Assignment on Modern Portfolio Theory

ECON F412 & FIN F313:

SECURITY ANALYSIS & PORTFOLIO MANAGEMENT

First Semester: 2024-2025

Under the guidance of:

Dr. Shreya Biswas

Group 34

Name	ID
DAKSH JAIN	2022A7PS0201H
MUGDHA GUPTA	2021B3A72724H
ISHAAN SINGH	2021B3A33043H
VELINENI HARSHA ARAVIND	2022AAPS0285H
MADALA SRIRAM	2022AAPS0394H
GAURANG MOONDRA	2022A4PS0709H
LAKSHMI VAISHNAVI DUVVURI	2022A5PS1267H
ANKIT PAREEK	2022A1PS1404H

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CONTENTS

INTRO: MODERN PORTFOLIO THEORY ANALYSIS

Refer Excel: Sheet 1

This study applies Modern Portfolio Theory to construct and analyze optimized portfolios using a diverse set of securities. It creates the Markowitz portfolio by balancing risk and return, as invented by Harry Markowitz.

The analysis encompasses two scenarios: a domestic portfolio comprising eight Indian companies, and an international portfolio that includes the domestic portfolio along with an international security and a cryptocurrency. The research utilizes data for the most recent financial year (Apr ’23 to Mar ’24), employing the risk-free rate derived from Indian T-bill rates and index values derived from NIFTY 50.

The methodology involves generating efficient frontiers according to Markowitz Portfolio Theory and constructing tangency portfolios for both scenarios to conduct further analysis.

The project aims to provide insights into portfolio optimization strategies in the Indian market context and explore the potential effects of including international and cryptocurrency assets in investment portfolios. This research contributes to the broader understanding of applying Modern Portfolio Theory in emerging markets with consideration for alternative assets.

PORTFOLIO OVERVIEW

Mahindra Lifespace Developers Ltd. (MAHLIFE)

MAHLIFE, part of the Mahindra Group, is a top urban developer in India, focusing on sustainable living with major projects in cities like Mumbai and Chennai. Its Mahindra Global Cities in Chennai and Jaipur drive economic growth.

Federal Bank (FEDERALBNK)

Federal Bank, founded in 1931 and based in Kerala, is a major commercial bank in India with a strong focus on digital banking. It operates over 1,200 branches, serving individual and corporate clients, including many NRIs.

AIA Engineering Ltd (AIAENG)

AIA Engineering, founded in 1979, is a leading Indian metallurgy company serving cement, mining, and power sectors. Based in Ahmedabad, it exports to over 120 countries and focuses on R&D and sustainability.

Indian Hotels Company Limited (INDHOTEL)

IHCL, a Tata Group company founded in 1899, is a global hospitality leader known for its Taj brand. Operating over 200 hotels, including Vivanta and Ginger, it focuses on sustainable tourism and is famed for landmarks like Mumbai's Taj.

IRB Infrastructure Developers Ltd. (IRB)

Founded in 1998, IRB is a leading Indian road development corporation specializing in BOT projects. It manages over 14,000 kilometers of roads and operates India's first Road Sector Infrastructure Investment Trust (InvIT).

Astral Limited (ASTRAL)

Founded in 1996, Astral is a leading Indian manufacturer of pipes and plumbing systems, known for CPVC pipes and water management solutions. The company has expanded into fire sprinkler systems as well.

Dr. LalpathLabs (LALPATHLAB)

Founded in 1949, Dr. Lal Path Labs is India's largest diagnostic services provider, offering over 4,000 tests through a wide network. Known for its accuracy and technology integration, it also provides home sample collection services.

CERA

CERA, established in 1980, is a leading Indian manufacturer of sanitaryware and bathroom solutions. Known for its innovative designs and quality products, the company offers a wide range of ceramics and fittings and is committed to sustainability.

DOMESTIC PORTFOLIO: MARKOWITZ INPUT LIST

Refer Excel: Sheet 2

Annualised Returns

Returns were calculated by annualising the average daily returns of the 8 securities, which were found using the historic price data.

