

FINANCE AND RISK ANALYTICS PROJECT

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Case 1: Credit Risk Analysis

Businesses or companies can fall prey to default if they are not able to keep up their debt obligations. Defaults will lead to a lower credit rating for the company which in turn reduces its chances of getting credit in the future and may have to pay higher interest on existing debts as well as any new obligations. From an investor's point of view, he would want to invest in a company if it is capable of handling its financial obligations, can grow quickly, and is able to manage the growth scale.

A balance sheet is a financial statement of a company that provides a snapshot of what a company owns, owes, and the amount invested by the shareholders. Thus, it is an important tool that helps evaluate the performance of a business.

Data that is available includes information from the financial statement of the companies for the previous year.

Dependent variable - No need to create any new variable, as the 'Default' variable is already provided in the dataset, which can be considered as the dependent variable.

Test Train Split - Split the data into train and test datasets in the ratio of 67:33 and use a random state of 42 (*random_state=42*). Model building is to be done on the train dataset and model validation is to be done on the test dataset.

1. Outlier Treatment.

Out[8]:	#	count #	mean #	std #	min #	25% #	50% #	75% #	max #
Co_Code	2058.0	1.757211e+04	2.189289e+04	4.0000	3.674000e+03	6.240000e+03	2.428075e+04	7.249300e+04	
Operating_Expense_Rate	2058.0	2.052389e+09	3.252624e+09	0.0001	2.000000e-04	3.000000e-04	4.110000e+09	9.980000e+09	
Research_and_development_expense_rate	2058.0	1.209834e+09	2.144568e+09	0.0000	0.000000e+00	2.000000e-04	1.550000e+09	9.980000e+09	
Cash_flow_rate	2058.0	4.652000e-01	2.270000e-02	0.0000	4.801000e-01	4.634000e-01	4.681000e-01	1.000000e+00	
Interest_bearing_debt_Interest_rate	2058.0	1.113022e+07	9.042595e+07	0.0000	3.000000e-04	5.000000e-04	7.000000e-04	9.900000e+08	
Tax_rate_A	2058.0	1.148000e-01	1.524000e-01	0.0000	0.000000e+00	3.710000e-02	2.162000e-01	9.997000e-01	
Cash_Flow_Per_Share	1891.0	3.200000e-01	1.530000e-02	0.1694	3.150000e-01	3.208000e-01	3.259000e-01	4.622000e-01	
Per_Share_Net_profit_before_tax_Yuan_	2058.0	1.770000e-01	3.020000e-02	0.0000	1.668000e-01	1.758000e-01	1.859000e-01	7.923000e-01	
Realized_Sales_Gross_Profit_Growth_Rate	2058.0	2.280000e-02	2.170000e-02	0.0043	2.210000e-02	2.210000e-02	2.220000e-02	1.000000e+00	
Operating_Profit_Growth_Rate	2058.0	8.481000e-01	4.600000e-03	0.7364	8.480000e-01	8.480000e-01	8.481000e-01	1.000000e+00	
Continuous_Net_Profit_Growth_Rate	2058.0	2.174000e-01	5.700000e-03	0.0000	2.178000e-01	2.178000e-01	2.176000e-01	2.332000e-01	
Total_Asset_Growth_Rate	2058.0	5.287863e+09	9.212615e+09	0.0000	4.315000e+09	6.225000e+09	7.220000e+09	9.980000e+09	
Net_Value_Growth_Rate	2058.0	5.189504e+06	2.077918e+06	0.0000	4.000000e-04	5.000000e-04	5.000000e-04	9.330000e+09	
Total_Asset_Return_Growth_Rate_Ratio	2058.0	2.641000e-01	2.400000e-03	0.2516	2.637000e-01	2.640000e-01	2.643000e-01	3.589000e-01	
Cash_Reinvestment_perc	2058.0	3.772000e-01	2.740000e-02	0.0258	3.707000e-01	3.790000e-01	3.856000e-01	1.000000e+00	
Current_Ratio	2058.0	1.336249e+06	6.081917e+07	0.0000	6.600000e-03	8.900000e-03	1.350000e-02	2.750000e+09	
Quick_Ratio	2058.0	2.775510e+07	4.448654e+08	0.0000	2.900000e-03	5.300000e-03	8.900000e-03	9.230000e+09	
Interest_Expense_Ratio	2058.0	6.313000e-01	6.800000e-03	0.5251	6.308000e-01	6.308000e-01	6.317000e-01	8.122000e-01	
Total_debt_to_Total_net_worth	2037.0	1.071429e+07	2.696960e+08	0.0000	3.900000e-03	7.300000e-03	1.310000e-02	9.940000e+09	
Long_term_fund_equitability_ratio_A	2058.0	9.000000e-03	3.490000e-02	0.0041	5.200000e-03	5.500000e-03	6.400000e-03	1.000000e+00	
Net_profit_before_tax_to_Paid_In_capital	2058.0	1.754000e-01	2.620000e-02	0.0000	1.659000e-01	1.746000e-01	1.844000e-01	7.921000e-01	
Total_Asset_Turnover	2058.0	1.286000e-01	1.036000e-01	0.0000	6.150000e-02	1.034000e-01	1.679000e-01	9.190000e-01	
Accounts_Receivable_Turnover	2058.0	4.159864e+07	5.047673e+08	0.0000	7.000000e-04	1.100000e-03	1.900000e-03	9.740000e+09	
Average_Collection_Days	2058.0	2.629786e+07	4.109967e+08	0.0000	3.600000e-03	6.000000e-03	8.600000e-03	8.800000e+09	
Inventory_Turnover_Rate_timea	2058.0	2.030227e+09	3.077250e+09	0.0000	2.000000e-04	1.910000e+07	3.815000e+09	9.990000e+09	
Fixed_Assets_Turnover_Frequency	2058.0	1.230886e+09	2.649289e+09	0.0000	2.000000e-04	6.000000e-04	8.400000e-03	9.990000e+09	
Net_Worth_Turnover_Rate_timea	2058.0	3.960000e-02	4.240000e-02	0.0089	2.050000e-02	2.870000e-02	4.440000e-02	1.000000e+00	
Operating_profit_per_person	2058.0	4.037000e-01	5.360000e-02	0.0000	3.914000e-01	3.951000e-01	4.009000e-01	1.000000e+00	
Allocation_rate_per_person	2058.0	5.725559e+06	1.979500e+08	0.0000	4.700000e-03	1.080000e-02	2.460000e-02	8.280000e+09	
Quick_Assets_to_Total_Assets	2058.0	3.422000e-01	2.104000e-01	0.0000	1.735000e-01	3.061000e-01	4.845000e-01	9.889000e-01	
Cash_to_Total_Assets	1962.0	7.990000e-02	9.860000e-02	0.0002	2.060000e-02	4.560000e-02	9.770000e-02	9.250000e-01	
Quick_Assets_to_Current_Liability	2058.0	1.190476e+07	3.122923e+08	0.0000	3.600000e-03	6.000000e-03	9.600000e-03	8.820000e+09	
Cash_to_Current_Liability	2058.0	9.282507e+07	7.851899e+08	0.0001	1.100000e-03	2.700000e-03	7.500000e-03	9.170000e+09	
Operating_Funds_to_Liability	2058.0	3.482000e-01	3.840000e-02	0.0263	3.377000e-01	3.450000e-01	3.541000e-01	1.000000e+00	
Inventory_to_Working_Capital	2058.0	2.777000e-01	1.840000e-02	0.0000	2.770000e-01	2.773000e-01	2.777000e-01	1.000000e+00	
Inventory_to_Current_Liability	2058.0	5.798346e+07	6.278795e+08	0.0000	2.900000e-03	6.800000e-03	1.280000e-02	9.600000e+09	
Long_term_liability_to_Current_Assets	2058.0	7.340107e+07	6.693526e+08	0.0000	0.000000e+00	2.600000e-03	1.050000e-02	9.310000e+09	
Retained_Earnings_to_Total_Assets	2058.0	9.304000e-01	2.980000e-02	0.0000	9.279000e-01	9.351000e-01	9.409000e-01	9.728000e-01	
Total_Income_to_Total_expenses	2058.0	2.400000e-03	5.000000e-04	0.0000	2.200000e-03	2.300000e-03	2.400000e-03	1.030000e-02	
Total_expense_to_Assets	2058.0	3.110000e-02	3.870000e-02	0.0009	1.270000e-02	2.090000e-02	3.530000e-02	1.000000e+00	
Current_Asset_Turnover_Rate	2058.0	1.273303e+09	2.839741e+09	0.0000	2.000000e-04	2.000000e-04	1.300000e-03	9.990000e+09	
Quick_Asset_Turnover_Rate	2058.0	2.571768e+09	3.453544e+09	0.0000	2.000000e-04	4.000000e-04	5.790000e+09	1.000000e+10	
Cash_Turnover_Rate	2058.0	2.653896e+09	2.821245e+09	0.0001	1.700000e-03	1.730000e+09	4.550000e+09	9.990000e+09	
Fixed_Assets_to_Assets	2058.0	4.042760e+06	1.834000e+08	0.0000	9.650000e-02	2.138000e-01	4.150000e-01	8.320000e+09	
Cash_Flow_to_Total_Assets	2058.0	6.442000e-01	4.510000e-02	0.0000	6.334000e-01	6.432000e-01	6.542000e-01	1.000000e+00	
Cash_Flow_to_Liability	2058.0	4.600000e-01	3.290000e-02	0.0328	4.575000e-01	4.593000e-01	4.617000e-01	9.051000e-01	
CFO_to_Assets	2058.0	5.797000e-01	6.380000e-02	0.0000	5.504000e-01	5.825000e-01	6.123000e-01	9.752000e-01	
Cash_Flow_to_Equity	2058.0	3.146000e-01	1.280000e-02	0.0000	3.128000e-01	3.148000e-01	3.165000e-01	5.692000e-01	
Current_Liability_to_Current_Assets	2044.0	3.940000e-02	4.800000e-02	0.0000	2.180000e-02	3.270000e-02	4.390000e-02	1.000000e+00	
Liability_Assets_Flag	2058.0	3.400000e-03	5.820000e-02	0.0000	0.000000e+00	0.000000e+00	0.000000e+00	1.000000e+00	
Total_assets_to_GNP_price	2058.0	2.779397e+07	4.717714e+08	0.0000	9.000000e-04	2.500000e-03	7.000000e-03	9.620000e+09	
No_credit_Interval	2058.0	6.237000e-01	1.160000e-02	0.0407	6.233000e-01	6.237000e-01	6.240000e-01	9.564000e-01	
Degree_of_Financial_Leverage_DFL	2058.0	2.790000e-02	1.380000e-02	0.0128	2.680000e-02	2.680000e-02	2.700000e-02	4.644000e-01	
Interest_Coverage_Ratio_Interest_expense_to_EBIT	2058.0	5.654000e-01	1.150000e-02	0.1721	5.652000e-01	5.653000e-01	5.662000e-01	6.688000e-01	
Net_Income_Flag	2058.0	1.000000e+00	0.000000e+00	1.0000	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	
Equity_to_Liability	2058.0	4.250000e-02	5.950000e-02	0.0039	2.040000e-02	2.850000e-02	4.340000e-02	1.000000e+00	

