FINANCE AND RISK ANALYTICS

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Problem - Statement

Part A

Context

In the realm of modern finance, businesses encounter the perpetual challenge of managing debt obligations effectively to maintain a favorable credit standing and foster sustainable growth. Investors keenly scrutinize companies capable of navigating financial complexities while ensuring stability and profitability. A pivotal instrument in this evaluation process is the balance sheet, which provides a comprehensive overview of a company's assets, liabilities, and shareholder equity, offering insights into its financial health and operational efficiency. In this context, leveraging available financial data, particularly from preceding fiscal periods, becomes imperative for informed decision-making and strategic planning.

Objective

A group of venture capitalists want to develop a Financial Health Assessment Tool. With the help of the tool, it endeavors to empower businesses and investors with a robust mechanism for evaluating the financial well-being and creditworthiness of companies. By harnessing machine learning techniques, they aim to analyze historical financial statements and extract pertinent insights to facilitate informed decision-making via the tool. Specifically, they foresee facilitating the following with the help of the tool:

Debt Management Analysis: Identify patterns and trends in debt management practices to assess the ability of businesses to fulfill financial obligations promptly and efficiently, and identify potential cases of default.

Credit Risk Evaluation: Evaluate credit risk exposure by analyzing liquidity ratios, debt-to-equity ratios, and other key financial indicators to ascertain the likelihood of default and inform investment decisions.

They have hired you as a data scientist and provided you with the financial metrics of different companies. The task is to analyze the data provided and develop a predictive model leveraging machine learning techniques to identify whether a given company will be tagged as a defaulter in terms of net worth next year. The predictive model will help the organization anticipate potential challenges with the financial performance of the companies and enable proactive risk mitigation strategies.

SOLUTION

1. **Define the problem and perform Exploratory Data Analysis**

- **Problem Definition**
- The objective is to develop a predictive model to assess whether a company will be tagged as a defaulter based on its financial metrics. A company is considered a defaulter if its net worth next year is negative. We aim to leverage historical financial data to build this predictive model.

```
Shape of the dataset: (4256, 51)

Missing Values:
Num                                          0
Networth Next Year                           0
Total assets                                 0
Net worth                                    0
Total income                               231
Change in stock                            550
Total expenses                             165
Profit after tax                           154
PBDITA                                     154
PBT                                        154
Cash profit                                154
PBDITA as % of total income                 79
PBT as % of total income                    79
PAT as % of total income                    79
Cash profit as % of total income            79
PAT as % of net worth                        0
Sales                                      305
Income from fincial services              1111
Other income                              1556
Total capital                                5
Reserves and funds                          98
Borrowings                                 431
Current liabilities & provisions           110
Deferred tax liability                    1369
Shareholders funds                           0
Cumulative retained profits                 45
Capital employed                             0
TOL/TNW                                      0
Total term liabilities / tangible net worth  0
Contingent liabilities / Net worth (%)       0
Contingent liabilities                    1402
Net fixed assets                           132
Investments                               1715
Current assets                              80
Net working capital                         37
Quick ratio (times)                        105
Current ratio (times)                      105
Debt to equity ratio (times)                 0
```

- Missing values observed in multiple columns, which will be treated as we will drop the missing values.

```
Data shape after removing missing values: (655, 51)
```

