due to the much higher Beta value.

Annualized Return

Comparing annualized returns yields straightforward results. Portfolio 1 outperforms the other 2 portfolios significantly by a factor of 2. Portfolio 3 outperforms Portfolio 2 but, only by 2.7%.

However, a decision cannot be made by solely annualized returns or risks in silos. A measure accounting for both factors must be used. Thus, the calculation of Risk-Adjusted Return using the Sharpe Ratio is used.

Risk-Adjusted Return using Sharpe Ratio

Sharpe ratio suggests that Portfolio 1 will provide the best RAR followed by portfolios 3 and 2. However, it is good to note that all portfolios show a greater than 1 Shape ratio which suggests that all portfolios yield an acceptable RAR (Expected not to return less than invested).

Current Market

Using the analysis above, Portfolio 1 can be declared as the “Best” based on its RAR. However, it is important to consider the current market conditions. This is because the analytics above only accurately represents the historical performance of the stocks. Any predictions beyond the 5 years are only a statistical extension of the analysis. Although such an extension can be assumed as accurate under similar circumstances to that of the 5 years, the market is currently facing abnormal circumstances. Thus, a market-based informed decision must be factored in.

The stock market is tumbling due to rising interest rates imposed by the government to curb high inflation. In such a situation, it would be preferred to have a portfolio that is market insensitive or, more preferably, moves in opposite direction to the market. Additionally, given that prices tend to move extremely in extreme situations, low volatility is preferred to maintain the stability of the portfolio.

Of the 3 portfolios, portfolios 2 and 3 best fit the description. The 2 has comparable low volatility and beta value. Portfolio 1 is out of the picture in this situation given the high beta and significantly higher volatility compared to the other 2 portfolios.

Comparing portfolios 2 and 3, Portfolio 3 appears to be a better option. Portfolio 3 has a lower market correlation along with a higher annualized return and higher RAR. Additionally, it has a lower kurtosis meaning the less likely occurrence of extreme events compared to Portfolio 2. Thus, Portfolio 3 appears to be a stronger recommendation after considering the risk, return, and current market conditions.

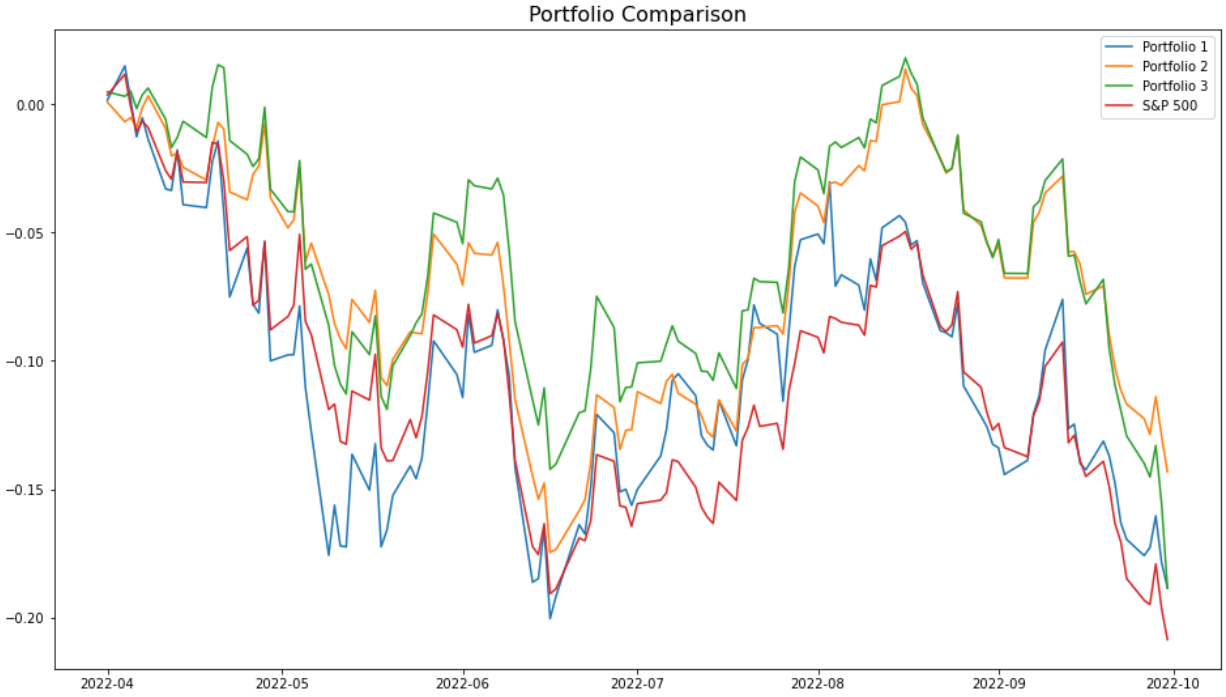


Image 3: Backtesting from 1st April 2022 to 1st October 2022 (Trailing 6 months)

We can see that Portfolio 3 consistently outperform the other 2 portfolios and the S&P 500 for most of the period. This behaviour is expected as less market-sensitive portfolios tend to do better during such a bear and volatile market, given that they are not affected as much as their counterparts.