Fig.1.1. Dataset Description before outlier treatment

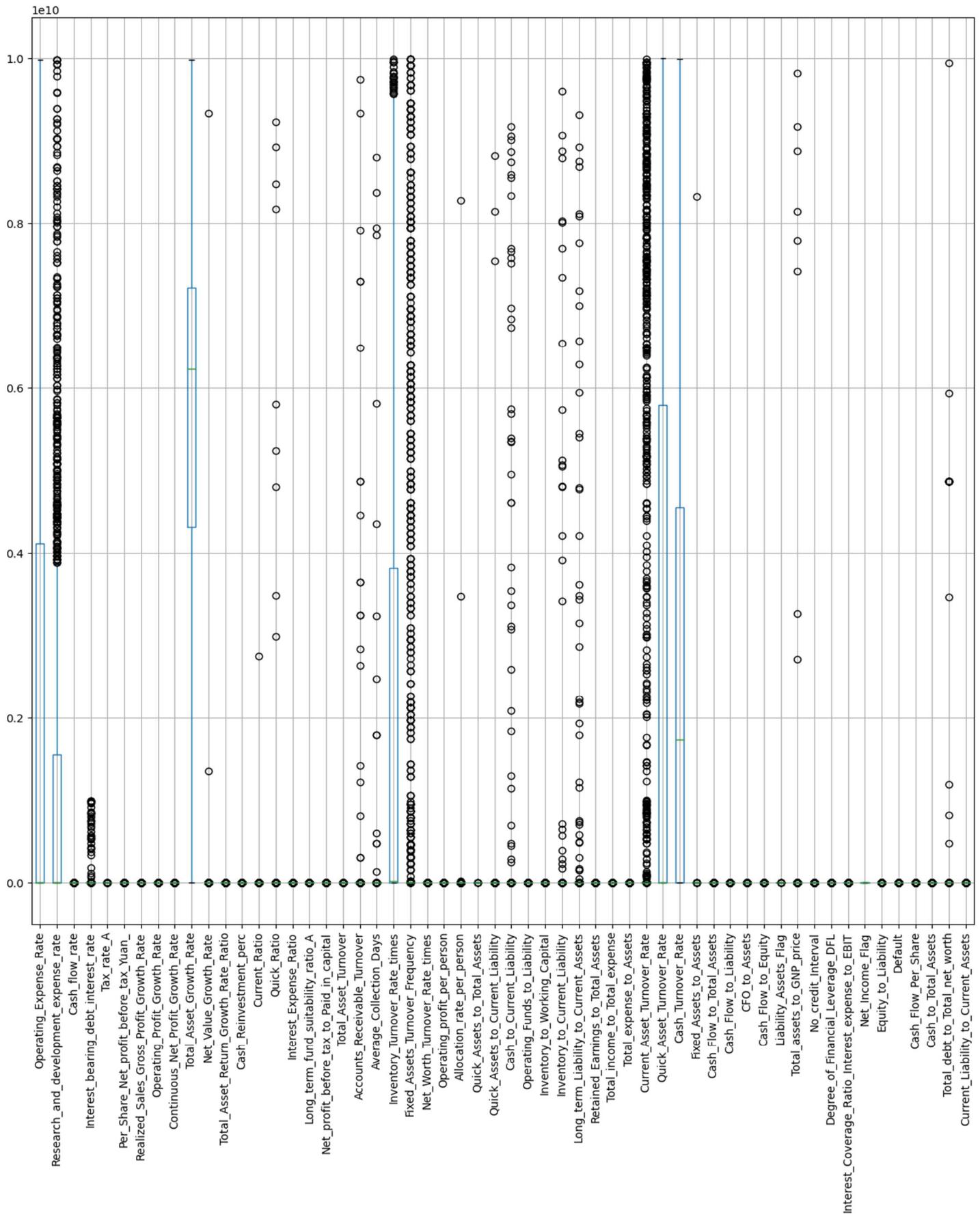


Fig.1.2. Boxplot of numerical variables before outlier treatment

```

Out[51]: Operating_Expense_Rate           0
         Research_and_development_expense_rate 264
         Cash_flow_rate                      206
         Interest_bearing_debt_interest_rate   94
         Tax_rate_A                          42
         Per_Share_Net_profit_before_tax_Yuan_ 186
         Realized_Sales_Gross_Profit_Growth_Rate 283
         Operating_Profit_Growth_Rate          317
         Continuous_Net_Profit_Growth_Rate     340
         Total_Asset_Growth_Rate                0
         Net_Value_Growth_Rate                 304
         Total_Asset_Return_Growth_Rate_Ratio   226
         Cash_Reinvestment_perc               220
         Current_Ratio                        193
         Quick_Ratio                          190
         Interest_Expense_Ratio                328
         Long_term_fund_suitability_ratio_A    234
         Net_profit_before_tax_to_Paid_in_capital 173
         Total_Asset_Turnover                  101
         Accounts_Receivable_Turnover          281
         Average_Collection_Days              77
         Inventory_Turnover_Rate_times        29
         Fixed_Assets_Turnover_Frequency      501
         Net_Worth_Turnover_Rate_times        165
         Operating_profit_per_person          357
         Allocation_rate_per_person           200
         Quick_Assets_to_Total_Assets        4
         Quick_Assets_to_Current_Liability   185
         Cash_to_Current_Liability            253
         Operating_Funds_to_Liability         219
         Inventory_to_Working_Capital         247
         Inventory_to_Current_Liability       129
         Long_term_Liability_to_Current_Assets 213
         Retained_Earnings_to_Total_Assets    208
         Total_income_to_Total_expense        136
         Total_expense_to_Assets              168
         Current_Asset_Turnover_Rate          464
         Quick_Asset_Turnover_Rate             0
         Cash_Turnover_Rate                   0
         Fixed_Assets_to_Assets               10
         Cash_Flow_to_Total_Assets            317
         Cash_Flow_to_Liability                407
         CFO_to_Assets                        110
         Cash_Flow_to_Equity                  306
         Total_assets_to_GNP_price            235
         No_credit_Interval                  396
         Degree_of_Financial_Leverage_DFL     438
         Interest_Coverage_Ratio_Interest_expense_to_EBIT 376
         Equity_to_Liability                  190
         Cash_Flow_Per_Share                 173
         Cash_to_Total_Assets                 167
         Total_debt_to_Total_net_worth        125
         Current_Liability_to_Current_Assets 122
         Liability_Assets_Flag                7
         Net_Income_Flag                     0
dtype: int64

```

Fig.1.3. Number of outliers in each field

0	Operating_Expense_Rate	0.00
1	Research_and_development_expense_rate	12.83
2	Cash_flow_rate	10.01
3	Interest_bearing_debt_interest_rate	4.57
4	Tax_rate_A	2.04
5	Per_Share_Net_profit_before_tax_Yuan_	9.04
6	Realized_Sales_Gross_Profit_Growth_Rate	13.75
7	Operating_Profit_Growth_Rate	15.40
8	Continuous_Net_Profit_Growth_Rate	16.52
9	Total_Asset_Growth_Rate	0.00
10	Net_Value_Growth_Rate	14.77
11	Total_Asset_Return_Growth_Rate_Ratio	10.96
12	Cash_Reinvestment_perc	10.69
13	Current_Ratio	9.38
14	Quick_Ratio	9.23
15	Interest_Expense_Ratio	15.94
16	Long_term_fund_suitability_ratio_A	11.37
17	Net_profit_before_tax_to_PAid_in_capital	8.41
18	Total_Asset_Turnover	4.91
19	Accounts_Receivable_Turnover	13.65
20	Average_Collection_Days	3.74
21	Inventory_Turnover_Rate_times	1.41
22	Fixed_Assets_Turnover_Frequency	24.34
23	Net_Worth_Turnover_Rate_times	8.02
24	Operating_profit_per_person	17.35
25	Allocation_rate_per_person	9.72
26	Quick_Assets_to_Total_Assets	0.19
27	Quick_Assets_to_Current_Liability	8.99
28	Cash_to_Current_Liability	12.29
29	Operating_Funds_to_Liability	10.64
30	Inventory_to_Working_Capital	12.00
31	Inventory_to_Current_Liability	6.27
32	Long_term_Liability_to_Current_Assets	10.35
33	Retained_Earnings_to_Total_Assets	10.11
34	Total_Income_to_Total_expense	6.61
35	Total_expense_to_Assets	8.16
36	Current_Asset_Turnover_Rate	22.55
37	Quick_Asset_Turnover_Rate	0.00
38	Cash_Turnover_Rate	0.00
39	Fixed_Assets_to_Assets	0.49
40	Cash_Flow_to_Total_Assets	15.40
41	Cash_Flow_to_Liability	19.78
42	CFO_to_Assets	5.34
43	Cash_Flow_to_Equity	14.87
44	Total_assets_to_GNP_price	11.42
45	No_credit_Interval	19.24
46	Degree_of_Financial_Leverage_DFL	21.28
47	Interest_Coverage_Ratio_Interest_expense_to_EBIT	18.27
48	Equity_to_Liability	9.23
49	Cash_Flow_Per_Share	8.41
50	Cash_to_Total_Assets	8.11
51	Total_debt_to_Total_net_worth	6.07
52	Current_Liability_to_Current_Assets	5.93

Fig.1.4. Outlier percentage in each field

Observations:

- From the output above, almost all the fields have outliers and need to be cleaned before further analysis
- Fixed_Assets_Turnover_Frequency, Current_Asset_Turnover_Rate, Degree_of_Financial_Leverage_DFL all have more than 20% outliers
- More than half the fields have more than 10% outliers.
- These are treated by capping the outliers at the lower or upper bounds, determined by the interquartile range
- Also, in case of multicollinearity and elimination of variables, the percentage of outliers also need to be considered while choosing the significant variables and eliminating insignificant variables

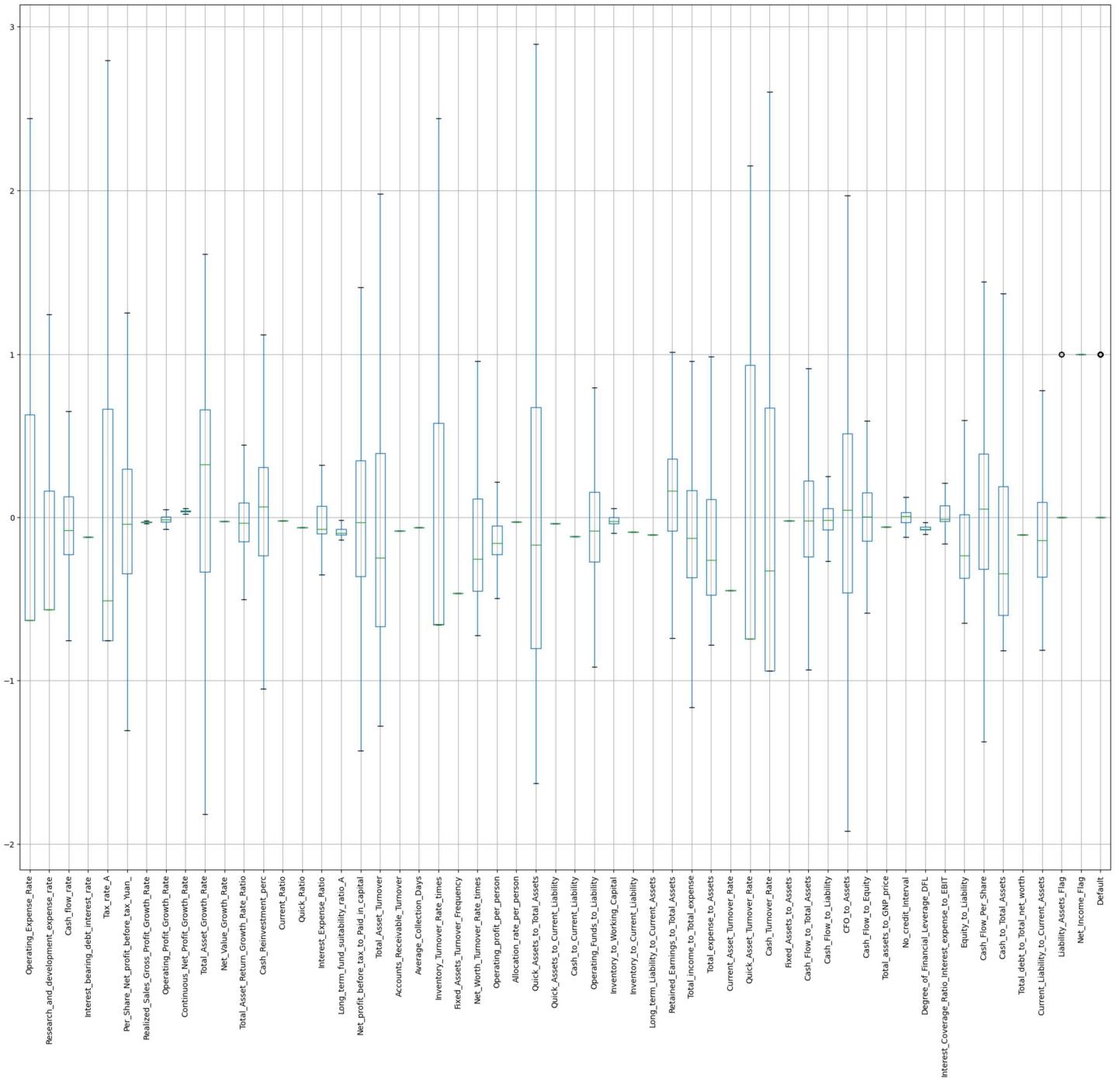


Fig.1.5. Boxplot of numerical variables after outlier treatment

[59]:		count	mean	std	min	25%	50%	75%	max
	<i>Operating_Expense_Rate</i>	2058.0	0.000000	1.000243	-0.631148	-0.631148	0.632754	2.437890	
	<i>Research_and_development_expense_rate</i>	2058.0	-0.129062	0.673889	-0.563716	-0.563716	0.192216	1.243613	
	<i>Cash_flow_rate</i>	2058.0	-0.036638	0.329112	-0.754655	-0.227011	-0.079339	0.124751	0.652394
	<i>Interest_bearing_debt_Interest_rate</i>	2058.0	-0.123117	0.000000	-0.123117	-0.123117	-0.123117	-0.123117	
	<i>Tax_rate_A</i>	2058.0	-0.028118	0.865169	-0.75087	-0.75087	-0.509670	0.685408	2.793151
	<i>Per_Share_Net_profit_before_tax_Yuan_</i>	2058.0	-0.019095	0.598367	-1.300005	-0.343727	-0.043953	0.295792	1.259507
	<i>Realized_Sales_Gross_Profit_Growth_Rate</i>	2058.0	-0.030028	0.004308	-0.038873	-0.032398	-0.030474	-0.028078	-0.021601
	<i>Operating_Profit_Growth_Rate</i>	2058.0	-0.013560	0.031153	-0.075299	-0.029271	-0.015179	0.001414	0.047441
	<i>Continuous_Net_Profit_Growth_Rate</i>	2058.0	0.03592	0.008275	0.020098	0.032168	0.036803	0.040214	0.052285
	<i>Total_Asset_Growth_Rate</i>	2058.0	0.000000	1.000243	-1.815876	-0.334030	0.321893	0.663598	1.811431
	<i>Net_Value_Growth_Rate</i>	2058.0	-0.024981	0.000000	-0.024981	-0.024981	-0.024981	-0.024981	-0.024981
	<i>Total_Asset_Return_Growth_Rate_Ratio</i>	2058.0	-0.029429	0.227635	-0.504753	-0.149901	-0.034875	0.088667	0.441518
	<i>Cash_Reinvestment_perc</i>	2058.0	0.03105	0.517215	-1.049080	-0.236330	0.064707	0.305503	1.118253
	<i>Current_Ratio</i>	2058.0	-0.022049	0.000000	-0.022049	-0.022049	-0.022049	-0.022049	-0.022049
	<i>Quick_Ratio</i>	2058.0	-0.082405	0.000000	-0.082405	-0.082405	-0.082405	-0.082405	-0.082405
	<i>Interest_Expense_Ratio</i>	2058.0	-0.023999	0.177035	-0.350522	-0.100202	-0.072437	0.066878	0.316998
	<i>Long_term_fund_suitability_ratio_A</i>	2058.0	-0.086203	0.014160	-0.139038	-0.039383	-0.09198	-0.073414	-0.019481
	<i>Net_profit_before_tax_to_Paid_In_capital</i>	2058.0	-0.006927	0.656551	-1.426975	-0.363775	-0.031703	0.345025	1.408225
	<i>Total_Asset_Turnover</i>	2058.0	-0.050218	0.829844	-1.278769	-0.667725	-0.250427	0.390424	1.977649
	<i>Accounts_Receivable_Turnover</i>	2058.0	-0.082432	0.000000	-0.082432	-0.082432	-0.082432	-0.082432	-0.082432
	<i>Average_Collection_Days</i>	2058.0	-0.08400	0.000000	-0.084001	-0.084001	-0.084001	-0.084001	-0.084001
	<i>Inventory_Turnover_Rate_times</i>	2058.0	-0.000978	0.997807	-1.659914	-0.659914	-0.653708	0.580130	2.440197
	<i>Fixed_Assets_Turnover_Frequency</i>	2058.0	0.464727	0.000000	-0.464727	-0.464727	-0.464727	-0.464727	-0.464727
	<i>Net_Worth_Turnover_Rate_times</i>	2058.0	-0.106170	0.465063	-0.724447	-0.450465	-0.253394	0.112721	0.957499
	<i>Operating_profit_per_person</i>	2058.0	-0.138935	0.168707	-0.495405	-0.229257	-0.16035	-0.051824	0.214324
	<i>Allocation_rate_per_person</i>	2058.0	-0.028931	0.000000	-0.028931	-0.028931	-0.028931	-0.028931	-0.028931
	<i>Quick_Assets_to_Total_Assets</i>	2058.0	-0.000194	0.999689	-1.628669	-0.802102	-0.171484	0.676736	2.894994
	<i>Quick_Assets_to_Current_Liability</i>	2058.0	-0.038130	0.000000	-0.038130	-0.038130	-0.038130	-0.038130	-0.038130
	<i>Cash_to_Current_Liability</i>	2058.0	-0.11624	0.000000	-0.118249	-0.118249	-0.118249	-0.118249	-0.118249
	<i>Operating_Funds_to_Liability</i>	2058.0	-0.045937	0.408645	-0.916455	-0.274280	-0.083558	0.153837	0.796012
	<i>Inventory_to_Working_Capital</i>	2058.0	-0.016991	0.035723	-0.097209	-0.040121	-0.027004	-0.002062	0.055026
	<i>Inventory_to_Current_Liability</i>	2058.0	-0.092179	0.000000	-0.092179	-0.092179	-0.092179	-0.092179	-0.092179
	<i>Long_term_Liability_to_Current_Assets</i>	2058.0	-0.106668	0.000000	-0.109886	-0.109886	-0.109886	-0.109886	-0.109886
	<i>Retained_Earnings_to_Total_Assets</i>	2058.0	0.101617	0.418248	-0.740865	-0.082942	0.158672	0.355673	0.1013594
	<i>Total_Income_to_Total_expense</i>	2058.0	-0.083678	0.480730	-1.163623	-0.368314	-0.130355	0.161892	0.957201
	<i>Total_expense_to_Assets</i>	2058.0	-0.110794	0.490448	-0.781558	-0.475248	-0.264373	0.108788	0.984842
	<i>Current_Asset_Turnover_Rate</i>	2058.0	-0.448498	0.000000	-0.448498	-0.448498	-0.448498	-0.448498	-0.448498
	<i>Quick_Asset_Turnover_Rate</i>	2058.0	-0.000000	1.000243	-0.744856	-0.744856	-0.744856	0.932090	2.151424
	<i>Cash_Turnover_Rate</i>	2058.0	-0.000000	1.000243	-0.940840	-0.940840	-0.327487	0.672315	2.601011
	<i>Fixed_Assets_to_Assets</i>	2058.0	-0.022049	0.000000	-0.022049	-0.022049	-0.022049	-0.022049	-0.022049
	<i>Cash_Flow_to_Total_Assets</i>	2058.0	-0.007198	0.482681	-0.93867	-0.241253	-0.021895	0.230323	0.912687
	<i>Cash_Flow_to_Liability</i>	2058.0	-0.012198	0.141788	-0.270408	-0.075882	-0.019281	0.053802	0.248329
	<i>CFO_to_Assets</i>	2058.0	0.014167	0.8035605	-1.918397	-0.460585	0.044068	0.511289	1.989100
	<i>Cash_Flow_to_Equity</i>	2058.0	0.005662	0.304143	-0.586277	-0.144498	0.001028	0.150022	0.591801
	<i>Total_Assets_to_GNP_price</i>	2058.0	-0.058928	0.000000	-0.058928	-0.058928	-0.058928	-0.058928	-0.058928
	<i>No_credit_Interval</i>	2058.0	-0.003480	0.068329	-0.123421	-0.030813	0.005550	0.030927	0.123536
	<i>Degree_of_Financial_Leverage_DFL</i>	2058.0	-0.069252	0.020608	-0.105361	-0.077838	-0.075013	-0.059489	-0.031967
	<i>Interest_Coverage_Ratio_Interest_expense_to_EBIT</i>	2058.0	0.016544	0.102107	-0.163802	-0.024062	-0.010457	0.069097	0.208837
	<i>Equity_to_Liability</i>	2058.0	-0.128961	0.325687	-0.648334	-0.371709	-0.238402	0.015191	0.595541
	<i>Cash_Flow_Per_Share</i>	2058.0	0.026902	0.643117	-1.374507	-0.371921	0.048880	0.386470	1.443058
	<i>Cash_to_Total_Assets</i>	2058.0	-0.106903	0.651499	-0.817737	-0.599945	-0.344128	0.187932	1.369748
	<i>Total_debt_to_Total_net_worth</i>	2058.0	-0.108218	0.000000	-0.108218	-0.108218	-0.108218	-0.108218	-0.108218
	<i>Current_Liability_to_Current_Assets</i>	2058.0	-0.098490	0.373757	-0.813996	-0.366068	-0.142151	0.092575	0.780539
	<i>Liability_Assets_Flag</i>	2058.0	0.003401	0.058236	0.000000	0.000000	0.000000	0.000000	1.000000