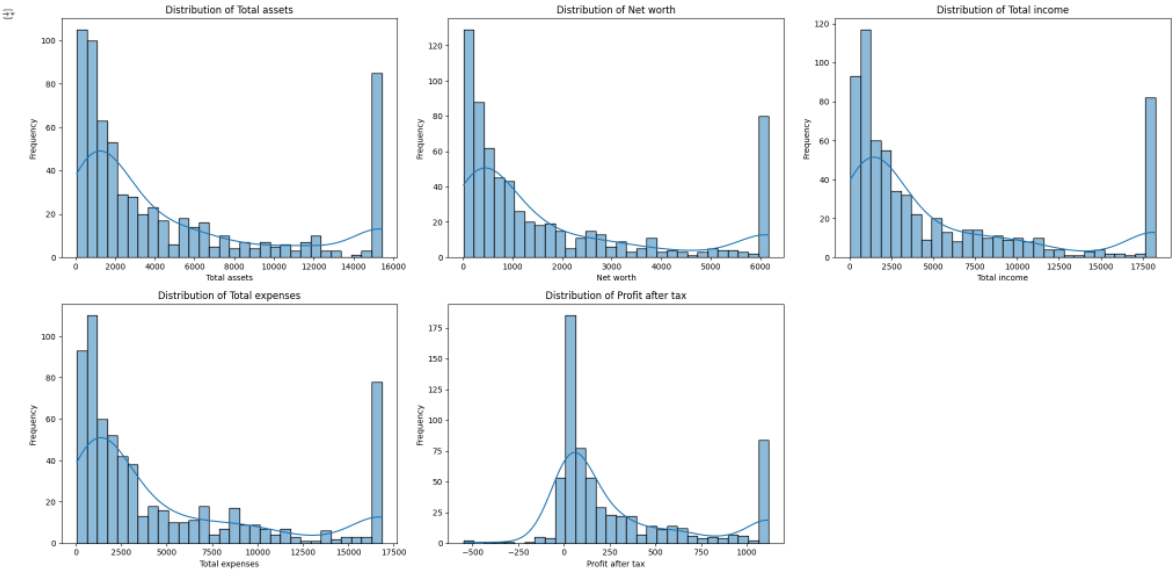
- Statistical Description of the data

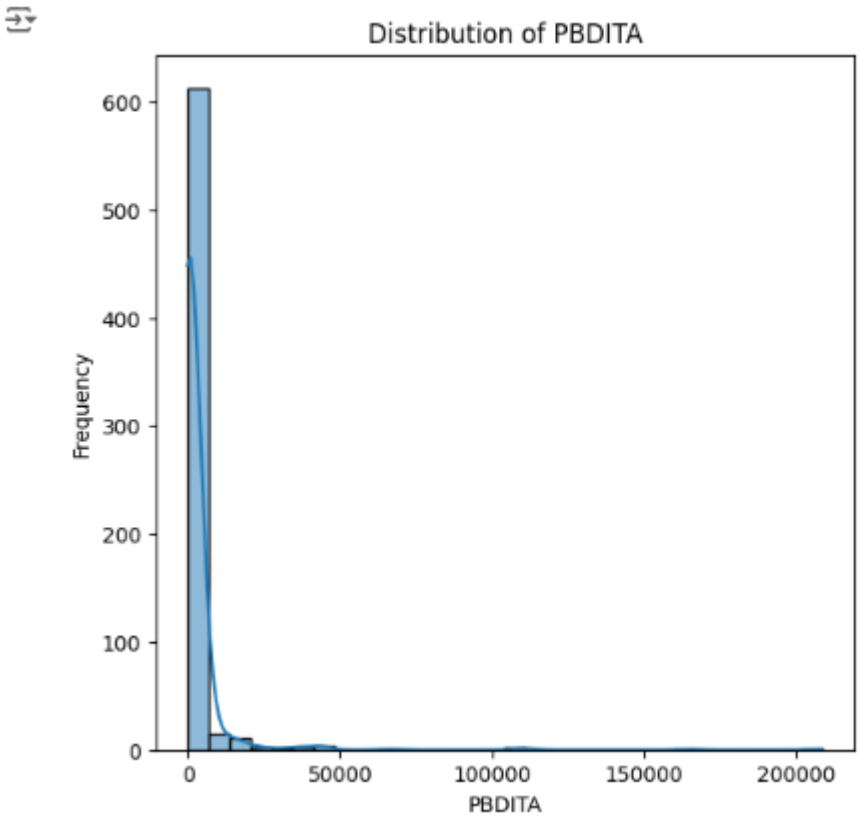
```
[10] Statistical summary of the dataset:
                Num  Networth Next Year  Total assets      Net worth  \
count  4256.000000         4256.000000  4.256000e+03    4256.000000
mean   2128.500000         1344.740883  3.573617e+03    1351.949601
std    1228.745702        15936.743168  3.007444e+04   12961.311651
min       1.000000       -74265.600000  1.000000e-01       0.000000
25%    1064.750000            3.975000  9.130000e+01      31.475000
50%    2128.500000           72.100000  3.155000e+02     104.800000
75%    3192.250000          330.825000  1.120800e+03     389.850000
max    4256.000000       805773.400000  1.176509e+06  613151.600000

       Total income  Change in stock  Total expenses  Profit after tax  \
count  4.025000e+03      3706.000000    4.091000e+03       4102.000000
mean   4.688190e+03        43.702482    4.356301e+03        295.050585
std    5.391895e+04       436.915048    5.139809e+04       3079.902071
min    0.000000e+00     -3029.400000   -1.000000e-01      -3908.300000
25%    1.071000e+02        -1.800000    9.680000e+01          0.500000
50%    4.551000e+02         1.600000    4.268000e+02          9.000000
75%    1.485000e+03        18.400000    1.395700e+03         53.300000
max    2.442828e+06     14185.500000    2.366035e+06     119439.100000

              PBDITA            PBT  ...  Debtors turnover  \
count    4102.000000    4102.000000  ...       3871.000000
mean      605.940639     410.259044  ...         17.929029
std      5646.230633    4217.415307  ...         90.164435
min      -440.700000   -3894.800000  ...          0.000000
25%         6.925000       0.800000  ...          3.810000
50%        36.900000      12.600000  ...          6.470000
75%       158.700000      74.175000  ...         11.850000
max    208576.500000  145292.600000  ...       3135.200000

       Finished goods turnover  WIP turnover  Raw material turnover  \
count              3382.000000   3492.000000            3828.000000
mean                 84.369988     28.684513              17.733926
std                 562.637359    169.650915             343.125864
min                  -0.090000     -0.180000              -2.000000
25%                   8.190000      5.100000               3.020000
50%                  17.320000      9.860000               6.410000
75%                  40.012500     20.240000              11.822500
max               17947.600000   5651.400000           21092.000000

       Shares outstanding  Equity face value            EPS   Adjusted EPS  \
count        3.446000e+03        3446.000000    4256.000000    4256.000000
```