Conclusion

After factoring the risk, return, and current vs historical market conditions, portfolio 3 stood out as the most suitable portfolio today.

Appendix

The 30 Randomly Selected Stock

No	Company	Symbol	Industry	SMR Rtg
1	Apple	AAPL	Telecommunications-Consumer Products	A
2	Accenture	ACN	Computer-Tech Services	A
3	Ameriprise	AMP	Finance-Investment Banks	A
4	American Tower	AMT	Finance-Property REIT	A
5	Alexandria Real Estate Equities	ARE	Finance-Property REIT	A
6	ASGN	ASGN	Commercial Services-Staffing	B
7	Advansix	ASIX	Chemicals-Plastics	B
8	Brinks	BCO	Security/Safety	A
9	Cabot	CBT	Chemicals-Specialty	B
10	Chemours Co.	CC	Chemicals-Specialty	A
11	Cadence Design Systems	CDNS	Computer Software-Design	A
12	Salesforce.com	CRM	Computer Software-Enterprise	A
13	EBAY	EBAY	Retail-Internet	A
14	Five Below	FIVE	Retail-Discount & Variety	A
15	Fabrinet	FN	Electronic-Contract Mfg	B
16	First Industrial Realty	FR	Finance-Property REIT	B
17	Fortinet	FTNT	Computer Software-Security	A
18	Hologic	HOLX	Medical-Systems/Equipment	A
19	J.B. Hunt	JBHT	Transportation-Trucking	B
20	Kimco Realty	KIM	Finance-Property REIT	A
21	Matson	MATX	Transportation-Shipping	A
22	Mohawk Industries	MHK	Building-Construction Products/Misc.	B
23	Nike	NKE	Apparel-Shoes & Related Mfg	A
24	Nvidia	NVDA	Electronics-Semiconductor Fabless Mfg	A
25	ON Semiconductor	ON	Electronics-Semiconductor Mfg	B
26	Simon Property Group	SPG	Finance-Property REIT	B
27	STMicroelectronics	STM	Electronics-Semiconductor Mfg	B
28	TE Connectivity	TEL	Electronics-Parts	A
29	Workday	WDAY	Computer Software-Enterprise	A
30	Waste Management	WM	Pollution Control	A

The 30 stocks are spread across 23 industries with 20 A and 10 B SMR Ratings.

The portfolio analysis is done based on 5 years of data ranging from 2017-01-01 to 2022-01-01

Portfolio 1: Maximum Sharpe Ratio portfolio

Weights

Asset	Weight
AAPL	0.169610553
ACN	6.52995E-16
AMP	0
AMT	0.113276145
ARE	0
ASGN	8.60381E-18
ASIX	0
BCO	0
CBT	0
CC	1.89024E-16

Asset	Weight
CDNS	0.122893721
CRM	2.71586E-16
EBAY	0
FIVE	0.060414976
FN	0
FR	0
FTNT	0.293414109
HOLX	9.06257E-17
JBHT	0
KIM	2.40698E-16

Asset	Weight
MATX	0.018932468
MHK	2.49556E-16
NKE	0.009260496
NVDA	0.066096481
ON	1.29131E-16
SPG	0
STM	0
TEL	0
WDAY	0
WM	0.146101051

Performance (Annualized)
Excess Return : 42.84%
Volatility : 0.2436
Sharpe Ratio : 1.7583

Against S&P500:
Beta : 1.0902
Correlation : 0.8608

Pyfolio Report:

Start date	**2017-01-04**
End date	**2021-12-31**
Total months	**59**
	Backtest
Annual return	48.9%
Cumulative returns	630.5%
Annual volatility	24.4%
Sharpe ratio	1.76
Calmar ratio	1.61
Stability	0.97
Max drawdown	-30.4%
Omega ratio	1.39
Sortino ratio	2.58
Skew	-0.28
Kurtosis	11.59
Tail ratio	0.98
Daily value at risk	-2.9%

Portfolio 2: Minimum Volatility portfolio

Weights

Asset	Weight
AAPL	2.78387E-17
ACN	3.18863E-17
AMP	0
AMT	0.082707119
ARE	0.10932524
ASGN	3.87277E-17
ASIX	3.19409E-18
BCO	0
CBT	0
CC	6.73807E-17