Fig.1.6. Description of dataset after outlier treatment

2. Missing Value Treatment

```

Out[26]: Operating_Expense_Rate          0
         Research_and_development_expense_rate 0
         Cash_flow_rate                      0
         Interest_bearing_debt_interest_rate 0
         Tax_rate_A                          0
         Cash_Flow_Per_Share                167
         Per_Share_Net_profit_before_tax_Yuan_ 0
         Realized_Sales_Gross_Profit_Growth_Rate 0
         Operating_Profit_Growth_Rate        0
         Continuous_Net_Profit_Growth_Rate   0
         Total_Asset_Growth_Rate            0
         Net_Value_Growth_Rate             0
         Total_Asset_Return_Growth_Rate_Ratio 0
         Cash_Reinvestment_perc            0
         Current_Ratio                     0
         Quick_Ratio                       0
         Interest_Expense_Ratio            0
         Total_debt_to_Total_net_worth     21
         Long_term_fund_suitability_ratio_A 0
         Net_profit_before_tax_to_Paid_in_capital 0
         Total_Asset_Turnover              0
         Accounts_Receivable_Turnover      0
         Average_Collection_Days          0
         Inventory_Turnover_Rate_times    0
         Fixed_Assets_Turnover_Frequency   0
         Net_Worth_Turnover_Rate_times     0
         Operating_profit_per_person      0
         Allocation_rate_per_person       0
         Quick_Assets_to_Total_Assets     0
         Cash_to_Total_Assets             96
         Quick_Assets_to_Current_Liability 0
         Cash_to_Current_Liability        0
         Operating_Funds_to_Liability     0
         Inventory_to_Working_Capital     0
         Inventory_to_Current_Liability   0
         Long_term_Liability_to_Current_Assets 0
         Retained_Earnings_to_Total_Assets 0
         Total_income_to_Total_expense    0
         Total_expense_to_Assets          0
         Current_Asset_Turnover_Rate      0
         Quick_Asset_Turnover_Rate        0
         Cash_Turnover_Rate               0
         Fixed_Assets_to_Assets          0
         Cash_Flow_to_Total_Assets        0
         Cash_Flow_to_Liability           0
         CFO_to_Assets                   0
         Cash_Flow_to_Equity              0
         Current_Liability_to_Current_Assets 14
         Liability_Assets_Flag            0
         Total_assets_to_GNP_price        0
         No_credit_Interval              0
         Degree_of_Financial_Leverage_DFL 0
         Interest_Coverage_Ratio_Interest_expense_to_EBIT 0
         Net_Income_Flag                 0
         Equity_to_Liability              0
         Default                         0
dtype: int64

```

Fig.1.7. Number of missing values in each field in the dataset

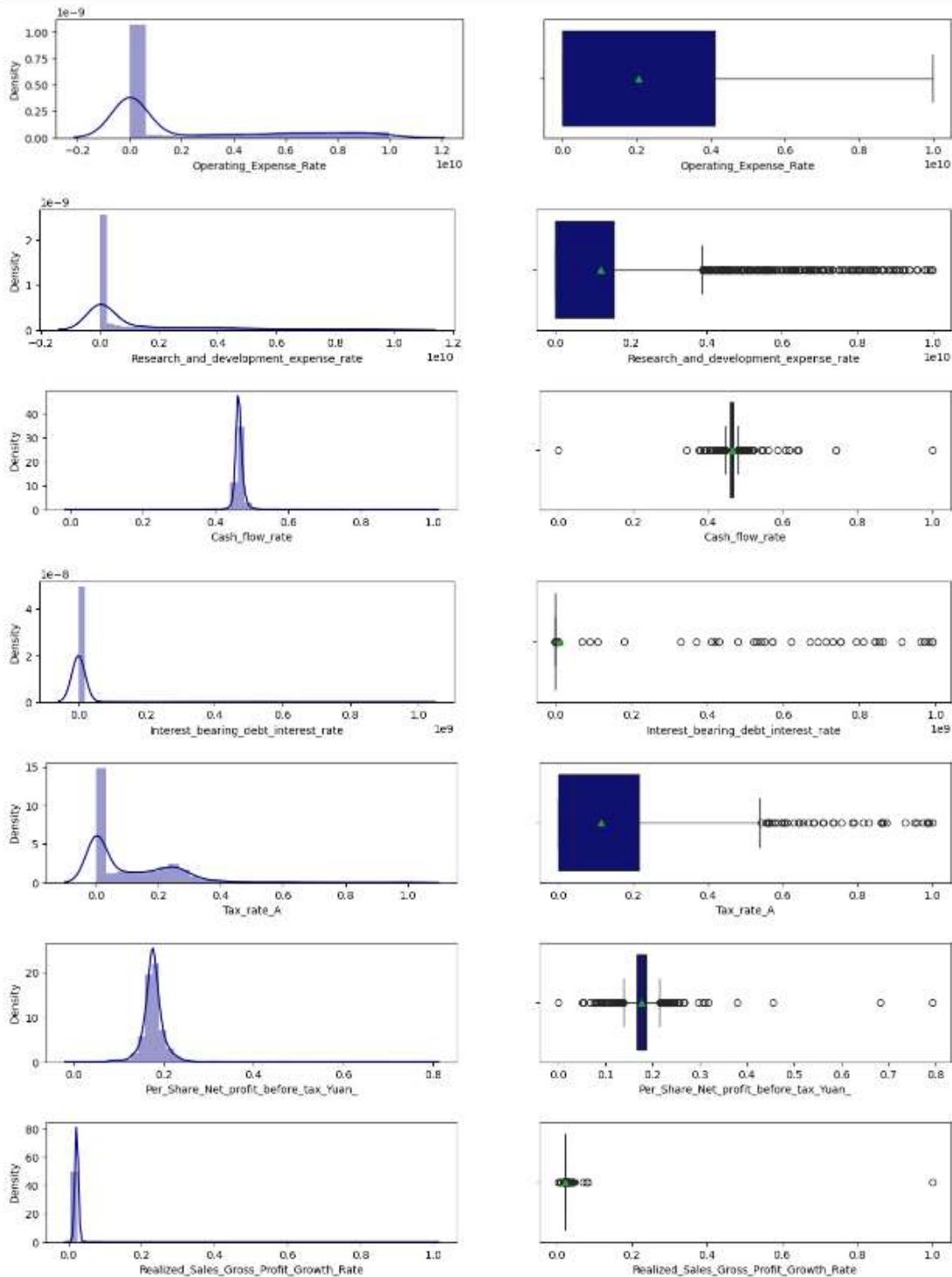
Observations:

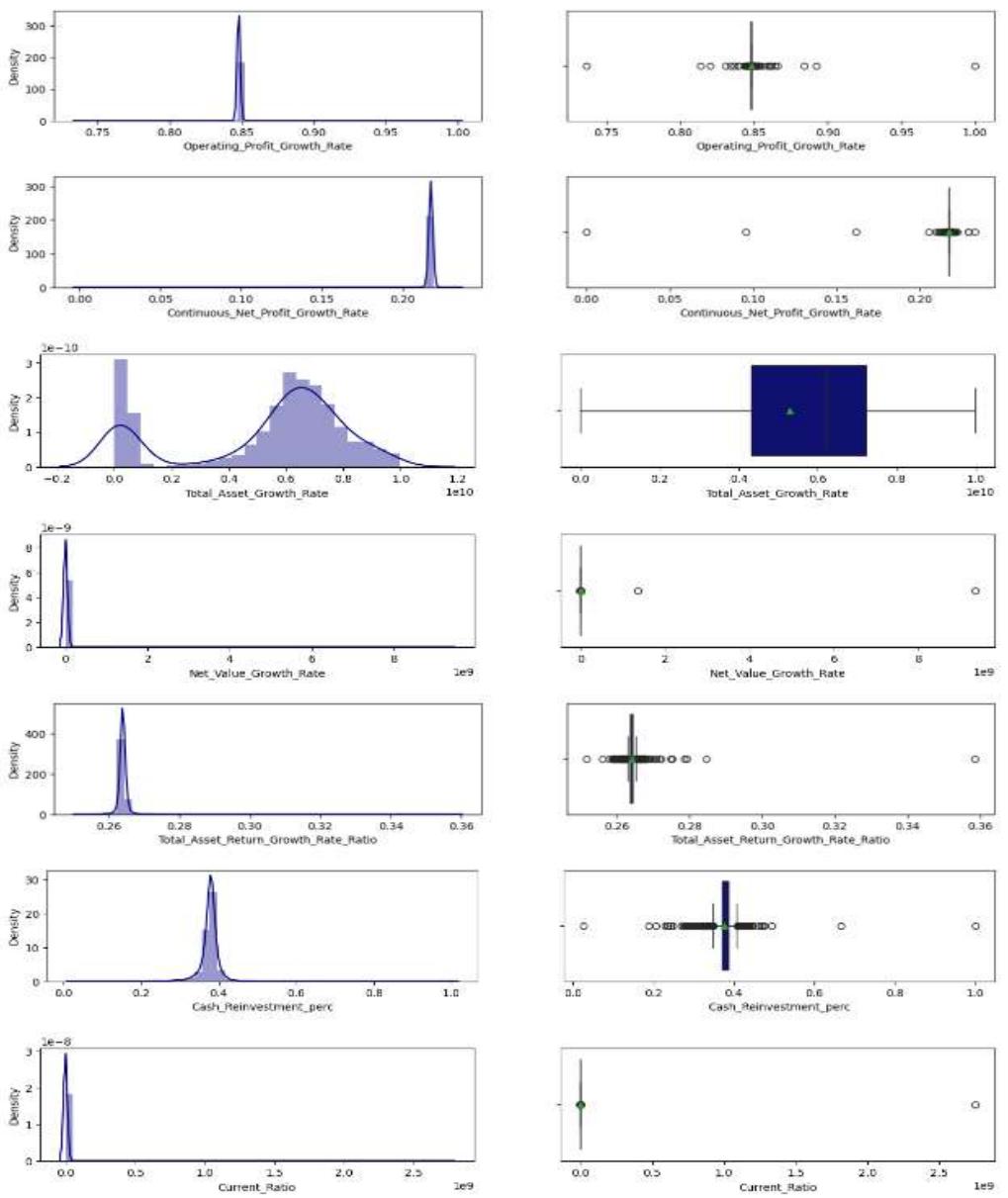
- There are about 5% of missing values in the Cash_flow_per_share and 6.4% in Cash_to_total_assets in rows where Default=1.
- Overall, about 13.18% of the rows having the desired class of the target variable have missing values