Annualised Returns	0.73998201	0.1670785	0.38829483	0.93149569	1.69366829	0.55560596	0.28598017	0.09310734

All stocks resulted in positive returns, with slight increase for FEDERALBNK, LALPATHLAB, CERA, moderate increase for MAHLIFE, AIAENG, ASTRAL, INDHOTEL and high increase for IRB.

Annualised Risk

Risk was calculated by square-rooting the variance of daily returns of the 8 securities, which were found using the historic price data. Most stocks showed risk between 24-29%, owing to similar returns.

Annualised Risk	0.27780866	0.24682381	0.27922186	0.24774157	0.48895046	0.25250693	0.28349878	0.268064

IRB had a risk of 49%, which highlights the risk-return payoff and such a high risk-high return stock can be chosen by less risk averse investors. INDHOTEL, MAHLIFE, ASTRAL are good choices for growth-oriented investors who would want strong returns with balanced risk. FEDERALBNK is a less appealing choice due to its high risk-low return nature.

Variance-Covariance Matrix

It shows how different securities move with respect to each other. Diagonal elements represent variance of each security. Other elements show covariance indicating the relationship between the price changes of securities. Positive covariance means they tend to move in the same direction whereas negative covariance means that they move in opposite directions. We aim for stocks that don’t move together and have low covariance to diversify.

Annualised Covariance Matrix								
	0.07717765	0.01607324	0.00405551	0.01812844	0.03065852	0.01468619	0.00738562	0.00672503
	0.01607324	0.06092199	0.00803372	0.01592354	0.02854636	0.00824368	0.01111746	0.00519941
	0.00405551	0.00803372	0.07796485	0.00675671	0.00487991	0.00680139	0.00593634	0.00317377
	0.01812844	0.01592354	0.00675671	0.06137589	0.04286275	0.02107403	0.01336234	0.00289792
	0.03065852	0.02854636	0.00487991	0.04286275	0.23907255	0.02246499	0.0150356	0.01352184
	0.01468619	0.00824368	0.00680139	0.02107403	0.02246499	0.06375975	0.01378643	0.00737712
	0.00738562	0.01111746	0.00593634	0.01336234	0.0150356	0.01378643	0.08037156	0.01214771
	0.00672503	0.00519941	0.00317377	0.00289792	0.01352184	0.00737712	0.01214771	0.07185831

For instance, INDHOTEL and IRB have a high covariance indicating a strong positive relationship, suggesting that they move in same direction. On the contrary, INDHOTEL and CERA have a low covariance value indicating a weak relationship, but in the same direction.

DOMESTIC PORTFOLIO: EFFICIENT FRONTIER AND TANGENCY PORTFOLIO

Refer Excel: Sheet 3

Minimum Variance Portfolio (MVP)

MVP represents the portfolio with the lowest risk on the efficient frontier. It does not provide the highest return, but it gives the least volatile portfolio that can be built. It forms the basis for the efficient frontier, by demarcating the efficient region above it and the inefficient region below it.

Expected Return	0.39985	
Variance	0.018171	(Minimise)
Risk	0.134799	
Sum of weights	1	(Constraint)