Asset	Weight
CDNS	8.44436E-18
CRM	0
EBAY	0.15057524
FIVE	0
FN	0.033604657
FR	0
FTNT	0.004370532
HOLX	0.083672365
JBHT	0.092661765
KIM	0

Asset	Weight
MATX	1.06138E-17
MHK	9.03612E-18
NKE	0.03482799
NVDA	0
ON	0
SPG	0
STM	0
TEL	0
WDAY	1.89577E-18
WM	0.408255091

Performance (Annualized)
Excess Return : 21.78%
Volatility : 0.1786
Sharpe Ratio : 1.2200

Against S&P500:
Beta : 0.7954
Correlation : 0.8569

Pyfolio Report:

Start date	**2017-01-04**
End date	**2021-12-31**
Total months	**59**
	Backtest
Annual return	22.4%
Cumulative returns	173.8%
Annual volatility	17.9%
Sharpe ratio	1.22
Calmar ratio	0.71
Stability	0.95
Max drawdown	-31.3%
Omega ratio	1.28
Sortino ratio	1.75
Skew	-0.60
Kurtosis	15.21
Tail ratio	1.01
Daily value at risk	-2.2%

Portfolio 3: Least Market Sensitive

Weights

Asset	Weight
AAPL	0
ACN	0
AMP	0
AMT	0.257798106
ARE	3.07371E-17
ASGN	0
ASIX	0
BCO	0
CBT	0
CC	0

Asset	Weight
CDNS	0
CRM	0
EBAY	0.1386506
FIVE	0
FN	0
FR	0.010945235
FTNT	0
HOLX	6.01732E-18
JBHT	0.033653845
KIM	0

Asset	Weight
MATX	0
MHK	0
NKE	0.249222472
NVDA	0
ON	0
SPG	0
STM	0
TEL	0
WDAY	0
WM	0.309729742

Performance (Annualized)
Excess Return : 24.21%
Volatility : 0.1892
Sharpe Ratio : 1.2800

Against S&P500
Beta : 0.8126
Correlation : 0.8264

Pyfolio Report:

Start date	**2017-01-04**
End date	**2021-12-31**
Total months	**59**
	Backtest
Annual return	25.1%
Cumulative returns	206.1%
Annual volatility	18.9%
Sharpe ratio	1.28
Calmar ratio	0.78
Stability	0.97
Max drawdown	-32.2%
Omega ratio	1.29
Sortino ratio	1.87
Skew	-0.34
Kurtosis	14.67
Tail ratio	1.08
Daily value at risk	-2.3%

Other Portfolio explored:

A market-insensitive portfolio is desirable, especially considering the volatile market in recent years. Thus, to account for beta in RAR, I explored 2 other portfolios that account for beta value.

Beta-Adjusted Sharpe Ratio

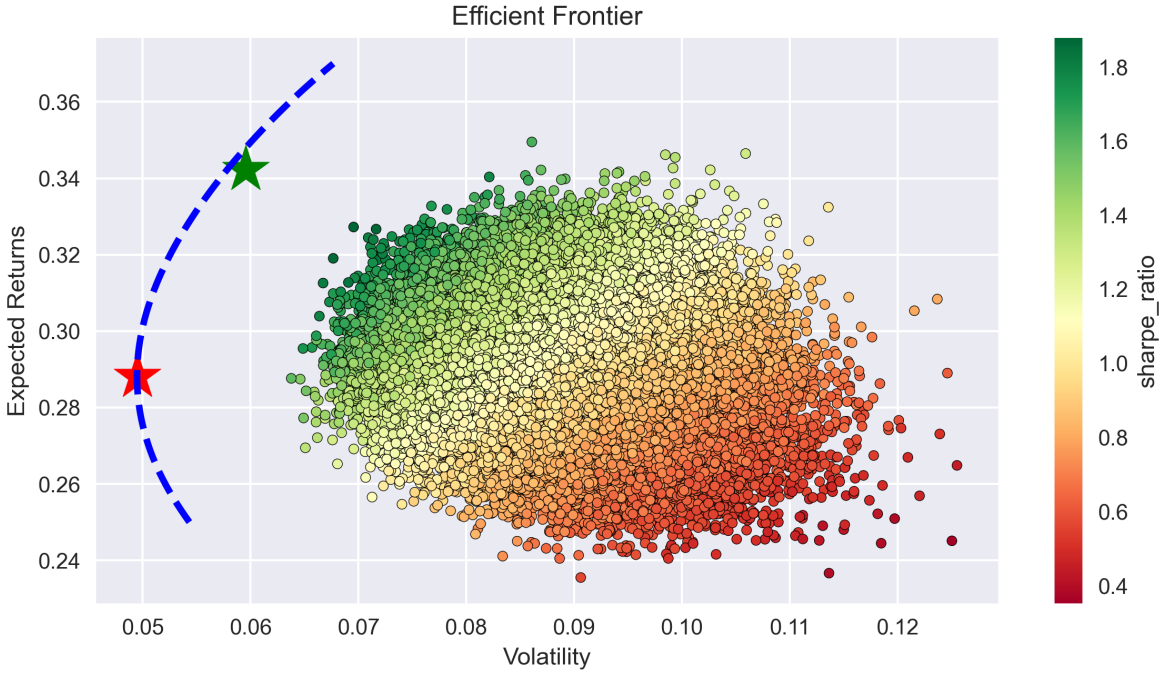
This method uses beta and market returns as the risk-free rate to find a portfolio that maximizes RAR excluding the market influence