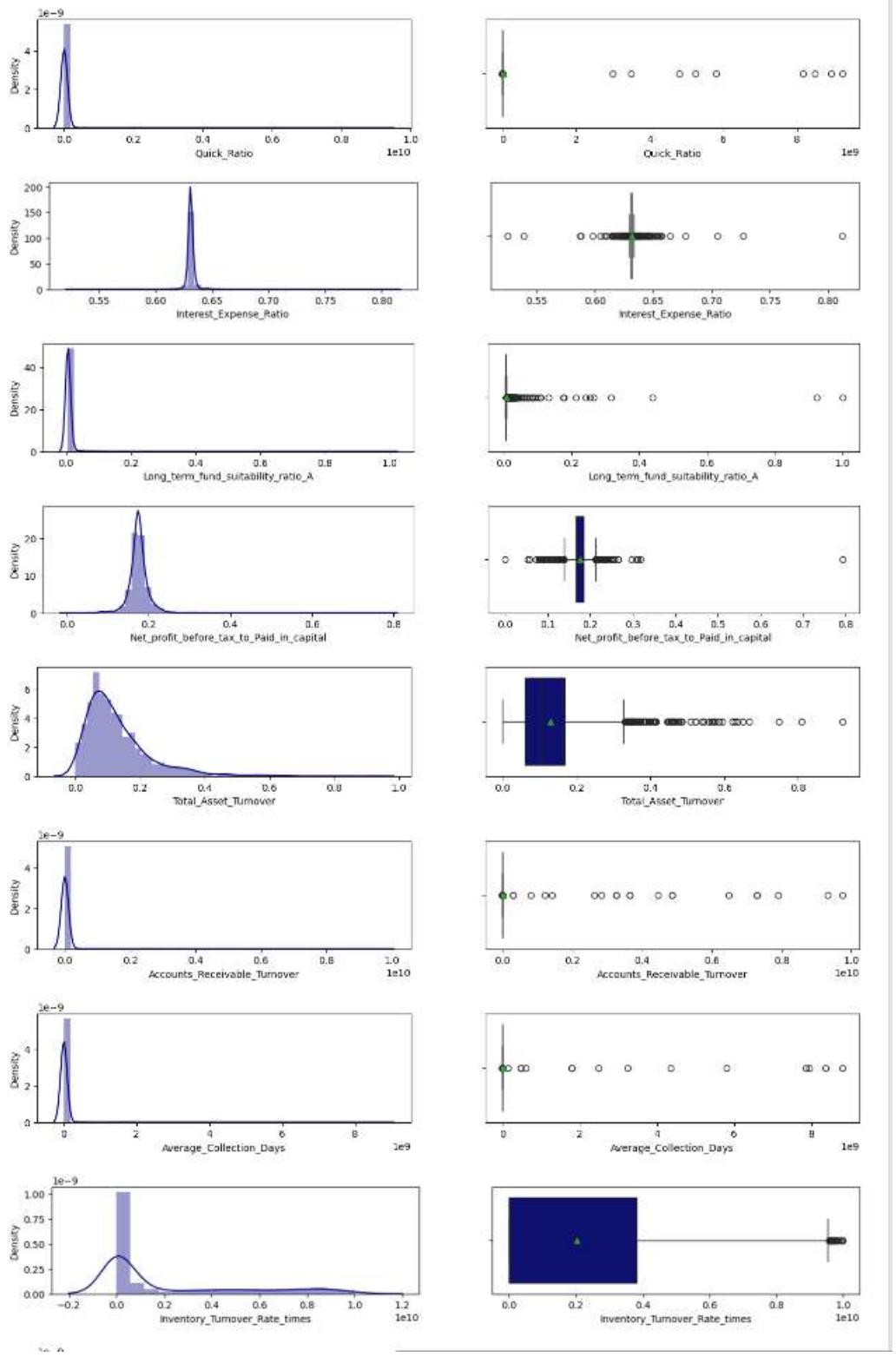
- Dropping these rows may impact the target variable and hence imputing might be a better option
- For the purpose of imputation, kNN imputer was used

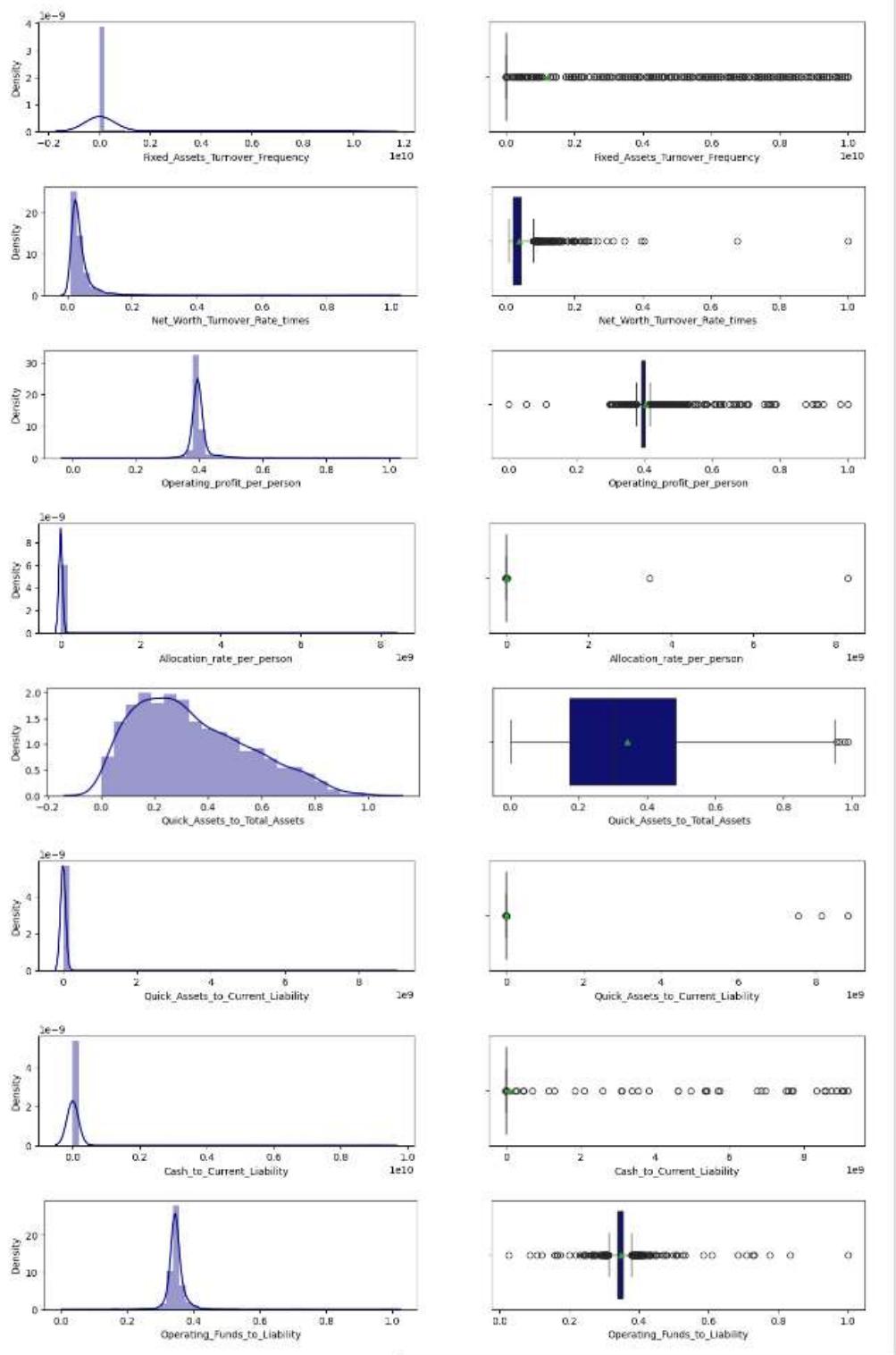
3. Univariate (4 marks) & Bivariate (6 marks) analysis with proper interpretation. (You may choose to include only those variables which were significant in the model building)

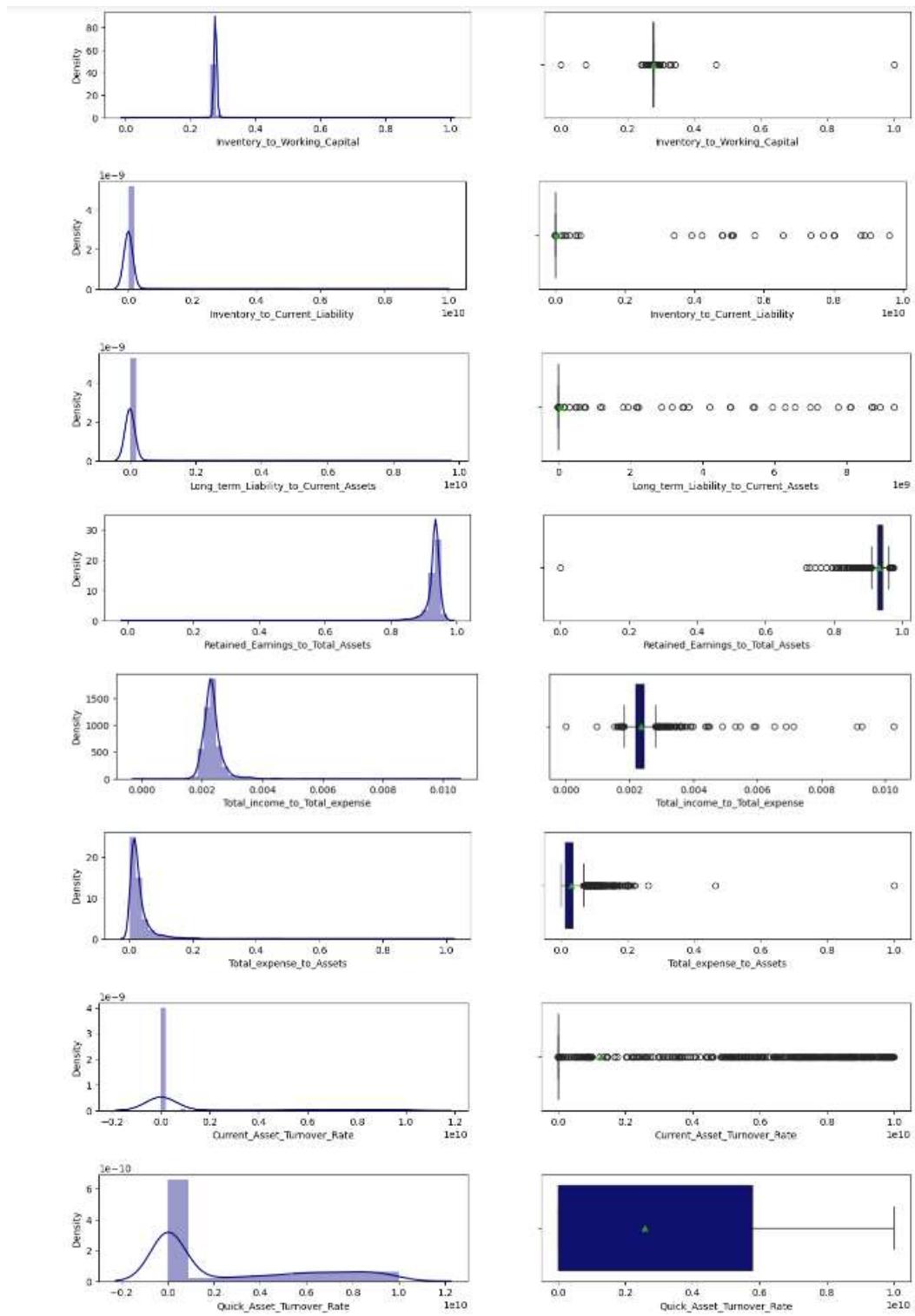
Univariate Analysis:

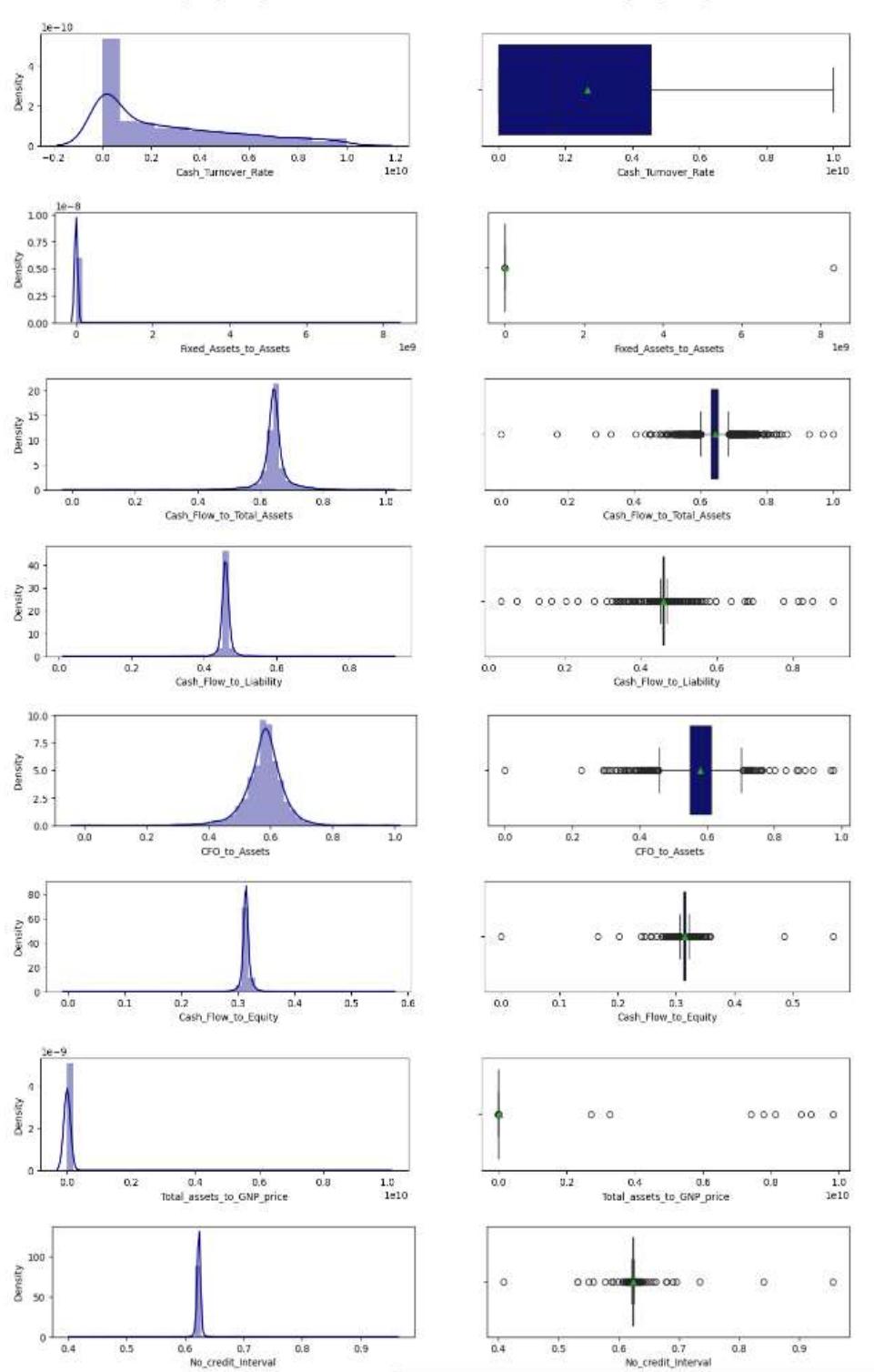












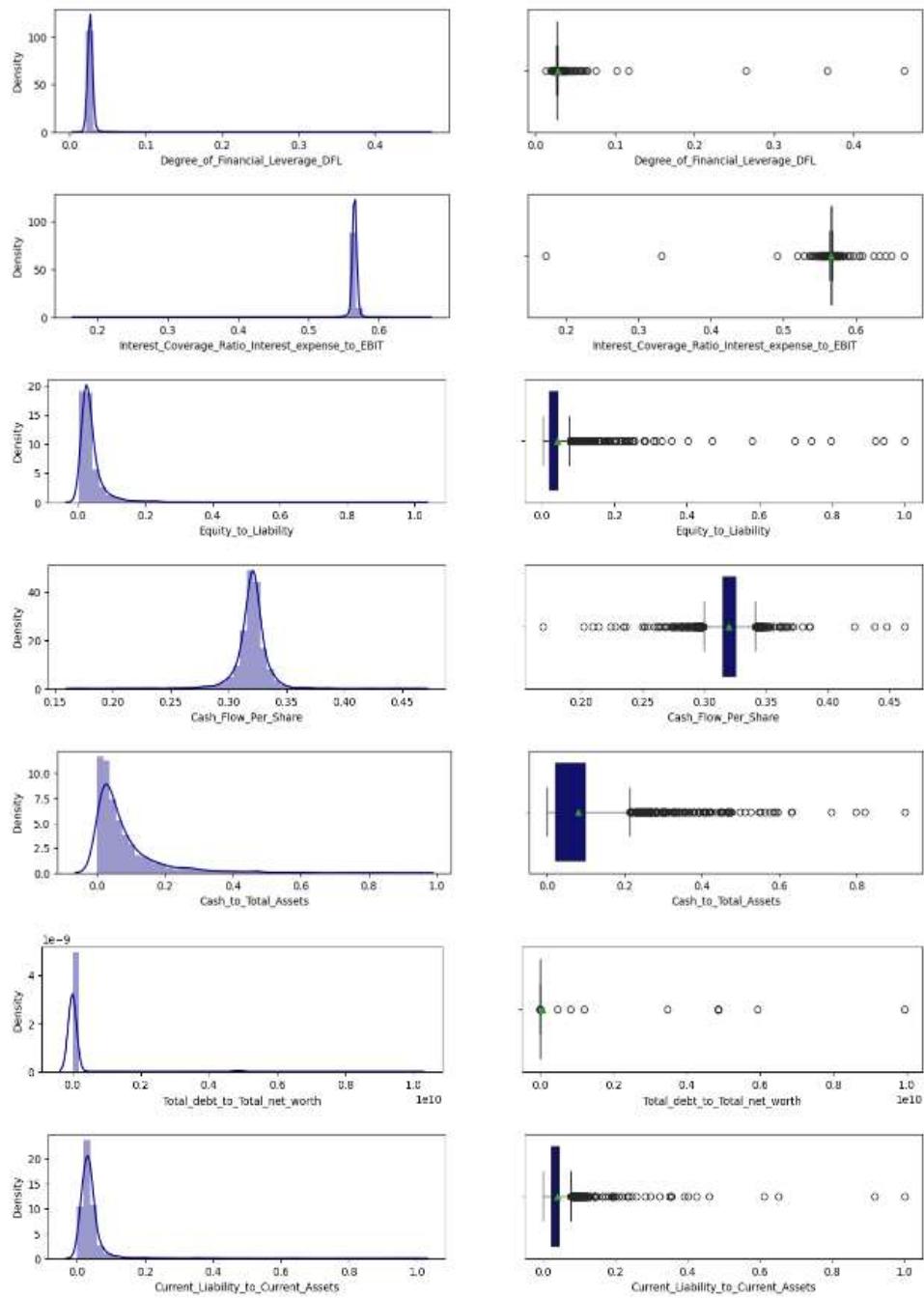


Fig.1.8. Univariate Analysis of Numerical Variables

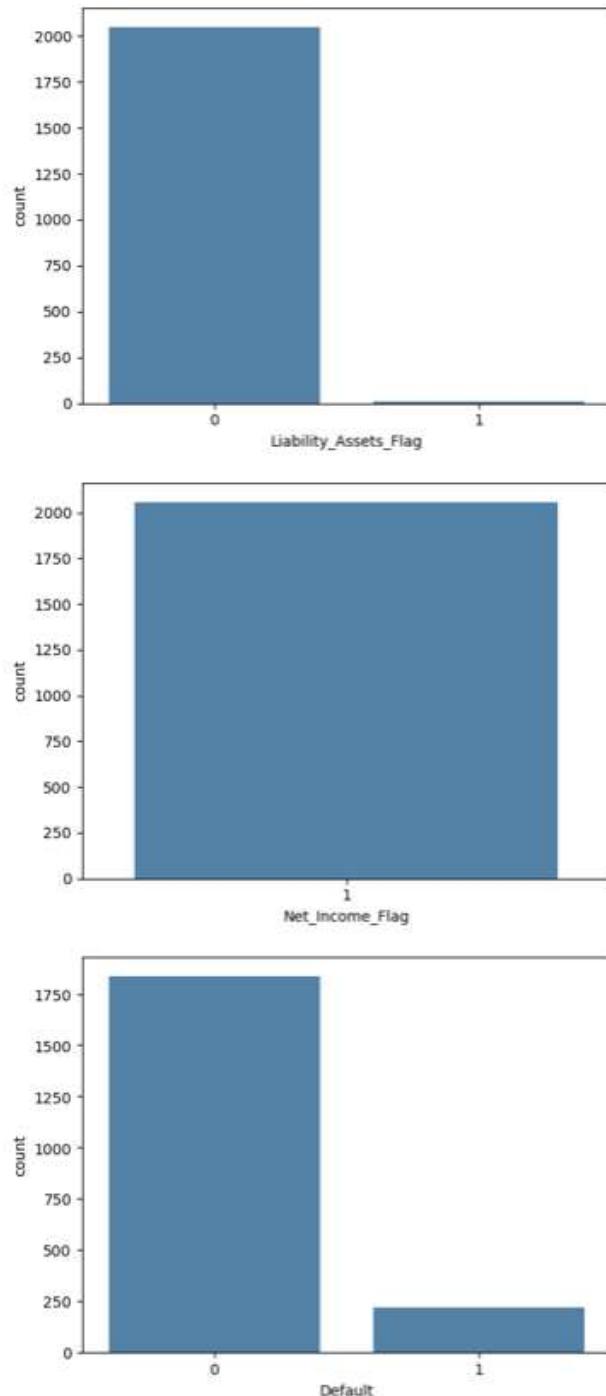


Fig.1.9. Univariate Analysis- Categorical Variables

Observations:

- The field 'Net_Income_Flag' has all values as 1. This variable can be dropped before further analysis

Bivariate Analysis:

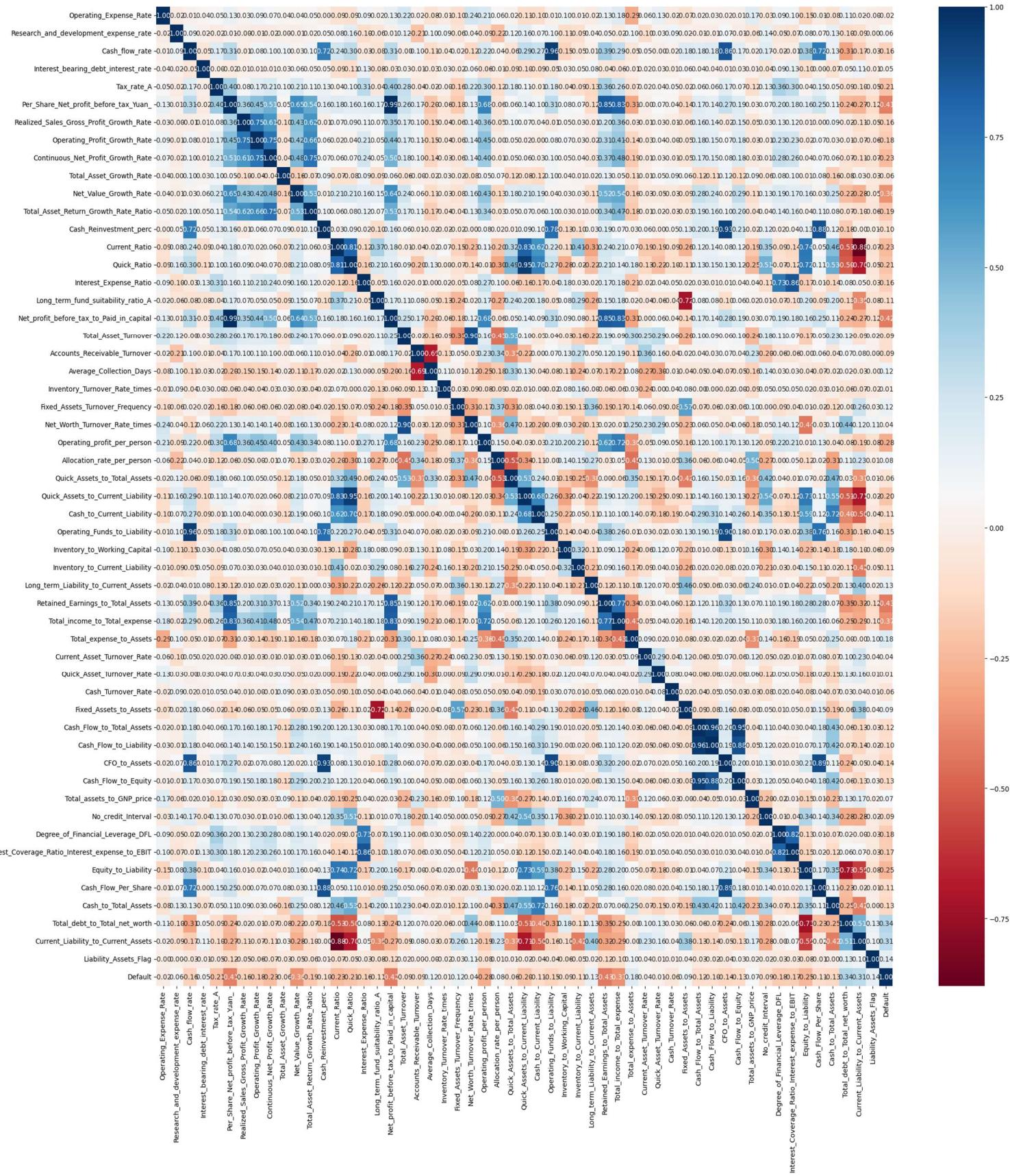
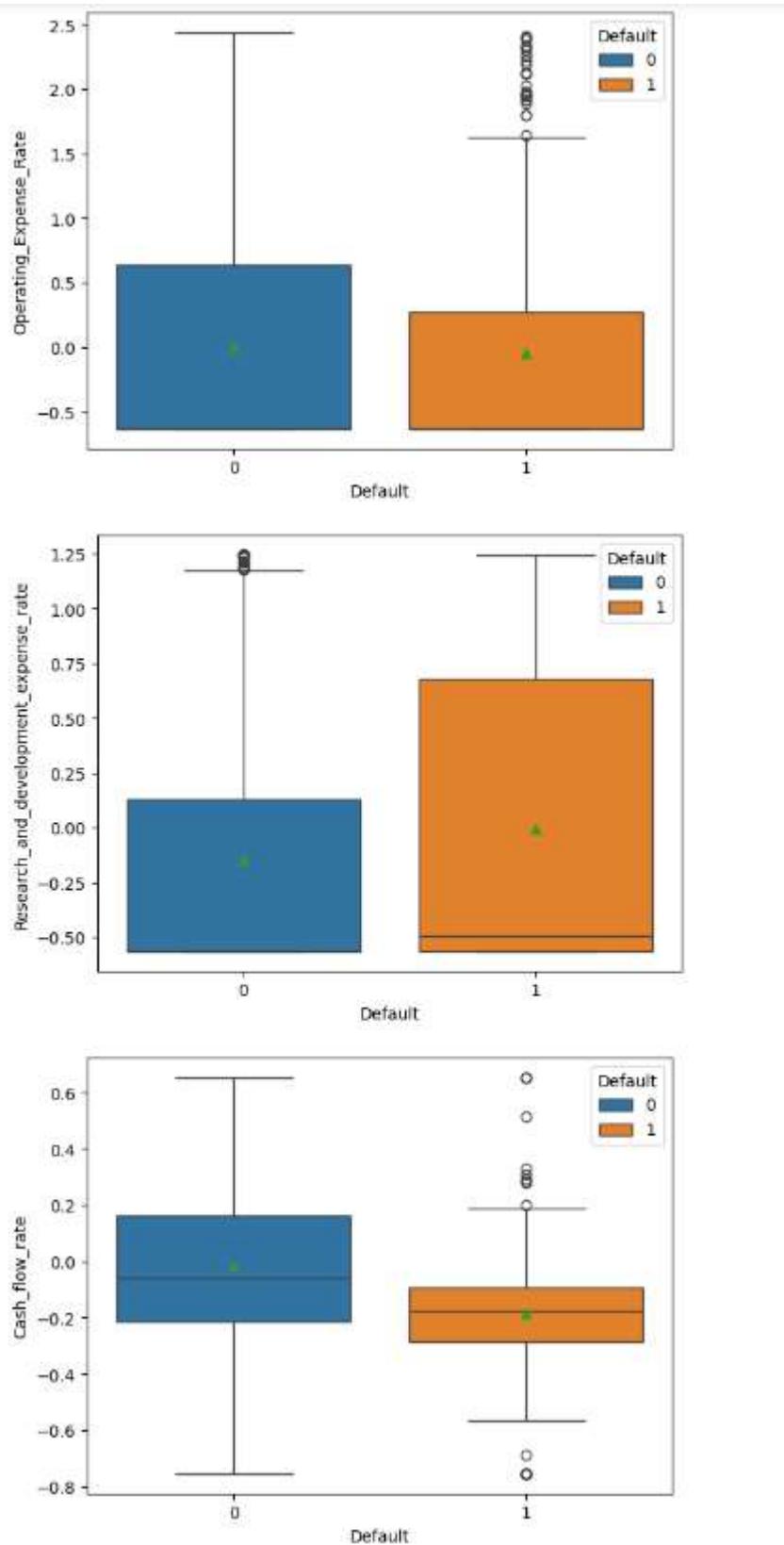
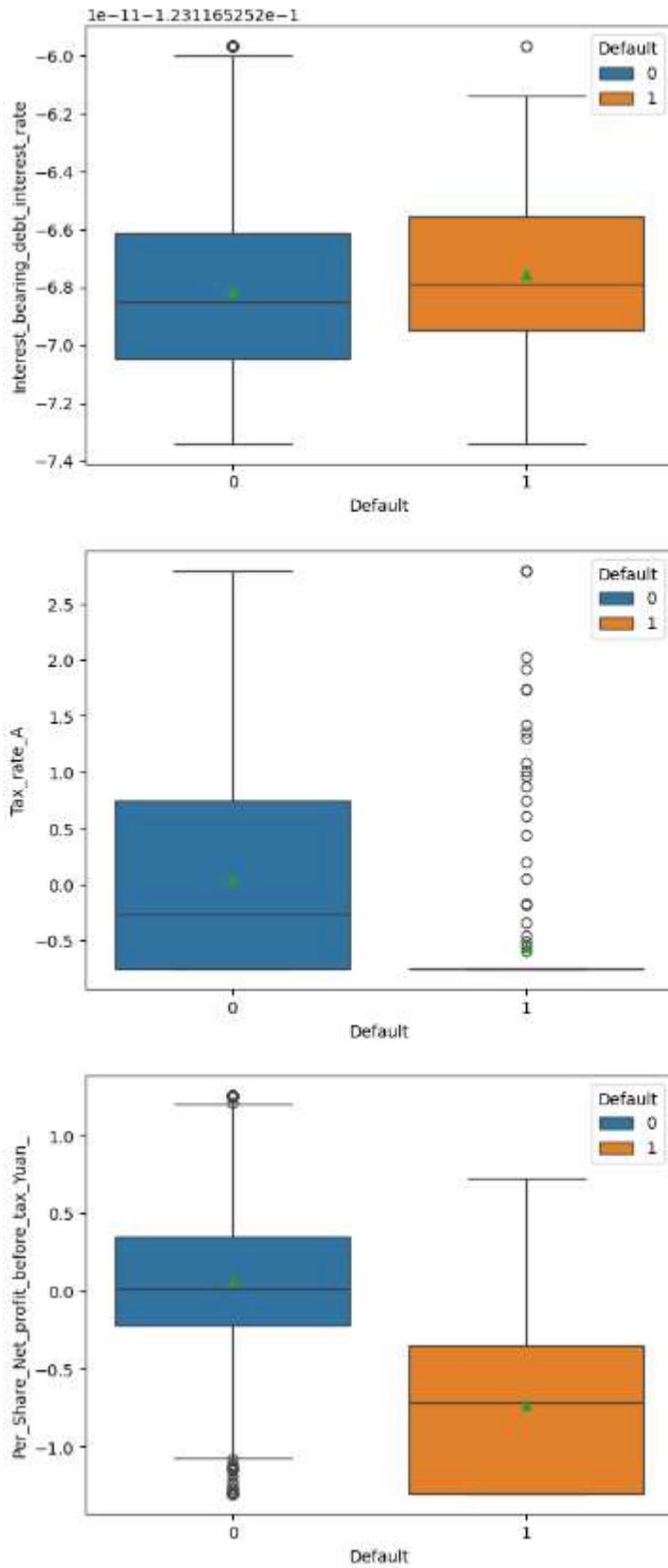