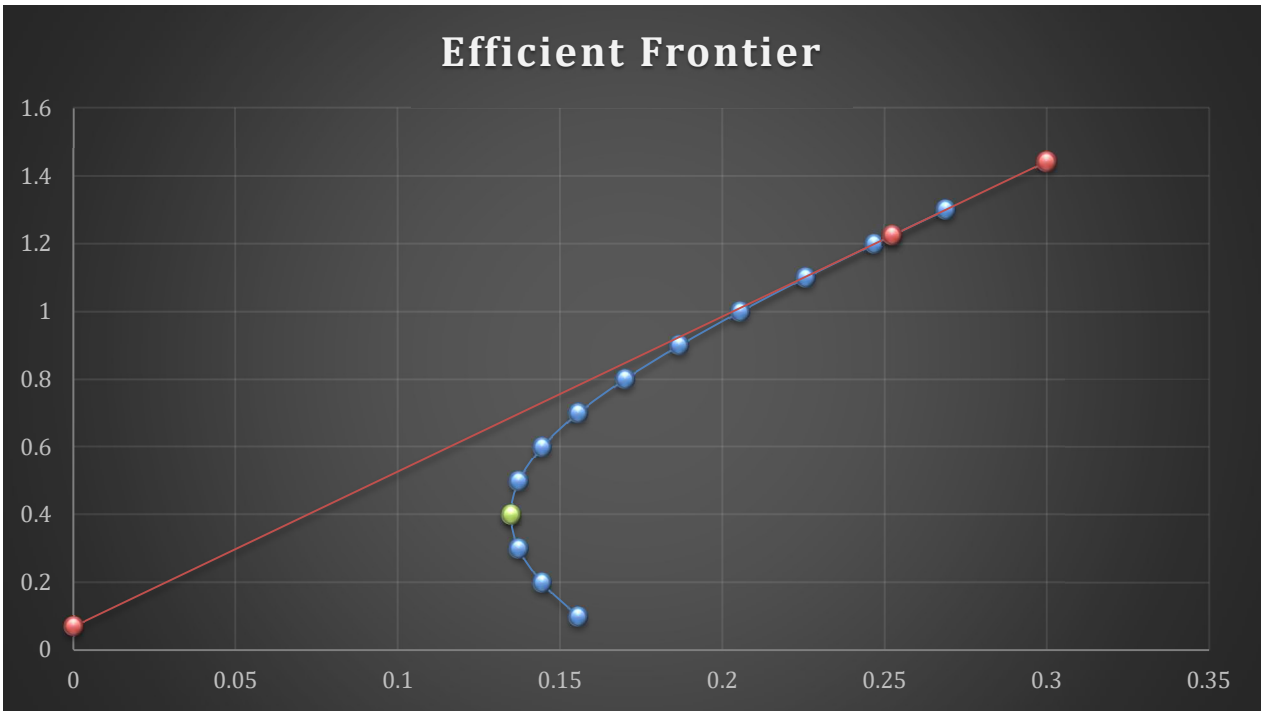
Securities	Weights
MAHLIFE	0.114822
FEDERALBNK	0.163715
AIAENG	0.171865
INDHOTEL	0.132633
IRB	-0.01579
ASTRAL	0.13533
LALPATHLAB	0.109455
CERA	0.187971

In our portfolio, minimum risk is 13.48% corresponding to an expected return of 40% for the MVP. It is marked as a yellow point on the efficient frontier.

Efficient Frontier

The efficient frontier is a line of portfolios that offer minimum risk for a given level of return. Low risk-low return portfolios are just above the MVP and are ideal for risk-averse investors. Portfolios with higher risk and higher returns keep forming as we go farther above the MVP, which are ideal for less risk-averseness.

Risk	Target Returns	Sharpe Ratio
0.268849	1.3	4.574050861
0.25235644	1.225407712	4.577401334
0.246831	1.2	4.576933205
0.225624	1.1	4.563916073
0.205482	1	4.524625028
0.186749	0.9	4.443017098
0.169891	0.8	4.29527756
0.15552	0.7	4.049183385
0.14438	0.6	3.66899155
0.13726	0.5	3.130766429
0.134799	0.4	2.446078977
0.137247	0.3	1.673836222
0.144355	0.2	0.898680337
0.155485	0.1	0.191201724



Weights are determined by solving an optimization problem that minimises the risk for given level of returns between 10% and 130%. The efficient frontier is blue. The shape of the curve shows the power of diversity – combining these funds from different sectors offers a much lower risk-to-return ratio than individual funds.

Capital Allocation Line

CAL illustrates the risk-return trade-off for portfolios when combining a risk-free asset with the tangency portfolio. Its slope is the Sharpe ratio, and higher Sharpe indicates better risk-return trade-off. For the domestic portfolio, Sharpe ratio is maximized at tangency point, where the CAL just touches the efficient frontier. CAL allows investors to borrowing amounts to increase their return, which entails a higher level of risk.

CAL	Risk	Expected Return	
	0	0.070271	(Rf Intercept)
	0.252356	1.225407712	(Tangency Point)
	0.3	1.4434914	

In our portfolio, CAL's slope is 4.5774, and it intercepts the y-axis at the risk-free rate 0.0703 (return for 0 risk). It is marked as orange on the efficient frontier.