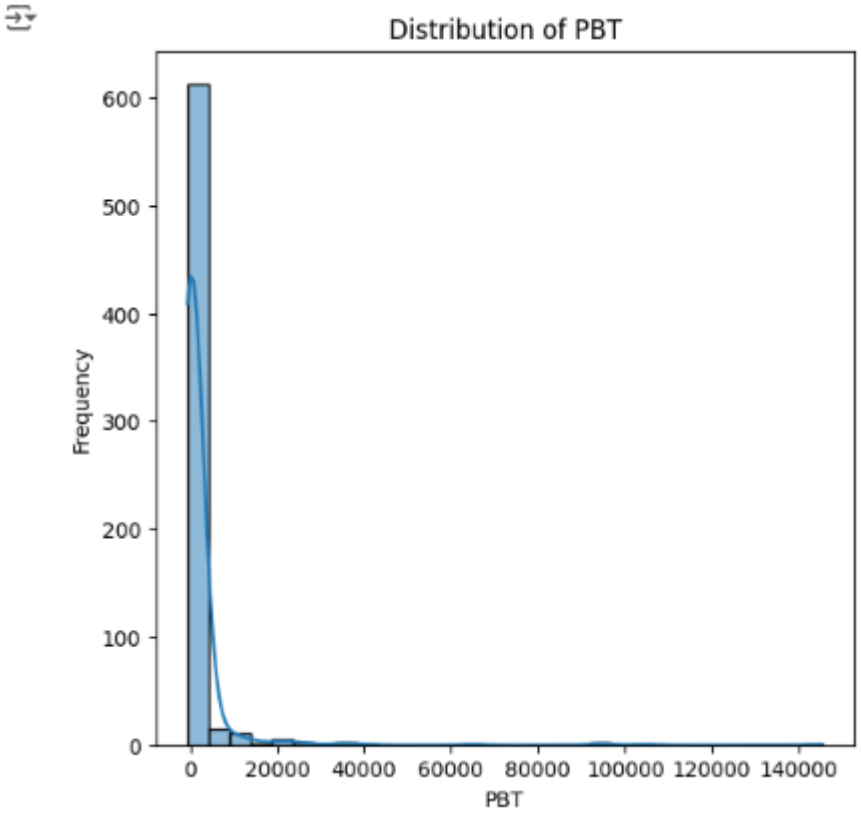
- Datatypes

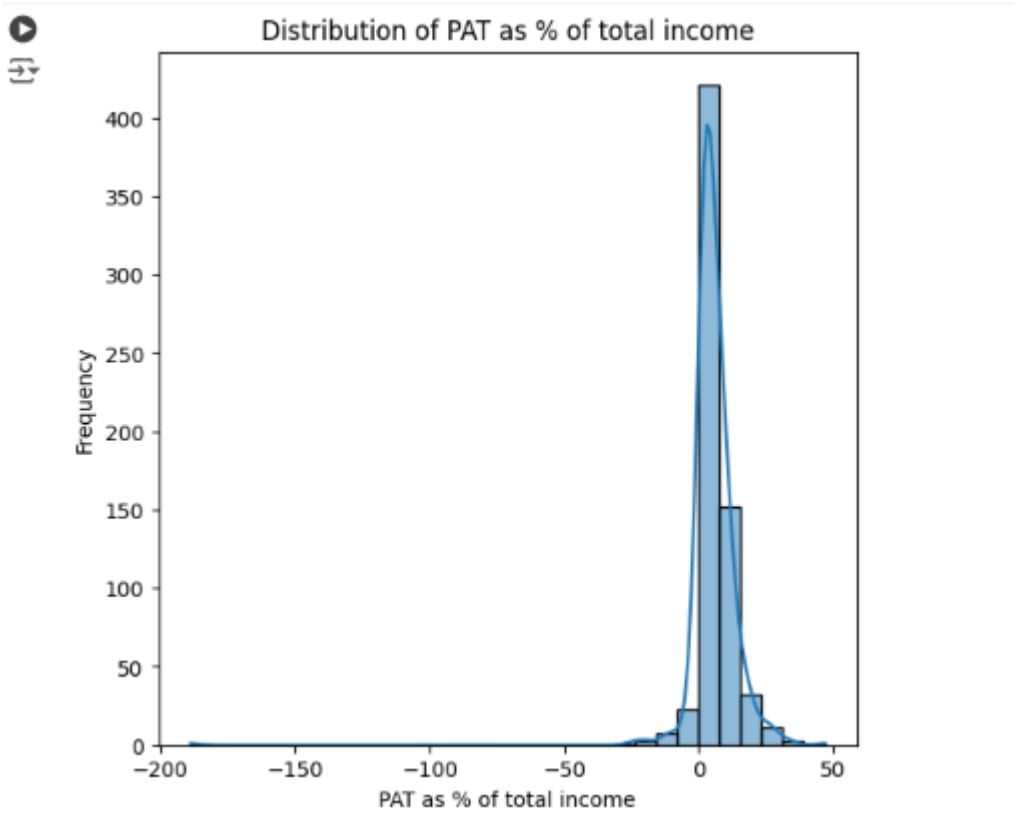
```
[10] Data types of each column:
Num                                        int64
Networth Next Year                       float64
Total assets                             float64
Net worth                                float64
Total income                             float64
Change in stock                          float64
Total expenses                           float64
Profit after tax                         float64
PBDITA                                   float64
PBT                                      float64
Cash profit                              float64
PBDITA as % of total income              float64
PBT as % of total income                 float64
PAT as % of total income                 float64
Cash profit as % of total income         float64
PAT as % of net worth                    float64
Sales                                    float64
Income from fincial services             float64
Other income                             float64
Total capital                            float64
Reserves and funds                       float64
Borrowings                               float64
Current liabilities & provisions         float64
Deferred tax liability                   float64
Shareholders funds                       float64
Cumulative retained profits              float64
Capital employed                         float64
TOL/TNW                                  float64
Total term liabilities / tangible net worth float64
Contingent liabilities / Net worth (%)   float64
Contingent liabilities                   float64
Net fixed assets                         float64
Investments                              float64
Current assets                           float64
Net working capital                      float64
Quick ratio (times)                      float64
Current ratio (times)                    float64
Debt to equity ratio (times)             float64
Cash to current liabilities (times)      float64
Cash to average cost of sales per day    float64
Creditors turnover                       float64
Debtors turnover                         float64
Finished goods turnover                  float64
```