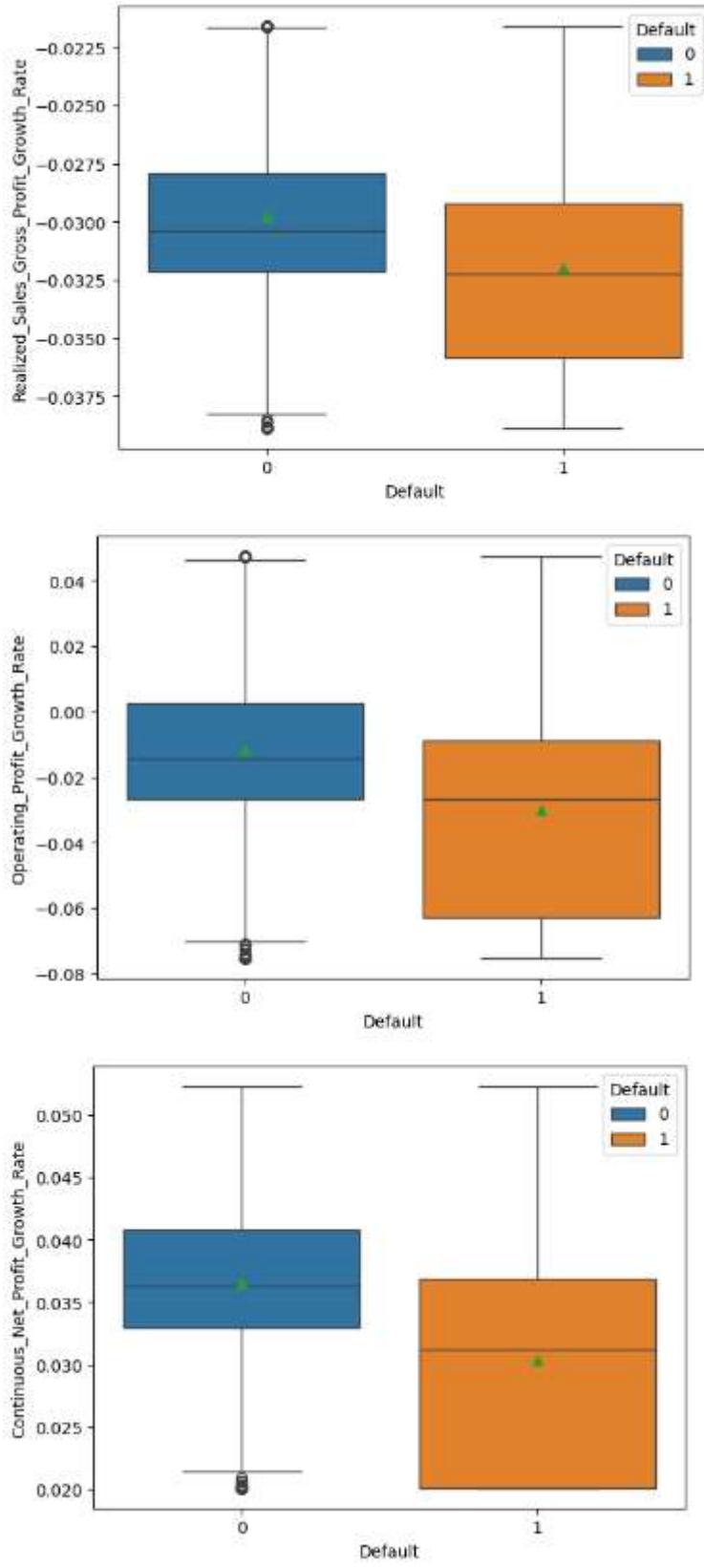
Fig.1.10 Bivariate analysis- Heatmap of numerical variables

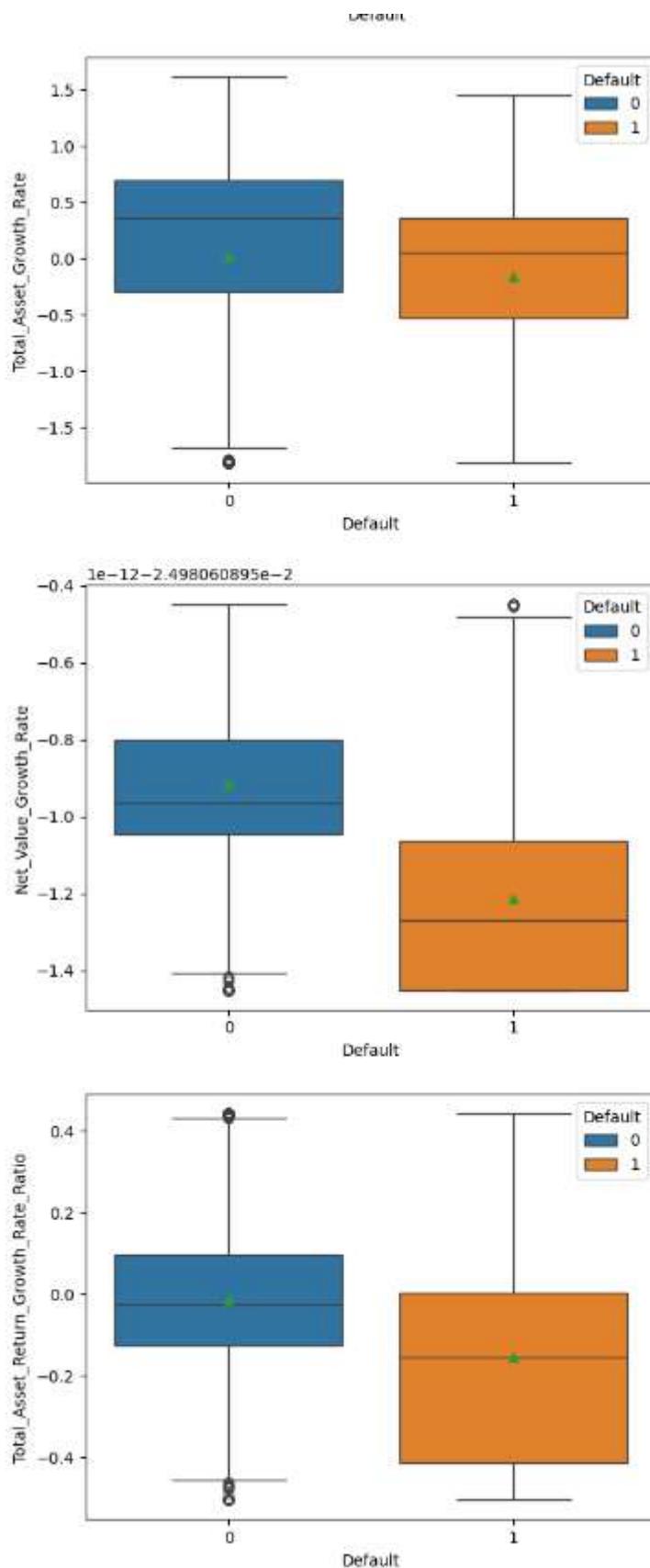
Observations:

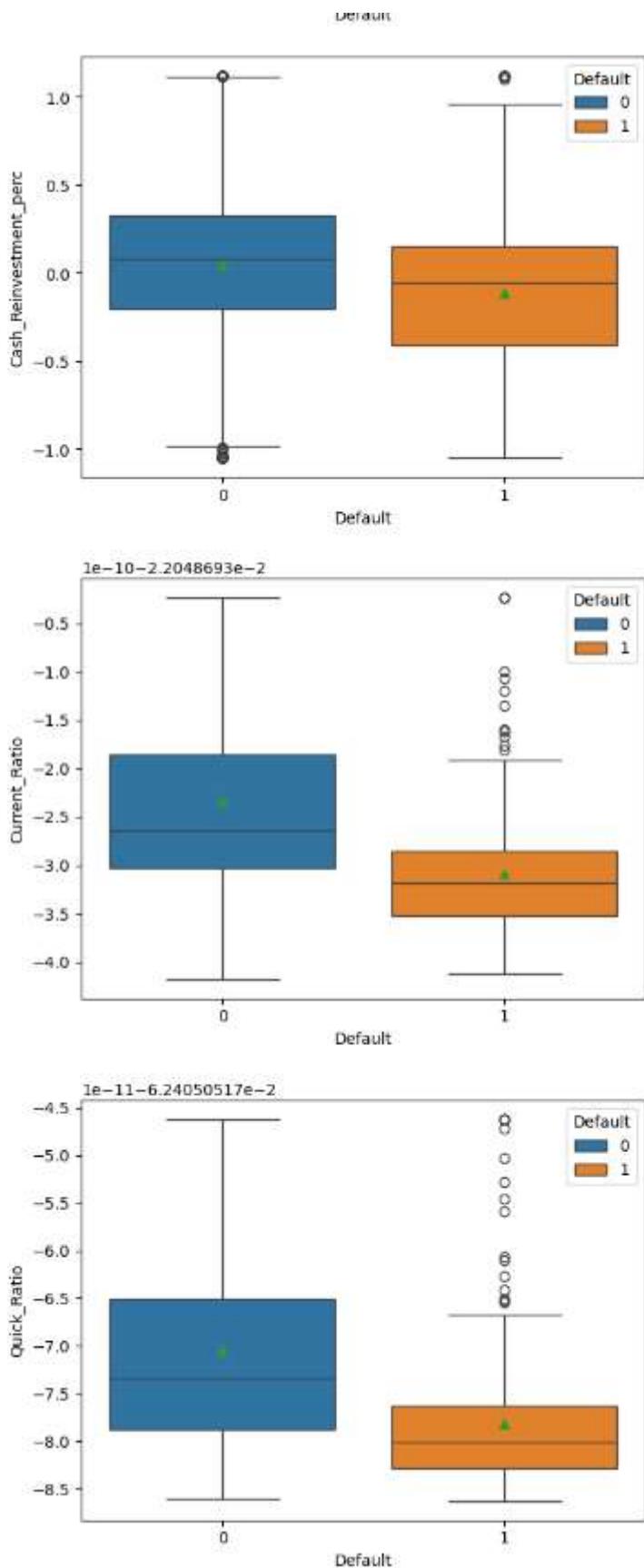
- Multicollinearity is present, which has to be addressed before further processing