Tangency Portfolio

It is the point at which the CAL is tangent to the efficient frontier and has the greatest Sharpe Ratio of all portfolios, thus the highest returns per unit risk. It is marked by the orange point tangent on the efficient frontier.

Expected Return	1.225408	
Variance	0.063684	
Risk	0.252356	
Risk Free Rate	0.070271	
Sum of weights	1	(Constraint)
Sharpe Ratio	4.577401	(Maximise)

Securities	Weights
MAHLIFE	0.2840341
FEDERALBNK	-0.280784349
AIAENG	0.170155415
INDHOTEL	0.520112353
IRB	0.268276823
ASTRAL	0.114362746
LALPATHLAB	0.003971232
CERA	-0.080128322

In our tangency portfolio, the expected return is 122.54% at a risk of 25.24%. Negative weights for Federal Bank and Cera indicate that a short position should be taken for these two stocks to maximise returns. When compared to the MVP, return for the tangency portfolio is tripled and the risk is doubled, thus it should be used by investors prepared to take risk to maximize efficiency as it offers the best reward-risk ratio.

DOMESTIC PORTFOLIO: COMPARISON

Efficient frontier / MVP vs Index

Risk	Target Returns	Sharpe Ratio
0.268849	1.3	4.574050861
0.252356442	1.225407712	4.577401334
0.246831	1.2	4.576933205
0.225624	1.1	4.563916073
0.205482	1	4.524625028
0.186749	0.9	4.443017098
0.169891	0.8	4.29527756
0.15552	0.7	4.049183385
0.14438	0.6	3.66899155
0.13726	0.5	3.130766429
0.134799	0.4	2.446078977

Mean Daily Returns	0.00103772
Annualised Returns	0.298707942
Daily Variance	3.83522E-05
Annualised Variance	0.009664762
Annualised Risk	0.098309524
Risk Free Rate	0.070271
NIFTY Sharpe Ratio	2.323650181

(a) Expected Returns

The efficient region of the frontier aims for returns ranging from 40% to upwards whereas NIFTY's return is 29.87%. This higher expected return means a more aggressive investment strategy through diversification and allocation across various securities. Even at the lowest target return of 40%, the portfolio performs NIFTY, which we will see using the Sharpe ratio.

(b) Risk (Volatility)

The standard deviations of the efficient region portfolios ranging from 13.5% to higher whereas NIFTY's is 9.63%. The higher risk indicates that the portfolio is much more volatile compared to NIFTY, but it seeks to compensate for this with higher returns.

(c) Sharpe Ratio

The Sharpe ratio for the efficient portfolios ranges between 2.45 to upwards (4.57 at 130% return), which is consistently higher than NIFTY's 2.32 at every target return. This indicates superior risk-adjusted performance of the portfolio compared to the index.

Overall, the portfolio is much better suited for investors seeking much higher returns and willing to accept slightly greater volatility, when compared to the NIFTY 50 index.

Tangency Portfolio vs Index

Expected Return	1.225408	
Variance	0.063684	
Risk	0.252356	
Risk Free Rate	0.070271	
Sum of weights	1	(Constraint)
Sharpe Ratio	4.577401	(Maximise)

Mean Daily Returns	0.00103772
Annualised Returns	0.298707942
Daily Variance	3.83522E-05
Annualised Variance	0.009664762
Annualised Risk	0.098309524
Risk Free Rate	0.070271
NIFTY Sharpe Ratio	2.323650181

(a) Expected Returns

The tangency portfolio provides a return of 122.5% whereas NIFTY's return is 29.87%. This higher expected return means a more aggressive investment strategy through diversification.

(b) Risk (Volatility)

The risk of the tangency portfolio is 25.23% whereas NIFTY's is 9.63%. The higher risk indicates that the portfolio is much more volatile compared to NIFTY, but it seeks to compensate for this with higher returns.

(c) Sharpe Ratio

The Sharpe ratio for the tangency portfolio is 4.58, which is significantly higher than NIFTY's 2.32. This implies that for every unit of risk taken, the portfolio is delivering far more return than the index.

In **conclusion**, while NIFTY indicates the typical performance of a broad-based market index, the Tangency Portfolio offers much better returns relative to the risk it carries compared to the market benchmark, justifying its volatility.