- Univariate Analysis

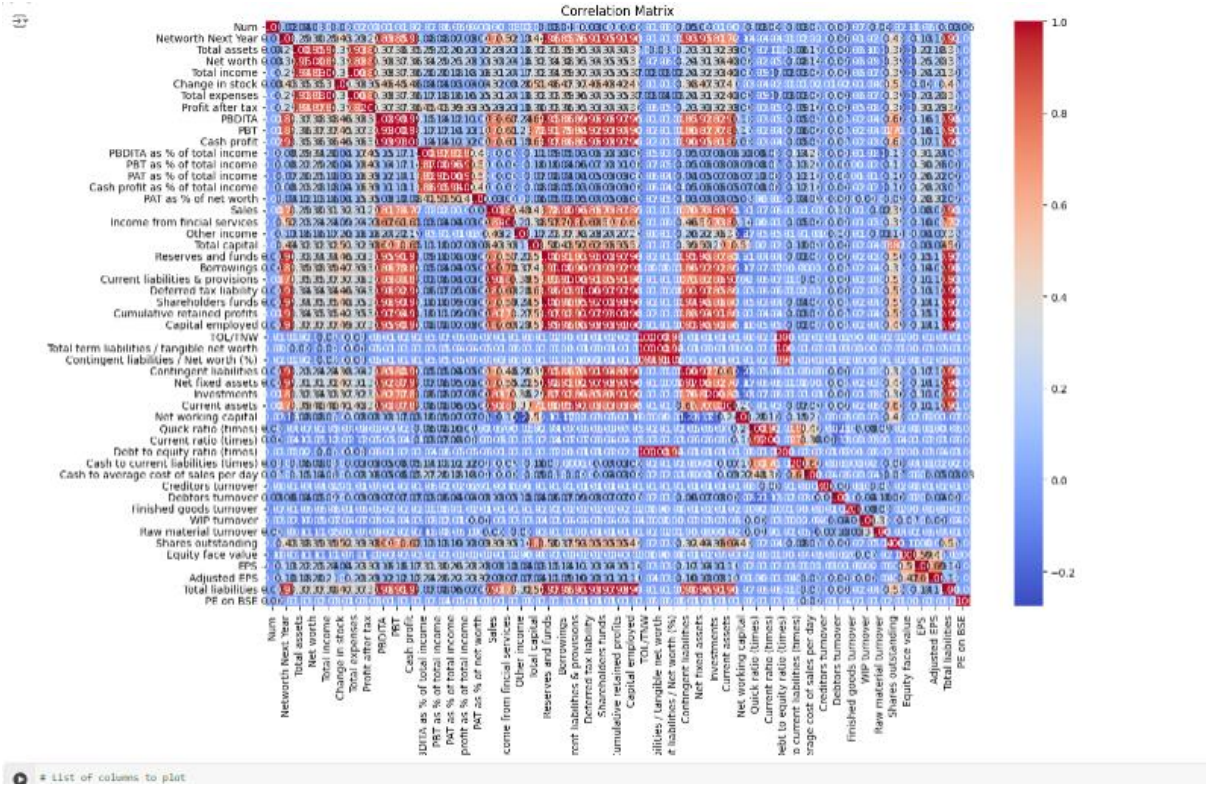


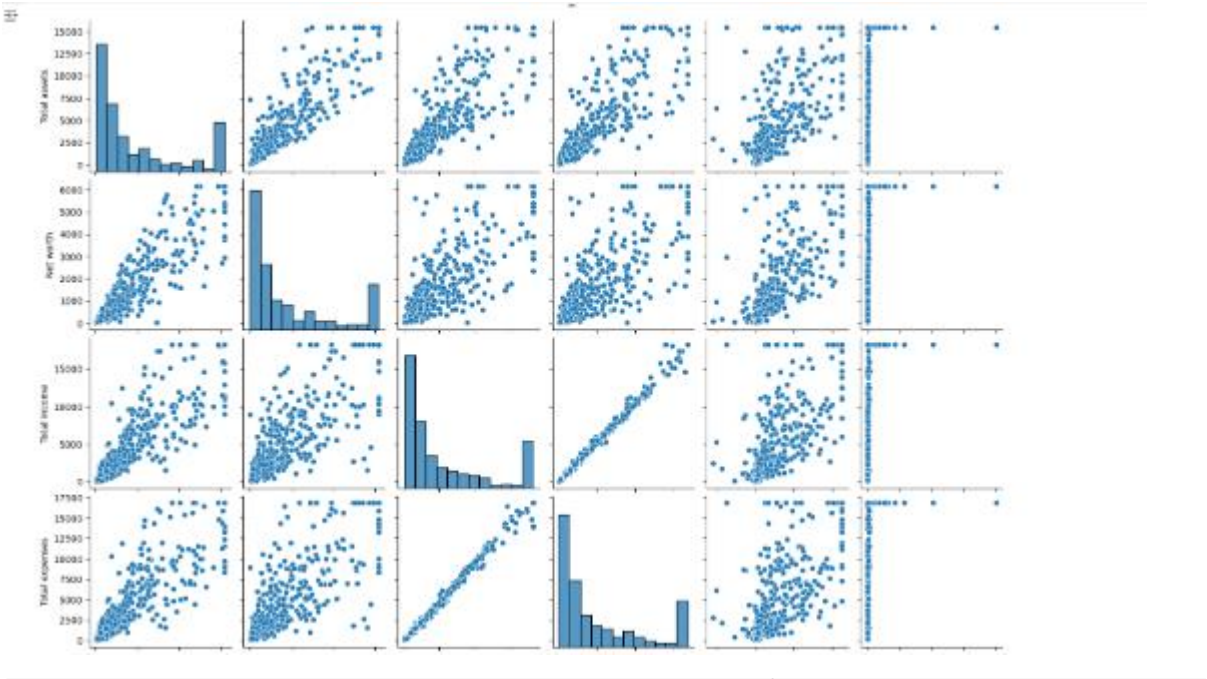

Distribution of PBDITA
Frequency
PBDITA
0
100
200
300
400
500
600
0
50000
100000
150000
200000

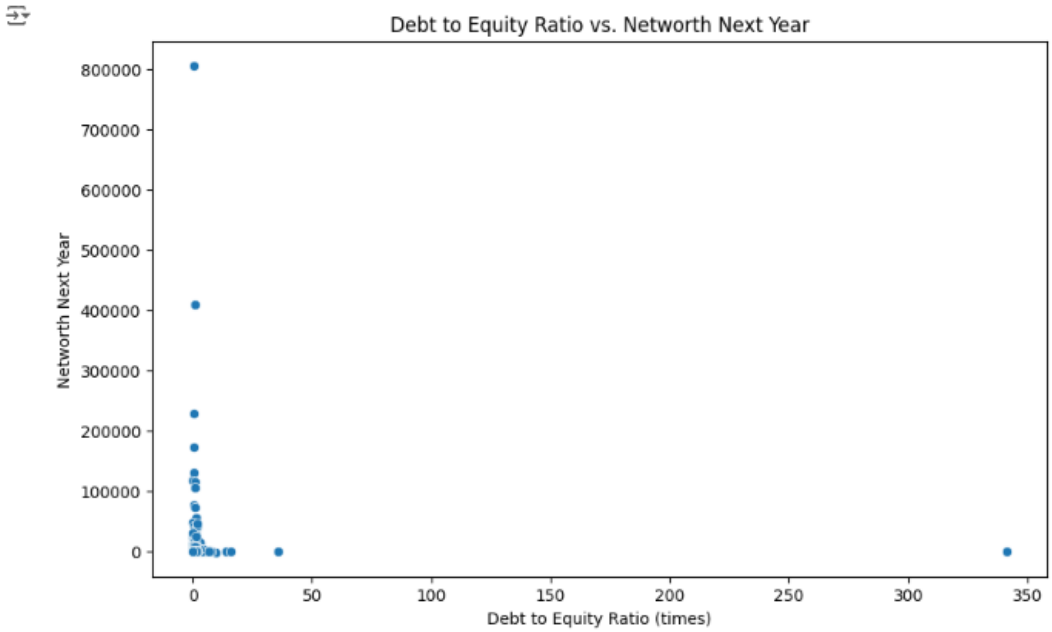

Distribution of PBT
Frequency
PBT
0
100
200
300
400
500
600
0
20000
40000
60000
80000
100000
120000
140000



- Multivariate Analysis







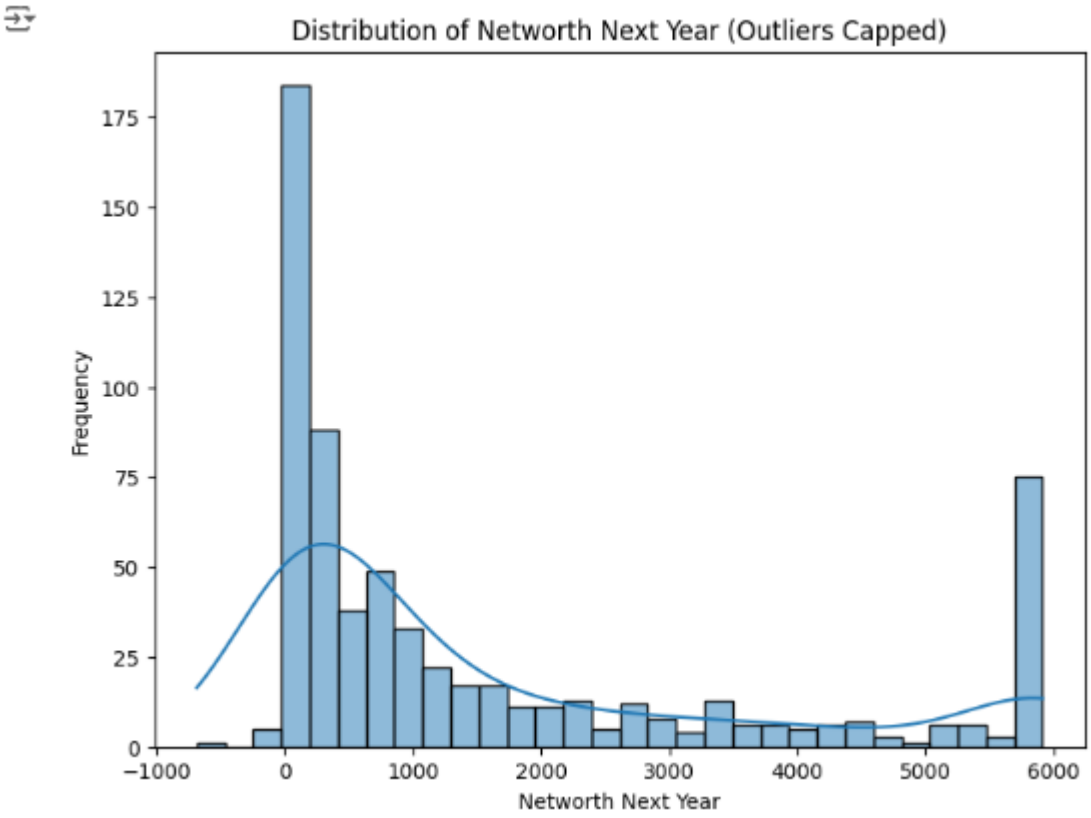
- Key Observations

  - **Networth Next Year**: This variable is the target, and its distribution helps us understand the proportion of companies likely to default (negative net worth) versus those that are not (positive net worth). As per the graph a significant portion of the data is above zero, which indicates there is no considerable risk of default among most of the companies.