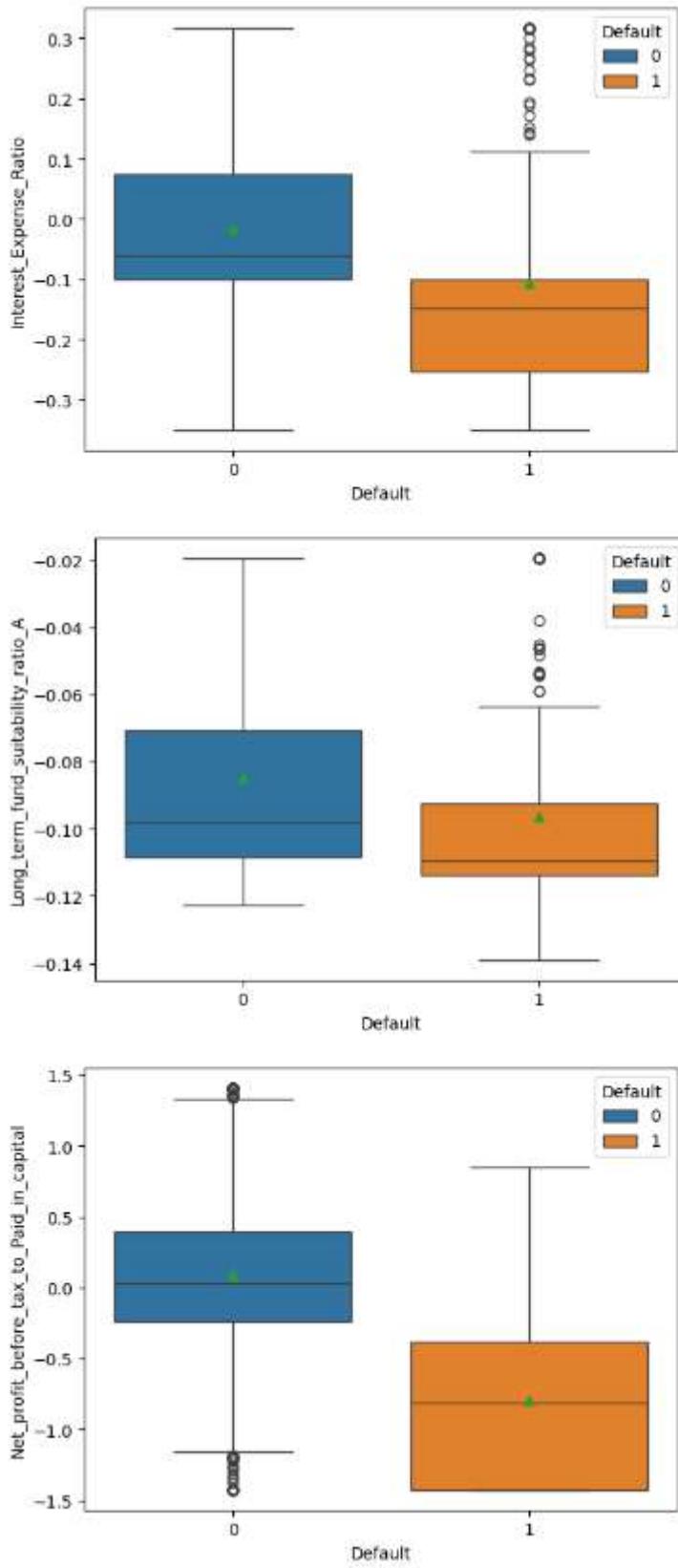


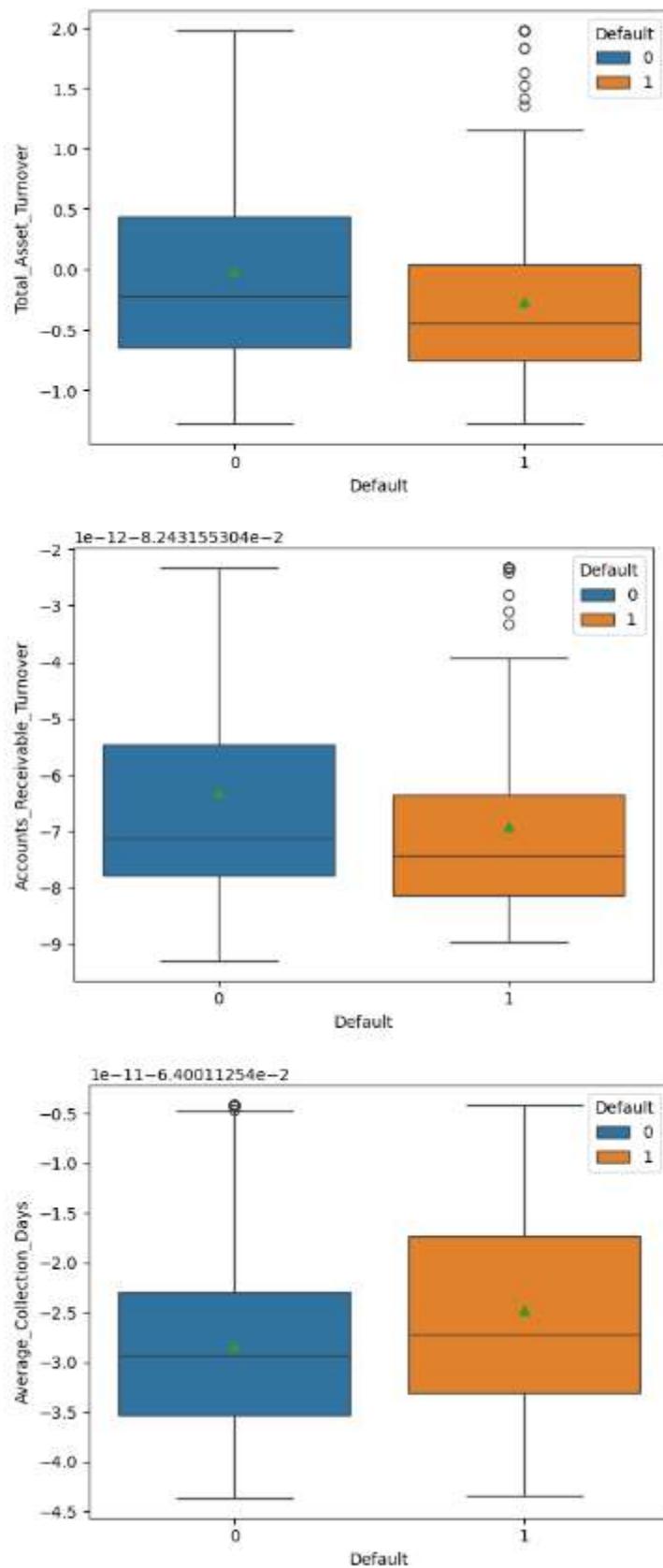


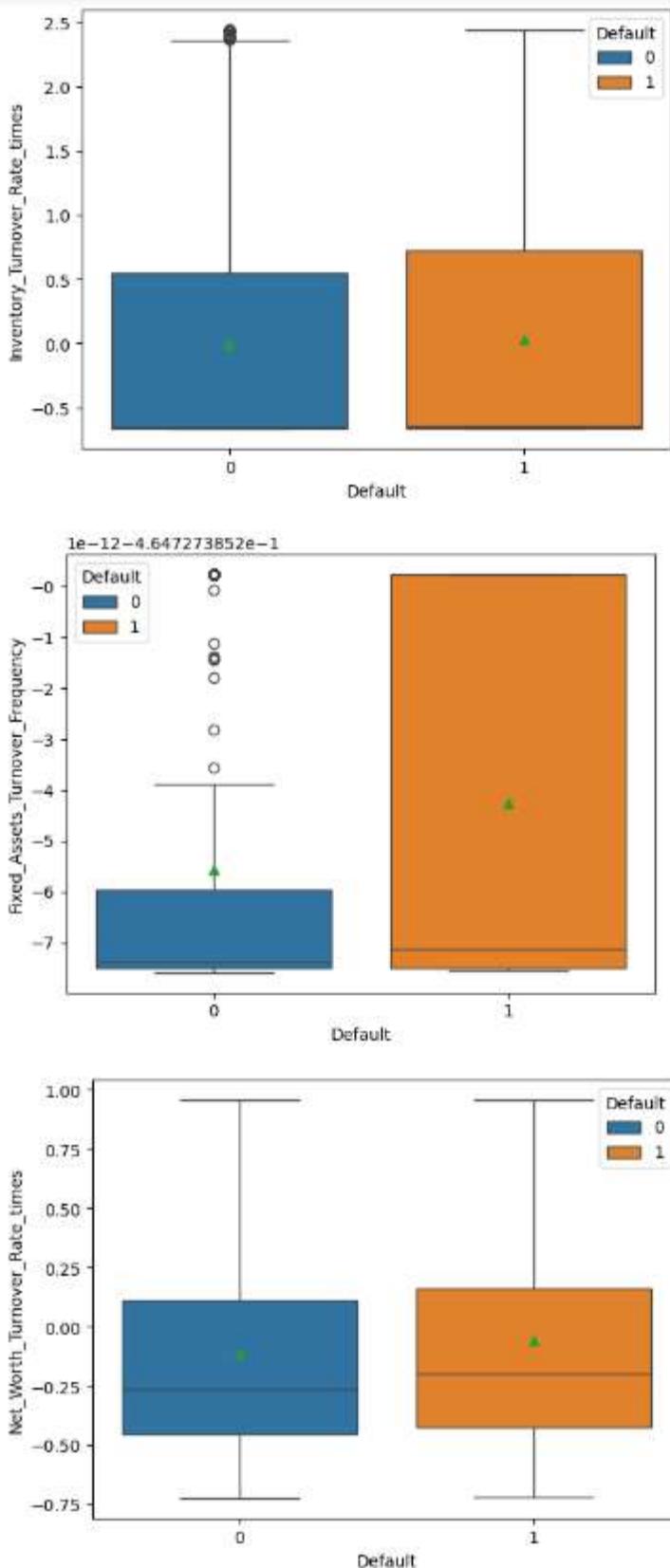


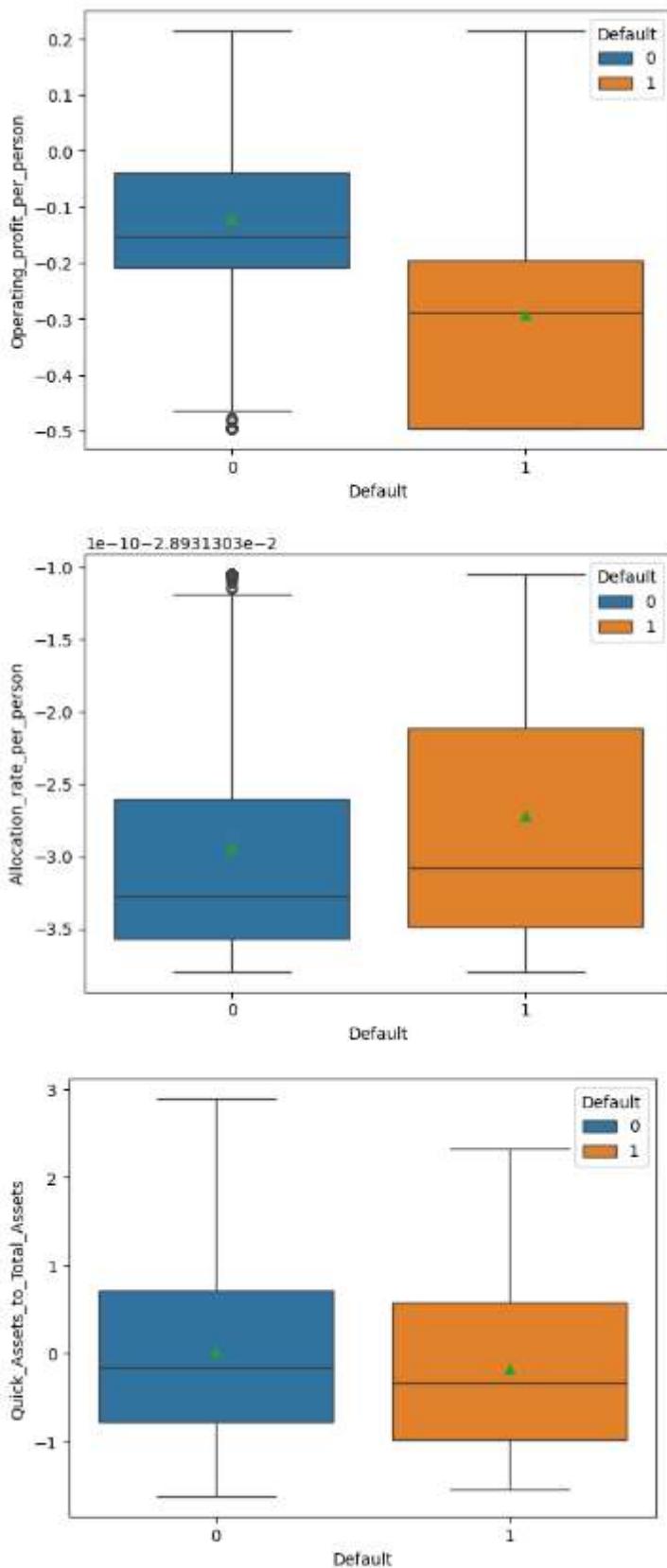