The Tangency Portfolio is constructed with specific weights assigned to each security and is actively managed and tailored for higher performance. NIFTY on the other hand, is a market-cap-weighted index with a fixed, passive structure representing top companies of the market. The Tangency Portfolio outperforms the index and is an ideal choice for investors who seek higher returns while managing risk through diversification.

INTERNATIONAL PORTFOLIO: INPUT LIST AND DOLLAR CONVERSION

Ford – Choice of International Security

Ford has demonstrated strong growth potential due to its aggressive push into the EV market, making it a valuable international asset.

Cardano – Choice of Cryptocurrency

Cardano has been a standout due to consistent technological development and popularity. Its cheap price makes it easily manageable in a diversified portfolio. It was narrowed down to only weekday prices using Excel's Vlookup function.

Refer Excel: Sheet 4

USD to INR conversion

To incorporate US-based securities into our portfolio, we have used daily conversion rates for the financial year and matched them with Vlookup.

Refer Excel: Sheet 5

Annualised Returns

Returns were calculated by annualising the average daily returns of the 10 securities, which were found using the historic price data.

Annualised Returns	0.739982	0.167078504	0.3882948	0.93149569	1.6936683	0.555606	0.285980165	0.0931073	0.1421058	1.186275

All stocks resulted in positive returns, with slight increase for FEDERALBNK, LALPATHLAB, CERA, FORD, moderate increase for MAHLIFE, AIAENG, ASTRAL, INDHOTEL and high increase for IRB and CARDANO.

Annualised Risk

Risk was calculated by square-rooting the variance of daily returns of the 10 securities, which were found using the historic price data. Most stocks showed risk between 24-34%, owing to similar returns.

Annualised Risk	0.2778087	0.246823807	0.2792219	0.24774157	0.4889505	0.2525069	0.283498782	0.268064	0.3443854	0.69624

IRB and CARDANO had a risk of 49% and 69.65% respectively, which highlights the risk-return payoff and such stocks can be chosen by less risk averse investors. INDHOTEL, MAHLIFE, ASTRAL are good choices for growth-oriented investors who would want strong returns with balanced risk. FEDERALBNK and FORD are less appealing choice due to their high risk-low return nature.

Variance-Covariance Matrix

Variance-covariance matrix was calculated in a similar way to the domestic portfolio.

Annualised Covariance Matrix										
	0.0771777	0.016073241	0.0040555	0.01812844	0.0306585	0.0146862	0.007385619	0.006725	0.0090418	-0.023718
	0.0160732	0.060921992	0.0080337	0.01592354	0.0285464	0.0082437	0.011117456	0.0051994	0.0002397	-0.007491
	0.0040555	0.008033717	0.0779648	0.00675671	0.0048799	0.0068014	0.005936339	0.0031738	0.0033199	-0.002388
	0.0181284	0.015923538	0.0067567	0.06137589	0.0428627	0.021074	0.013362338	0.0028979	-0.000455	-0.013771
	0.0306585	0.028546362	0.0048799	0.04286275	0.2390726	0.022465	0.015035601	0.0135218	0.0140631	0.017313
	0.0146862	0.008243675	0.0068014	0.02107403	0.022465	0.0637597	0.013786433	0.0073771	0.0022148	0.007033
	0.0073856	0.011117456	0.0059363	0.01336234	0.0150356	0.0137864	0.080371559	0.0121477	0.0067021	0.009741
	0.006725	0.005199412	0.0031738	0.00289792	0.0135218	0.0073771	0.012147705	0.0718583	-0.002835	-0.005344
	0.0090418	0.000239749	0.0033199	-0.0004552	0.0140631	0.0022148	0.006702068	-0.002835	0.1186013	0.017813
	-0.0237178	-0.007491184	-0.0023883	-0.0137709	0.0173133	0.0070326	0.009741459	-0.005344	0.0178128	0.48475

INDHOTEL and IRB again have high covariance indicating a strong positive relationship, suggesting that they move in same direction. On the contrary, MAHLIFE and CARDANO have highly negative covariance indicating a strong negative relationship, suggesting they move in opposite directions.