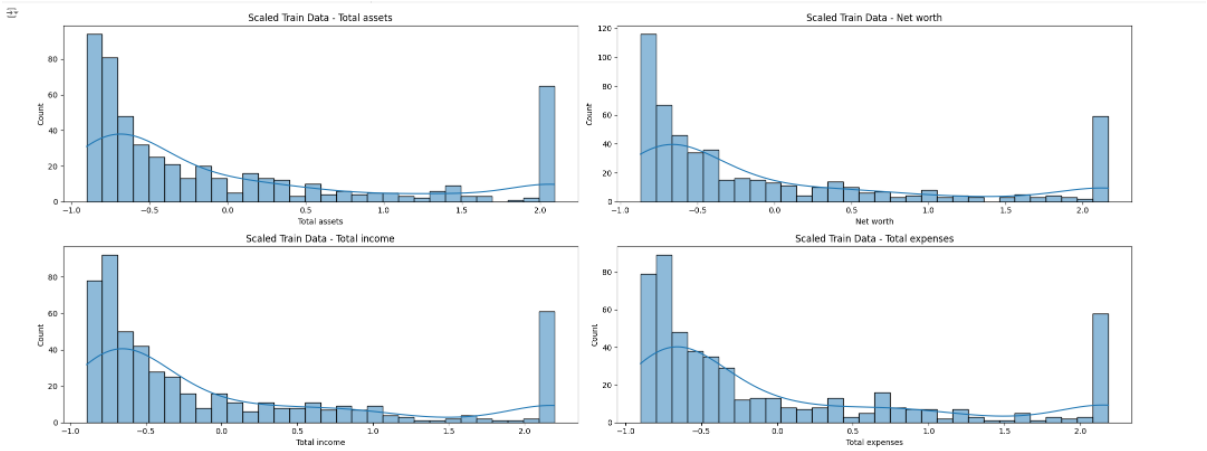
- **Total Assets, Total Income, Total Expenses:** Companies with higher total assets and income are generally more financially stable. Higher expenses without proportional income can indicate potential financial trouble.
- **Profitability Metrics (PBDITA, PBT, PAT):** There is inconsistency observed in the graphs of these metrics, certain companies facing loss after tax payments, majority of the companies are having profits post tax payments. Inconsistently high profitability metrics correlate with weaker financial health and higher default risk.
- **Networth vs. Total Assets:** A negative correlation is observed, which indicates that higher assets contribute to lower net-worth and financial stability.
- **Debt Ratios (e.g., Debt to Equity Ratio) vs. Networth Next Year:** High debt ratios negatively correlate with net worth next year, indicating higher risk of default.

2. **Data Pre-processing**

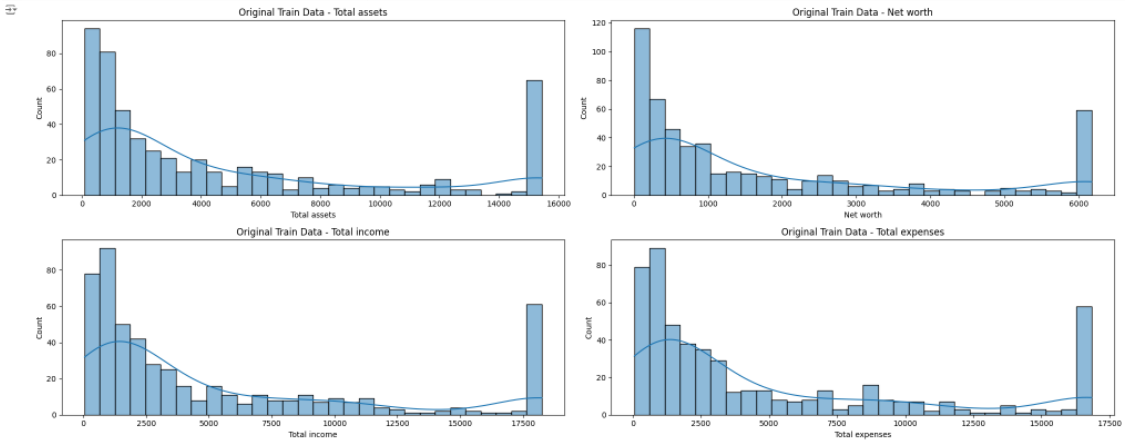
- Outliers Detected and Capped



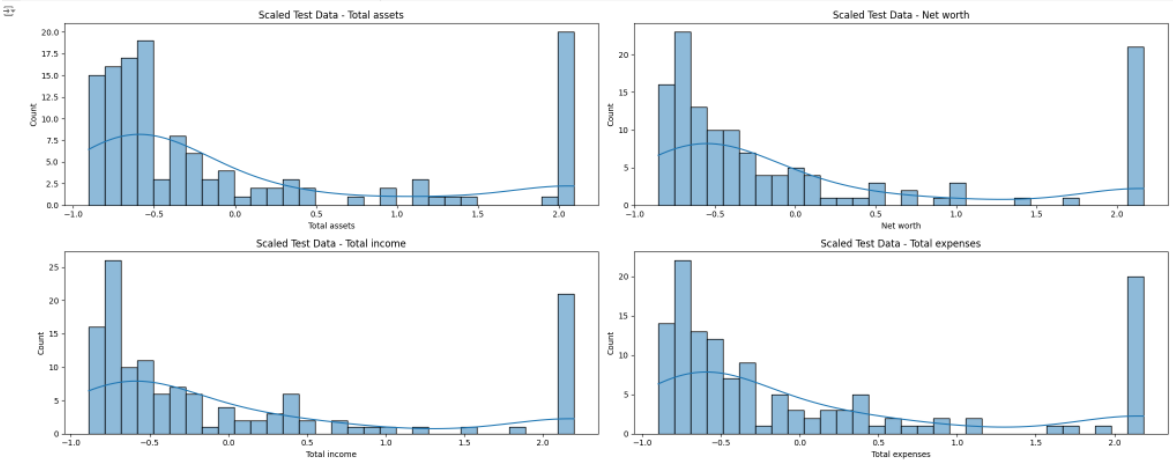
- Scaled Trained data



- Original Trained data



- Scaled Test data



3. **Model Building**

- Logistic Regression Scores

```
Logistic Regression Model Performance:
Accuracy: 0.9924
Precision: 0.0000
Recall: 0.0000
F1 Score: 0.0000
ROC AUC Score: 0.9692

Classification Report:
              precision    recall  f1-score   support

         0.0       0.99      1.00      1.00       130
         1.0       0.00      0.00      0.00         1

    accuracy                           0.99       131
   macro avg       0.50      0.50      0.50       131
weighted avg       0.98      0.99      0.99       131
```

- Random Forest Scores

```
Random Forest Model Performance:
Accuracy: 0.9847
Precision: 0.0000
Recall: 0.0000
F1 Score: 0.0000
ROC AUC Score: 0.9308

Classification Report:
              precision    recall  f1-score   support

         0.0       0.99      0.99      0.99       130
         1.0       0.00      0.00      0.00         1

    accuracy                           0.98       131
   macro avg       0.50      0.50      0.50       131
weighted avg       0.98      0.98      0.98       131
```

- Key Observations
  - Accuracy of Random Forest is more than Logistic regression due to its ability to capture complex patterns.
  - Precision and F1 Score is better in Logistic regression than random forest. This will help in predicting the class (0/1) for default column.
  - Same has been stated for the ROC AUC Score. Logistic regression model's ability to distinguish between defaulters and non-defaulters is slightly higher than random forest model.
  - Random Forest tends to perform better for this problem due to its robustness and ability to handle various types of data.
  - Logistic Regression might be simpler and faster but could underperform if the relationship between features and target is non-linear.