$$Beta\ Adjusted\ Sharpe\ Ratio = \frac{R_p - \beta R_f}{\sigma_p}$$

R_p : Return of portfolio

R_f : S&P 500 return is taken as Risk-free rate

σ_p : Standard deviation of the portfolio's excess return



This portfolio was not selected to be part of the 3 candidates, as further statistical measure shows no obvious advantage to it over the selected 3 candidates. Check the *Experimental Portfolio* Code folder to view the code and statistics.

Treynor Ratio

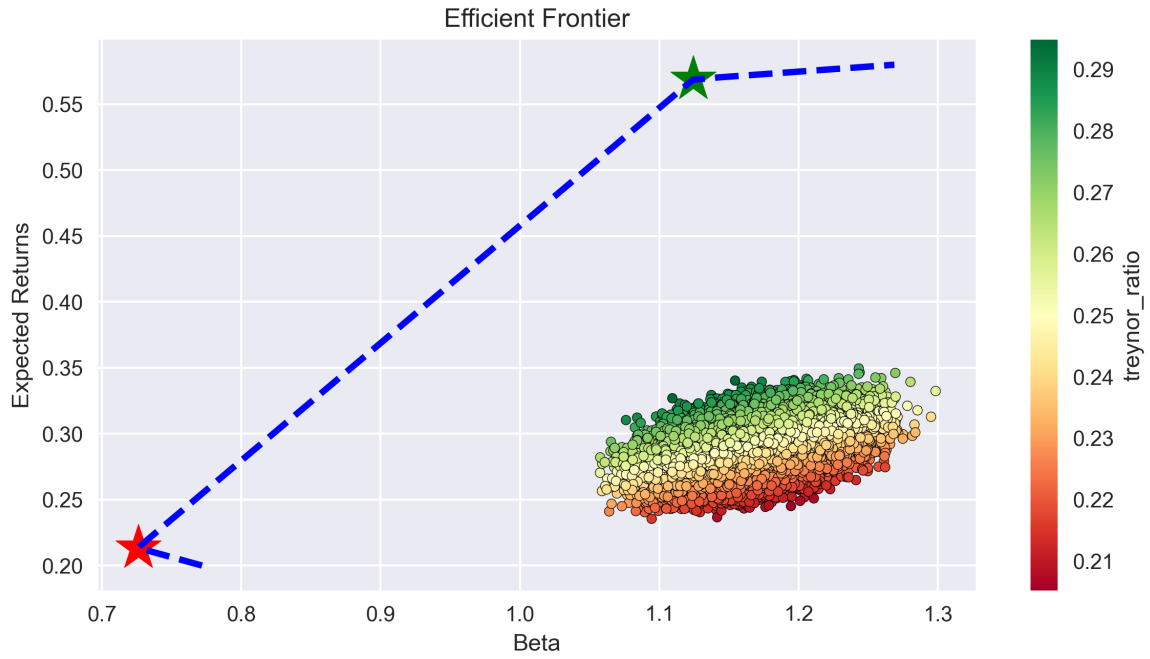
This method uses beta as the measure of risk to find a portfolio that maximizes the return to beta ratio.

$$Treynor\ Ratio = \frac{R_p - R_f}{\beta_p}$$

R_p : Return of portfolio

R_f : Risk-free rate set as 0 for ease of analysis

β_p : Systematic risk of the portfolio's excess return



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Reference

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Eric, L. (2020). *PacktPublishing/Python-for-finance-cookbook: Python for finance cookbook, published by Packt*. GitHub. Retrieved October 9, 2022, from https://github.com/PacktPublishing/Python-for-Finance-Cookbook