INTERNATIONAL PORTFOLIO: EFFICIENT FRONTIER AND TANGENCY PORTFOLIO

Refer Excel: Sheet 6

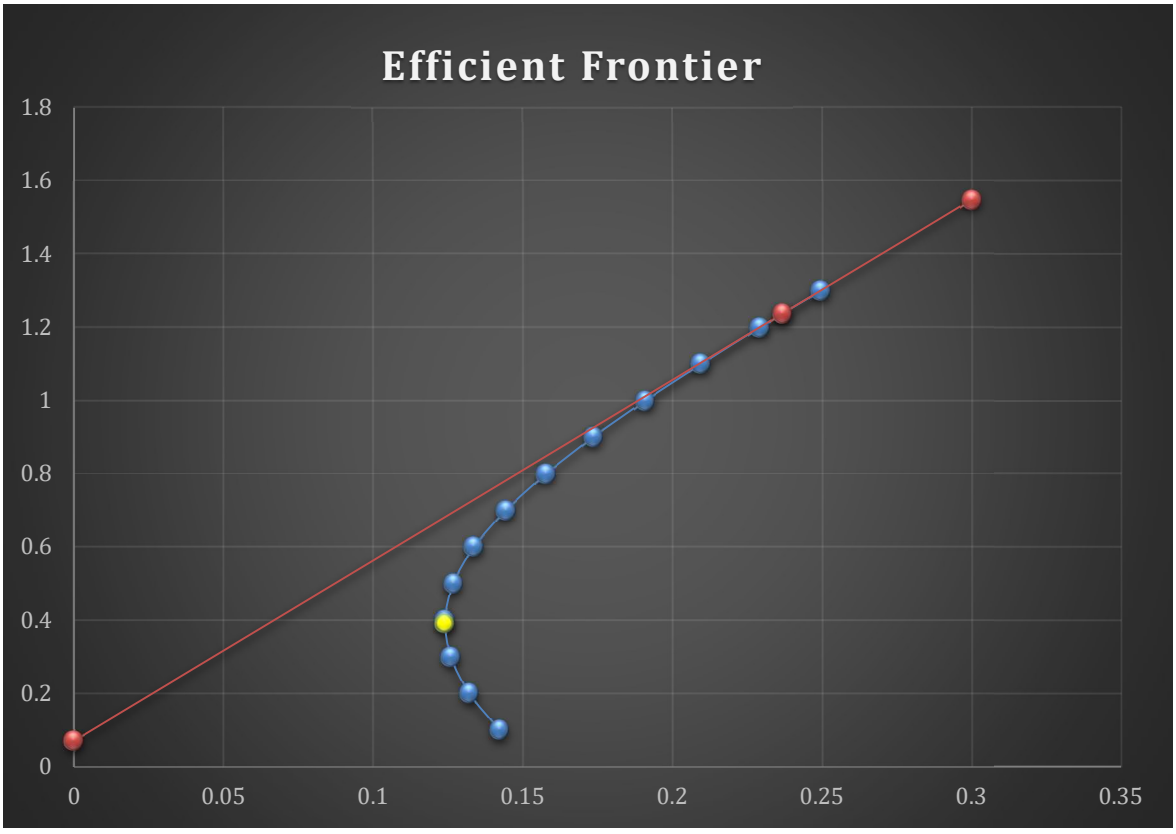
Minimum Variance Portfolio (MVP)

Expected Return	0.39087	
Variance	0.015395	(Minimise)
Risk	0.124076	
Sum of weights	1	(Constraint)

Securities	Weights
MAHLIFE	0.096455295
FEDERALBNK	0.147128979
AIAENG	0.141582924
INDHOTEL	0.136102436
IRB	-0.0267136
ASTRAL	0.104949453
LALPATHLAB	0.076131381
CERA	0.171578486
FORD	0.113871364
CARDANO	0.038913287

In our portfolio, minimum risk is 12.41% corresponding to an expected return of 39.1% for the MVP. It is marked as a yellow point on the efficient frontier.

Efficient Frontier



Weights are determined by solving an optimization problem that minimises the risk for given level of returns between 10% and 130%. The efficient frontier is blue.