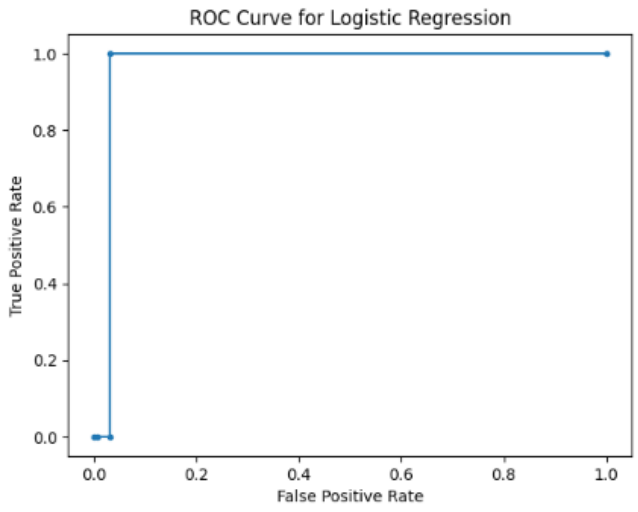
4. **Model Performance Improvement**

- VIF - severity of multicollinearity

[16]

	Feature	VIF
1	Total assets	2.078553e+01
2	Net worth	1.585879e+01
3	Total income	4.980345e+02
5	Total expenses	4.602950e+02
7	PBDITA	3.663332e+03
8	PBT	3.415372e+03
9	Cash profit	2.856496e+03
11	PBT as % of total income	2.461374e+01
12	PAT as % of total income	1.656312e+01
13	Cash profit as % of total income	1.884367e+01
15	Sales	1.207605e+02
16	Income from fincial services	4.220156e+01
17	Other income	1.182599e+01
18	Total capital	8.789767e+03
19	Reserves and funds	1.201355e+06
20	Borrowings	inf
21	Current liabilities & provisions	4.602092e+05
22	Deferred tax liability	2.156837e+04
23	Shareholders funds	inf
24	Cumulative retained profits	6.915702e+02
25	Capital employed	inf
26	TOL/TNW	7.102860e+02
27	Total term liabilities / tangible net worth	6.573323e+02
28	Contingent liabilities / Net worth (%)	1.462598e+01
29	Contingent liabilities	1.432834e+02
30	Net fixed assets	8.059308e+02
31	Investments	1.270530e+02
32	Current assets	1.250299e+03
33	Net working capital	5.405954e+01
34	Quick ratio (times)	1.079675e+01
36	Debt to equity ratio (times)	9.444208e+02
44	Shares outstanding	1.031128e+01
48	Total liabilities	6.240476e+06

- Optimal Thresholds and ROC curve




```
Optimal Threshold: 0.037956185695288046
```

```
Logistic Regression Model Performance with Optimal Threshold:
Accuracy: 0.9695
Precision: 0.2000
Recall: 1.0000
F1 Score: 0.3333
ROC AUC Score: 0.9692

Classification Report:
              precision    recall  f1-score   support

         0.0       1.00      0.97      0.98       130
         1.0       0.20      1.00      0.33         1

    accuracy                           0.97       131
   macro avg       0.60      0.98      0.66       131
weighted avg       0.99      0.97      0.98       131
```

- Hyperparameter Tuning

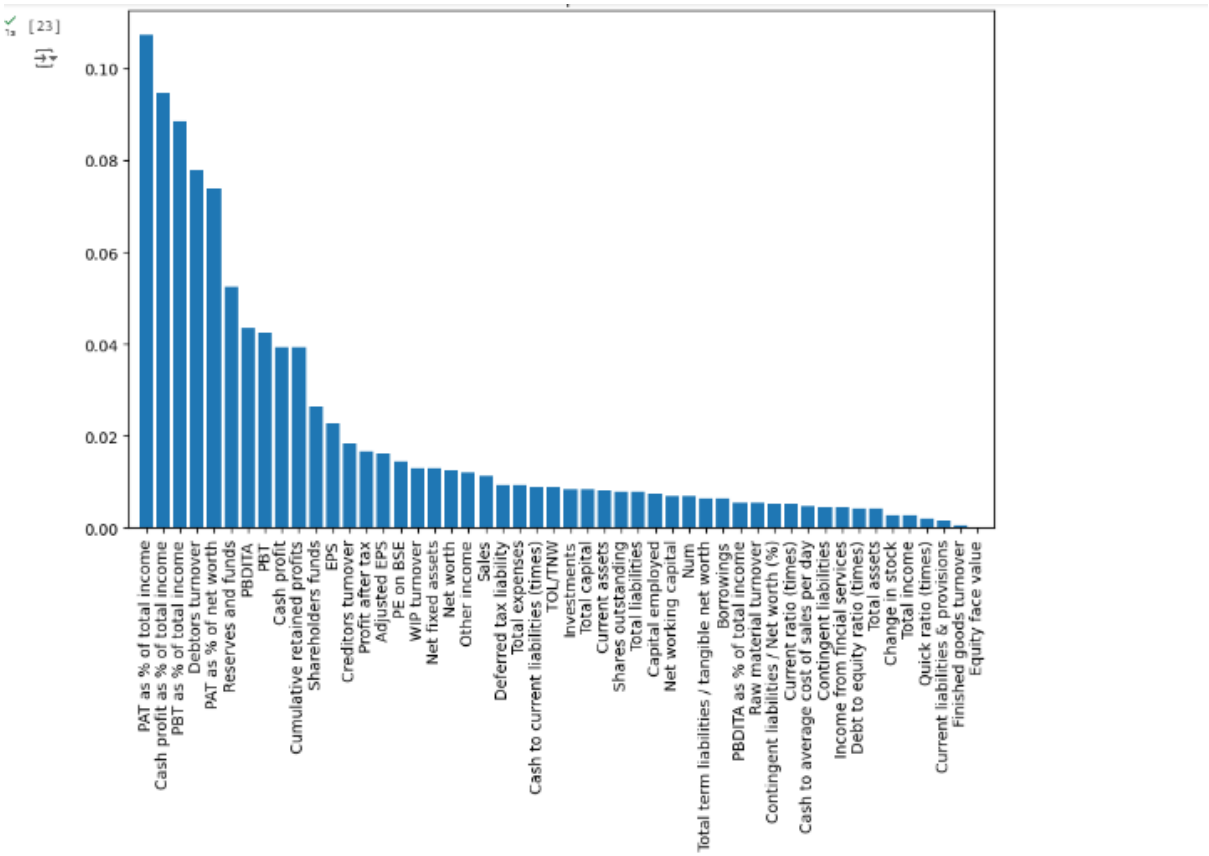
```
Best parameters for Random Forest: {'bootstrap': True, 'max_depth': 20, 'min_samples_leaf': 3, 'min_samples_split': 4, 'n_estimators': 187}
```

```
Best Random Forest Model Performance:
Accuracy: 0.9924
Precision: 0.0000
Recall: 0.0000
F1 Score: 0.0000
ROC AUC Score: 0.9231

Classification Report:
              precision    recall  f1-score   support

         0.0       0.99      1.00      1.00       130
         1.0       0.00      0.00      0.00         1

    accuracy                           0.99       131
   macro avg       0.50      0.50      0.50       131
weighted avg       0.98      0.99      0.99       131
```

- Post Hyperparameter Tuning for Random Forest Model, the model looks better than Logistic Regression model in the following aspects – Accuracy, Precision, f1-score.