Risk	Target Returns	Sharpe Ratio
0.249633	1.3	4.926147585
0.236656184	1.236661695	4.92862969
0.229263	1.2	4.927655138
0.209624	1.1	4.912266725
0.190964	1	4.868608743
0.173523	0.9	4.781665831
0.157788	0.8	4.624743326
0.14429	0.7	4.364328782
0.133707	0.6	3.961864375
0.126771	0.5	3.389805239
0.124095	0.4	2.657069181
0.125952	0.3	1.823940866
0.13215	0.2	0.981679909
0.142122	0.1	0.209179437

Capital Allocation Line

CAL	Risk	Expected Return	
	0	0.070271	(Rf Intercept)
	0.236656	1.236661695	(Tangency Point)
	0.3	1.548859907	

In our portfolio, CAL's slope is 4.92863, and it intercepts the y-axis at the risk-free rate 0.0703 (return for 0 risk). It is marked as orange on the efficient frontier.

Tangency Portfolio

Orange point tangent on the efficient frontier.

Expected Return	1.236662	
Variance	0.056006	
Risk	0.236656	
Risk Free Rate	0.070271	
Sum of weights	1	(Constraint)
Sharpe Ratio	4.92863	(Maximise)

Securities	Weights
MAHLIFE	0.294280171
FEDERALBNK	-0.236989365
AIAENG	0.151936745
INDHOTEL	0.490479556
IRB	0.216314756
ASTRAL	0.07099375
LALPATHLAB	-0.013872432
CERA	-0.059387547
FORD	-0.042135643
CARDANO	0.128380018

In our tangency portfolio, the expected return is 123.67% at a risk of 23.67%. Negative weights for Federal Bank, Cera, Lalpathlabs, Ford indicate that a short position should be taken for these stocks to maximise returns. When compared to the MVP, return for the tangency portfolio is tripled and the risk is doubled, thus it should be used by investors prepared to take risk to maximize efficiency as it offers the best reward-risk ratio.

INTERNATIONAL PORTFOLIO: COMPARISON

Intl. Efficient frontier / MVP vs Index

Risk	Target Returns	Sharpe Ratio
0.249633	1.3	4.926147585
0.236656184	1.236661695	4.92862969
0.229263	1.2	4.927655138
0.209624	1.1	4.912266725
0.190964	1	4.868608743
0.173523	0.9	4.781665831
0.157788	0.8	4.624743326
0.14429	0.7	4.364328782
0.133707	0.6	3.961864375
0.126771	0.5	3.389805239
0.124095	0.4	2.657069181

Mean Daily Returns	0.00103772
Annualised Returns	0.298707942
Daily Variance	3.83522E-05
Annualised Variance	0.009664762
Annualised Risk	0.098309524
Risk Free Rate	0.070271
NIFTY Sharpe Ratio	2.323650181

(a) Expected Returns

The efficient region of the frontier aims for returns ranging from 40% to upwards whereas NIFTY's return is 29.87%. This higher expected return means a more aggressive investment strategy through diversification. Even at the lowest return of 40%, the portfolio performs better than NIFTY, which we will see using Sharpe.

(b) Risk (Volatility)

The standard deviations of the efficient region portfolios ranging from 12.4% to higher whereas NIFTY's is 9.63%. The higher risk indicates that the portfolio is much more volatile compared to NIFTY, but it seeks to compensate for this with higher returns.

(c) Sharpe Ratio

The Sharpe ratio for the efficient portfolios ranges between 2.66 to higher (4.93 at 130% return), which is consistently higher than NIFTY's 2.32 at every target return. This indicates superior risk-adjusted performance of the portfolio compared to the index.

Overall, the portfolio is much better suited for investors seeking much higher returns and willing to accept slightly greater volatility, when compared to the NIFTY 50 index.

Intl. Tangency Portfolio vs Index

Expected Return	1.236662	
Variance	0.056006	
Risk	0.236656	
Risk Free Rate	0.070271	
Sum of weights	1	(Constraint)
Sharpe Ratio	4.92863	(Maximise)

Mean Daily Returns	0.00103772
Annualised Returns	0.298707942
Daily Variance	3.83522E-05
Annualised Variance	0.009664762
Annualised Risk	0.098309524
Risk Free Rate	0.070271
NIFTY Sharpe Ratio	2.323650181

(a) Expected Returns

The tangency portfolio provides a return of 123.67% whereas NIFTY's return is 29.87%. This higher expected return means a more aggressive investment strategy.