5. **Model Performance Comparison and Final Model Selection**

- Feature Importance



- Profitability Metrics (PAT, PBDITA, PBT): Highly important, significant features indicating that profitability is crucial for predicting net worth.
- Debt Metrics: Important in understanding the financial leverage and risk profile of companies.
- Cash Profit metrics: Important in understanding the liquid profit the company holds with them to predict the net worth next year.

6. **Actionable Insights & Recommendations**

Recommendations for Investors

- **Assess Financial Health:**
  - Evaluate a company's total assets, net worth, and liquidity position before making investment decisions.
  - Use profitability metrics (PAT, PBDITA, PBT, Cash Profit) to assess the company's ability to generate consistent profits.
- **Monitor Debt Levels:**
  - Pay close attention to a company's total liabilities, borrowings, and current liabilities.

- Invest in companies with manageable debt levels and a solid plan for debt repayment.

- **Focus on Operational Efficiency:**
- Invest in companies that demonstrate strong operational efficiency and the ability to control expenses while growing income.
- Look for companies with a history of stable or growing profit margins.

- **Diversify Investments:**
- Diversify your investment portfolio to spread risk and reduce exposure to any single company or sector.
- Consider investing in industries or companies with strong financial metrics and lower risk of default.

Recommendations for Businesses

- **Enhance Asset Base:**

- Invest in assets that can generate long-term value and improve the company's overall financial strength.
- Regularly assess the value of fixed and current assets to ensure they are being utilized efficiently.

- **Improve Operational Efficiency:**

- Focus on increasing total income through diversification of revenue streams and improving sales.
- Implement cost-control measures to manage and reduce unnecessary expenses.

- **Increase Profitability:**

- Enhance profitability by optimizing operational processes, reducing costs, and increasing productivity.
- Regularly review pricing strategies and market positioning to ensure competitive advantage.

- **Manage Debt Levels:**

  - Maintain an optimal debt-to-equity ratio to balance growth and financial stability.
  - Avoid excessive borrowing and ensure that debt levels are sustainable relative to the company's income and asset base.

- **Strengthen Liquidity:**

  - Ensure that the company maintains sufficient current assets to meet short-term liabilities.
  - Regularly monitor cash flow and liquidity ratios to ensure financial flexibility.

Conclusion

By focusing on enhancing asset base, improving operational efficiency, increasing profitability, managing debt levels, and strengthening liquidity, companies can significantly reduce their risk of default and maintain a healthy financial standing. Investors should use these insights to make informed decisions and select companies with strong financial health and sustainable growth prospects.

Problem - Statement

Part B

Context

Investors face market risk, arising from asset price fluctuations due to economic events, geopolitical developments, and investor sentiment changes. Understanding and analyzing this risk is crucial for informed decision-making and optimizing investment strategies.

Objective

The objective of this analysis is to conduct Market Risk Analysis on a portfolio of Indian stocks using Python. It uses historical stock price data to understand market volatility and riskiness. Using statistical measures like mean and standard deviation, investors gain a deeper understanding of individual stocks' performance and portfolio variability.

Through this analysis, investors can aim to achieve the following objectives:

- Risk Assessment: Analyze the historical volatility of individual stocks and the overall portfolio.
- Portfolio Optimization: Use Market Risk Analysis insights to enhance risk-adjusted returns.
- Performance Evaluation: Assess portfolio management strategies' effectiveness in mitigating market risk.
- Portfolio Performance Monitoring: Monitor portfolio performance over time and adjust as market conditions and risk preferences change.

SOLUTION

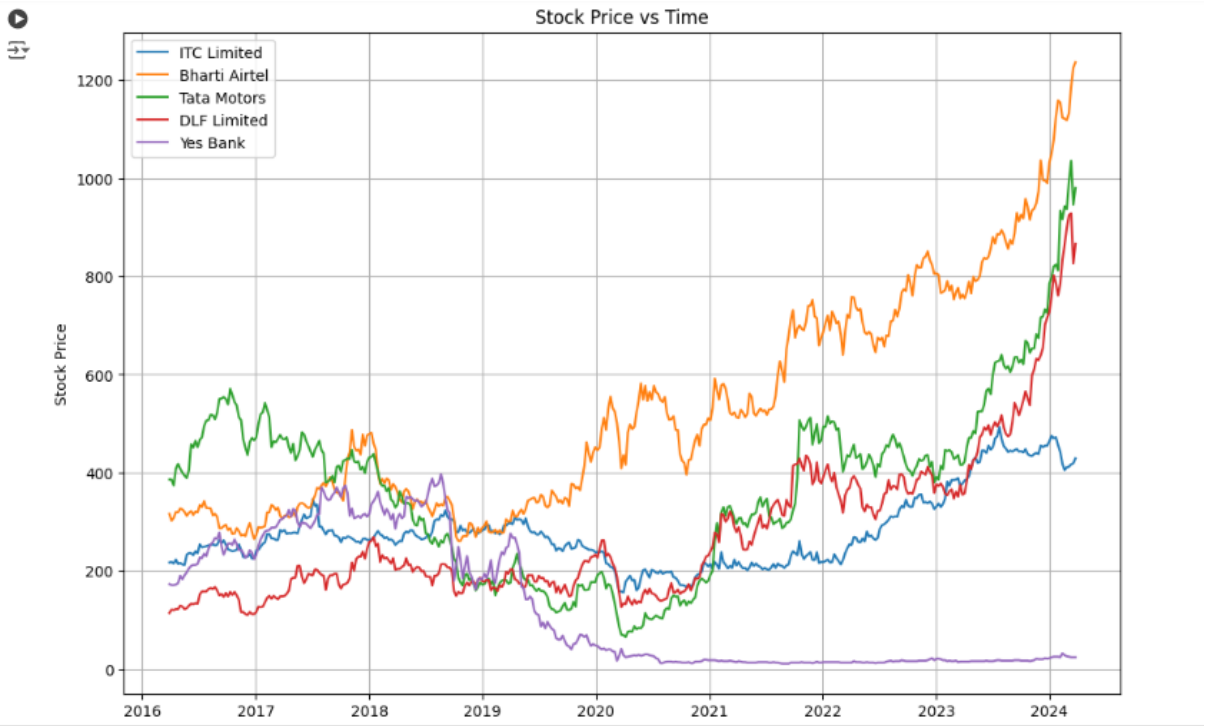
1. **Stock Price Graph Analysis:**

- No missing values observed

Date	ITC Limited	Bharti Airtel	Tata Motors	DLF Limited	Yes Bank
2016-03-28	217	316	386	114	173
2016-04-04	218	302	386	121	171
2016-04-11	215	308	374	120	171
2016-04-18	223	320	408	122	172
2016-04-25	214	319	418	122	175

```
ITC Limited      0
Bharti Airtel    0
Tata Motors      0
DLF Limited      0
Yes Bank         0
dtype: int64
```

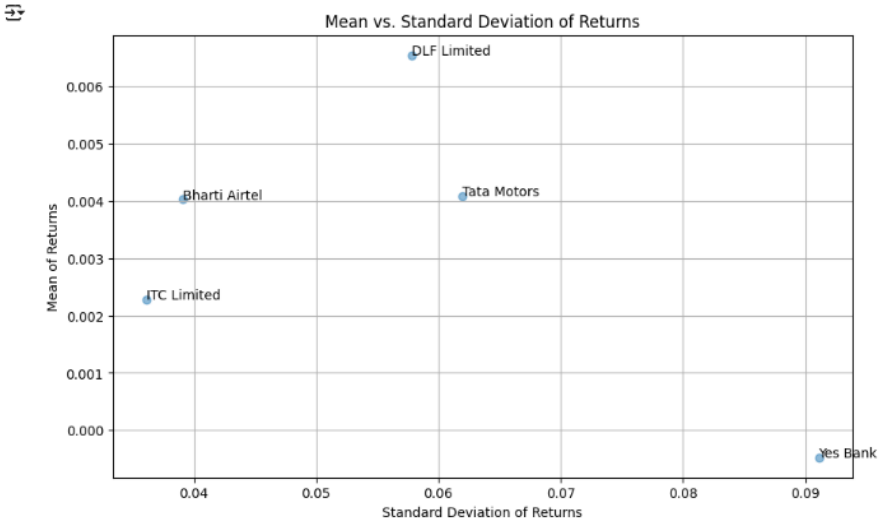
- Stock Price V/S Time Graph Analysis



- Bharti Airtel has shown a significant upward trend in its stock price over the observed period.
- Key periods of price increase were noticed post 2022,it broke the upper circuit quite a few times, possibly due to launch of 5G network by Indian Government.
- The price hikes indicate strong investor confidence and positive market sentiment toward Bharti Airtel.

- Tata Motors exhibited a noticeable increase in stock price, particularly post 2020.
- Major factors contributing to this hike could include introduction of first EV vehicle – Tigor EV in October 2019.
- The stock's upward movement suggests a positive outlook on the company's future growth and profitability.
- DLF Limited has experienced significant price appreciation, especially in post 2020.
- This increase might be attributed to the company making huge profit at Q3 net profit went up to 24% at 414cr in FY19-20. The company kept on growing post 2020.
- The trend reflects investor optimism regarding the company's prospects in the real estate sector.
- ITC's stock price has remained relatively stable throughout the observed period.
- The static growth suggests that while the company has maintained a steady performance, there have been no major events or changes to significantly alter investor perception.
- This stability might appeal to conservative investors looking for consistent returns without much volatility.
- Yes Bank's stock price experienced a significant decline post 2019.
- Over the last four years, the stock price has remained relatively static, indicating a loss of investor confidence and a struggle to regain market trust.
- The static period post-decline suggests the company might be stabilizing but hasn't shown signs of recovery.

2. **Stock Returns Calculation and Analysis**



- **Risk Meter**: Yes Bank > Tata Motors > DLF Limited > Bharti Airtel > ITC Limited
- **Return Meter**: DLF Limited > Tata Motors > Bharti Airtel > ITC Limited > Yes Bank
- **Observations and Inferences:**
  - **Risk-Return Tradeoff:** The plot illustrates the relationship between the mean and standard deviation of returns for each stock. Generally, we expect higher returns to be associated with higher levels of risk (standard deviation).
  - **Riskier Stocks:** Stocks positioned towards the upper right of the plot tend to have higher returns but also higher volatility. These stocks may offer greater potential for profit but come with increased risk.
  - **Safer Investments:** Stocks located towards the lower left of the plot have lower returns but also lower volatility. These stocks are considered safer investments as they exhibit more stable price movements, albeit with lower profit potential.
  - **Diversification:** Investors can use this plot to assess the diversification benefits of combining stocks with different risk-return profiles. By selecting stocks that offer complementary risk-return characteristics, investors can build a diversified portfolio that balances risk and return.
  - **Individual Stock Analysis:** Analyzing the position of each stock on the plot can provide insights into its risk-return profile. Stocks positioned far from the mean may warrant further investigation to understand the factors driving their performance and risk.
  - **Portfolio Construction:** Based on their risk tolerance and return objectives, investors can use this plot to select stocks for their portfolio. By considering the tradeoff between risk and return, investors can construct portfolios that align with their investment goals and risk preferences.

3. **Actionable Insights & Recommendations**

- **Diversification Strategy:** Would like to encourage investors to diversify their portfolios by selecting stocks with different risk-return profiles. By combining both high-risk, high-return stocks and low-risk, stable stocks, investors can achieve a balanced portfolio that mitigates overall risk while still potentially capturing attractive returns.
- **Risk Management:** Emphasize the importance of understanding and managing risk in investment decisions. Investors should carefully consider the risk associated with each stock in their portfolio and ensure that their overall portfolio risk aligns with their risk tolerance and investment objectives.
- **Portfolio Optimization:** Recommend investors to use modern portfolio theory principles to optimize their portfolios. By considering the covariance between stocks and the desired level of risk, investors can construct efficient portfolios that offer the

highest possible return for a given level of risk or the lowest possible risk for a given level of return.

- **Stress Testing:** Suggest conducting stress tests on the portfolio to evaluate its resilience to adverse market conditions. By simulating various scenarios, such as market downturns or economic recessions, investors can assess the portfolio's performance under different risk scenarios and make necessary adjustments to improve its robustness.
- **Active Monitoring and Rebalancing:** Would like to encourage investors to regularly monitor their portfolios and rebalance them as needed. Market conditions and individual stock performance can change over time, affecting the risk-return characteristics of the portfolio. By actively monitoring and rebalancing their portfolios, investors can ensure that their investments remain aligned with their goals and risk preferences.
- **Education and Consultation:** Provide educational resources and consultation services to help investors make informed decisions about their portfolios. Educating investors about risk management techniques, portfolio construction strategies, and the importance of diversification can empower them to make better investment choices and achieve their financial goals effectively.

By implementing these insights and recommendations, investors can optimize their portfolios for risk-adjusted returns, minimize potential losses during market downturns, and achieve long-term investment success.