(b) Risk (Volatility)

The risk of the tangency portfolio is 23.67% whereas NIFTY's is 9.63%. The higher risk indicates that the portfolio is much more volatile compared to NIFTY.

(c) Sharpe Ratio

The Sharpe ratio for the tangency portfolio is 4.93, which is significantly higher than NIFTY's 2.32. This implies that for every unit of risk taken, the portfolio is delivering far more return than the index.

Intl. vs Domestic Portfolio

Expected Return	1.236662	
Variance	0.056006	
Risk	0.236656	
Risk Free Rate	0.070271	
Sum of weights	1	(Constraint)
Sharpe Ratio	4.92863	(Maximise)

Expected Return	1.225408	
Variance	0.063684	
Risk	0.252356	
Risk Free Rate	0.070271	
Sum of weights	1	(Constraint)
Sharpe Ratio	4.577401	(Maximise)

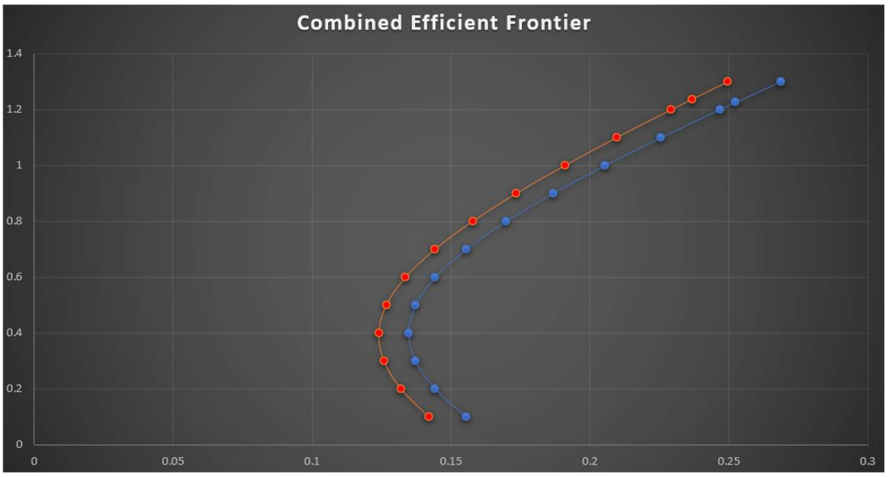
Because of the security-choice and diversification benefits, weights of international portfolio have been further optimised to yield the following comparison:

(a) **Return** for International portfolio is 123.67% which is higher than domestic portfolio's 122.54%.

(b) **Risk** for International portfolio is 23.67% which is lower than domestic portfolio's 25.24%.

(c) **Sharpe Ratio** for International portfolio is 4.93 which is higher than domestic portfolio's 4.58.

(d) **Efficient Frontier** for international portfolio is above and to the left of the domestic frontier, indicating higher returns for lower risks as show below:



CONCLUSION

The **impact of diversification** is significant due to inclusion of automotive and cryptocurrency securities. Reduction of unsystematic risk and stabilization of performance is seen clearly. Thus, carefully choosing global stocks leads to a better portfolio performance and investors should capitalize on such international opportunities.

Note: Apart from diversification, the international portfolio could be better than the domestic due to: (i) Currency fluctuations (ii) Asynchronous business cycles (iii) Lower correlation with domestic market so reduced sensitivity to domestic events.

Both portfolios **outperform the index** benchmark demonstrating the benefits of an active modern strategy over a passive index approach.

In conclusion, this analysis demonstrates the potential benefits of constructing optimized portfolios with both domestic and international assets, including alternative investments like cryptocurrencies. While the results are promising, investors should remain mindful of their high-risk nature and consider their individual risk preferences and investment goals when making decisions.

REFERENCES

1. investing.com (for historic data on prices of all securities)
2. tradingview.com (for graphs of historic prices of all securities)
3. SAPM_Grp34 Excel Sheet attached