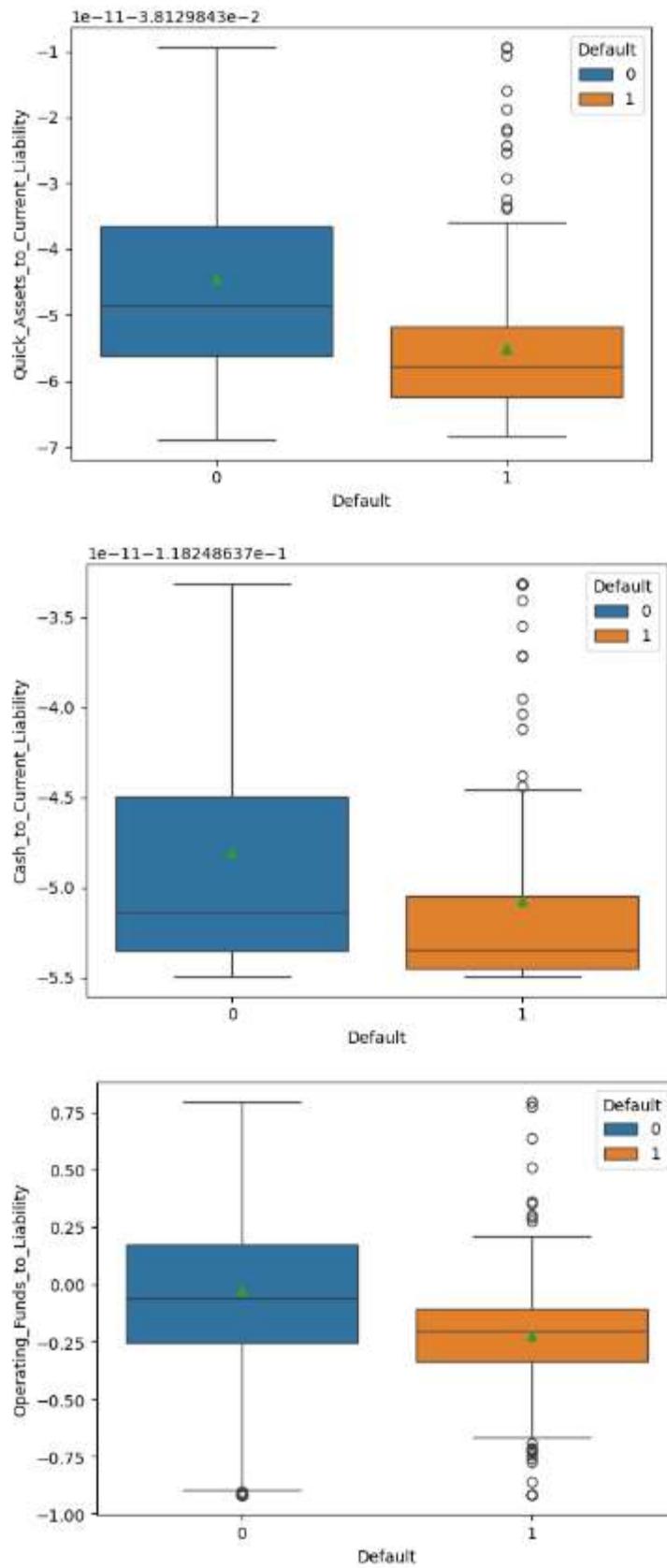


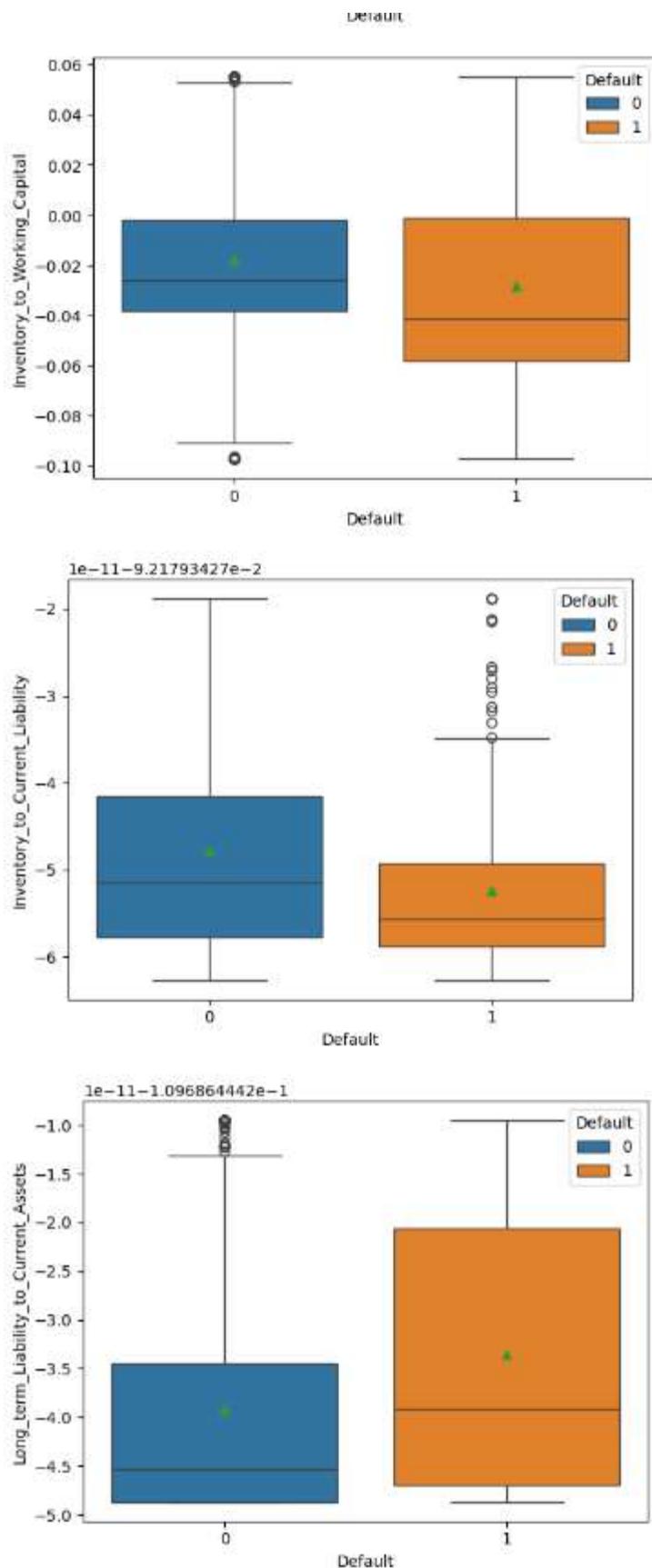


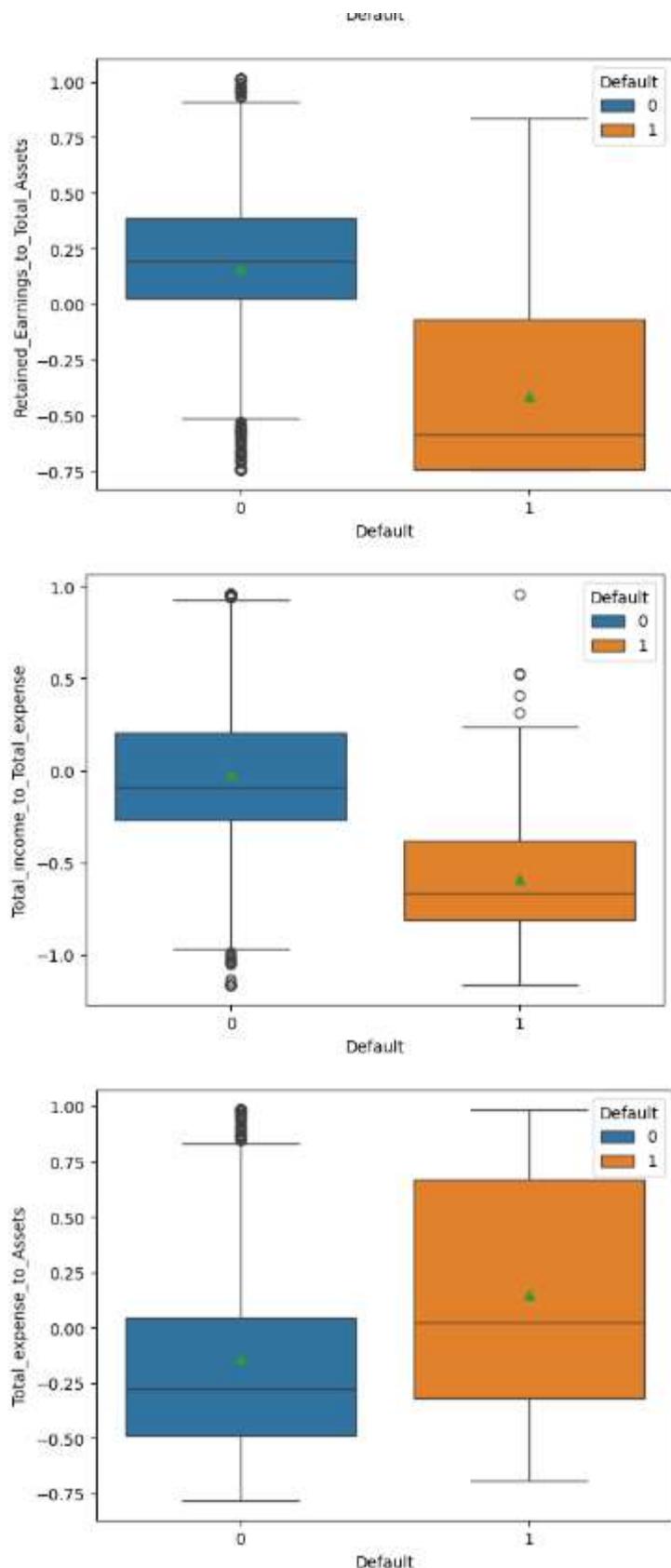


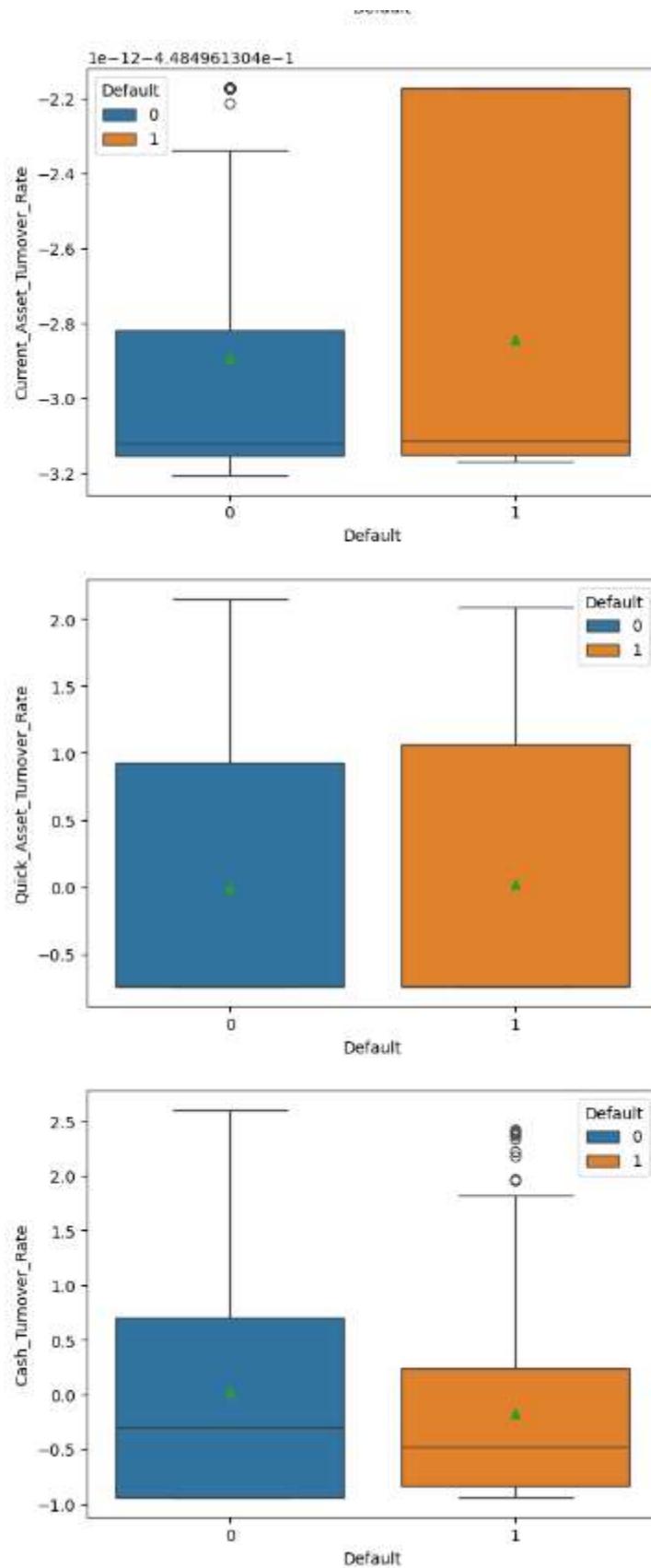


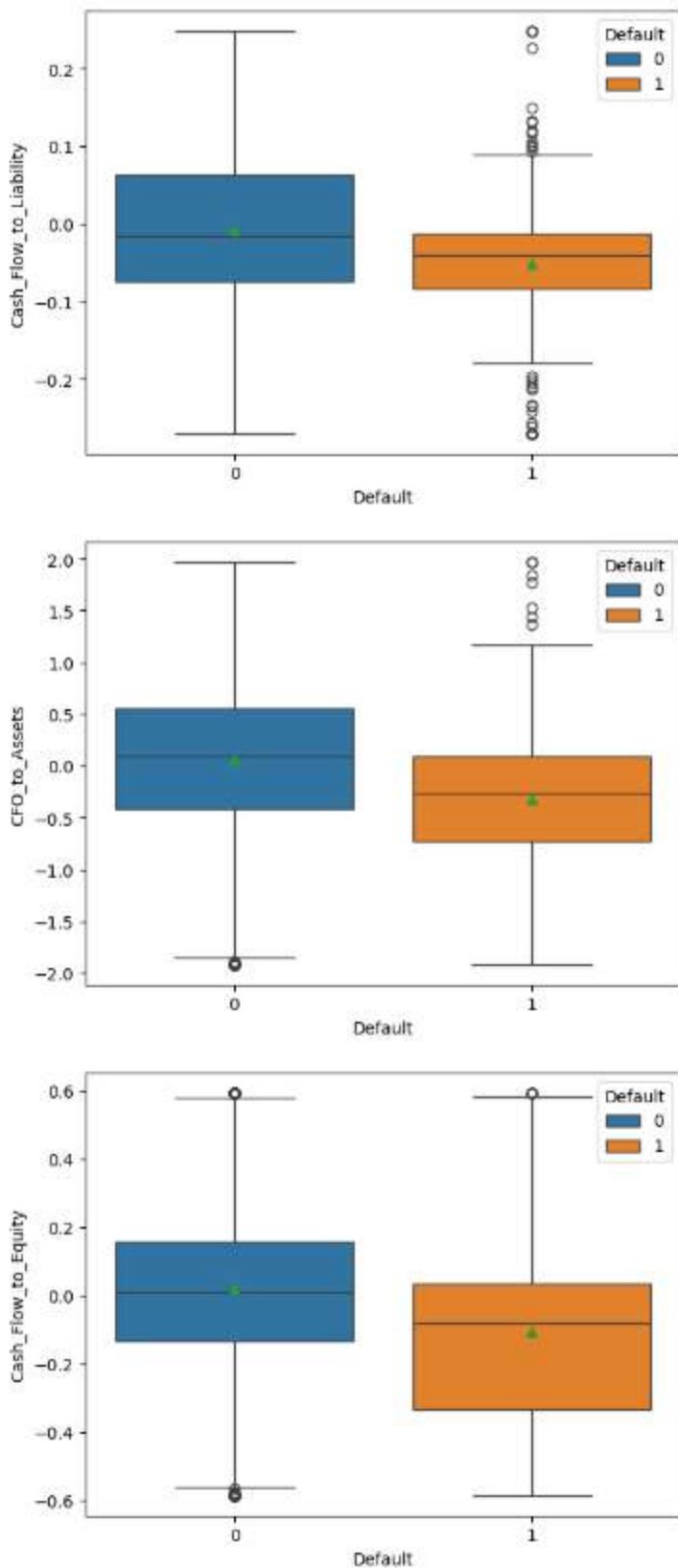


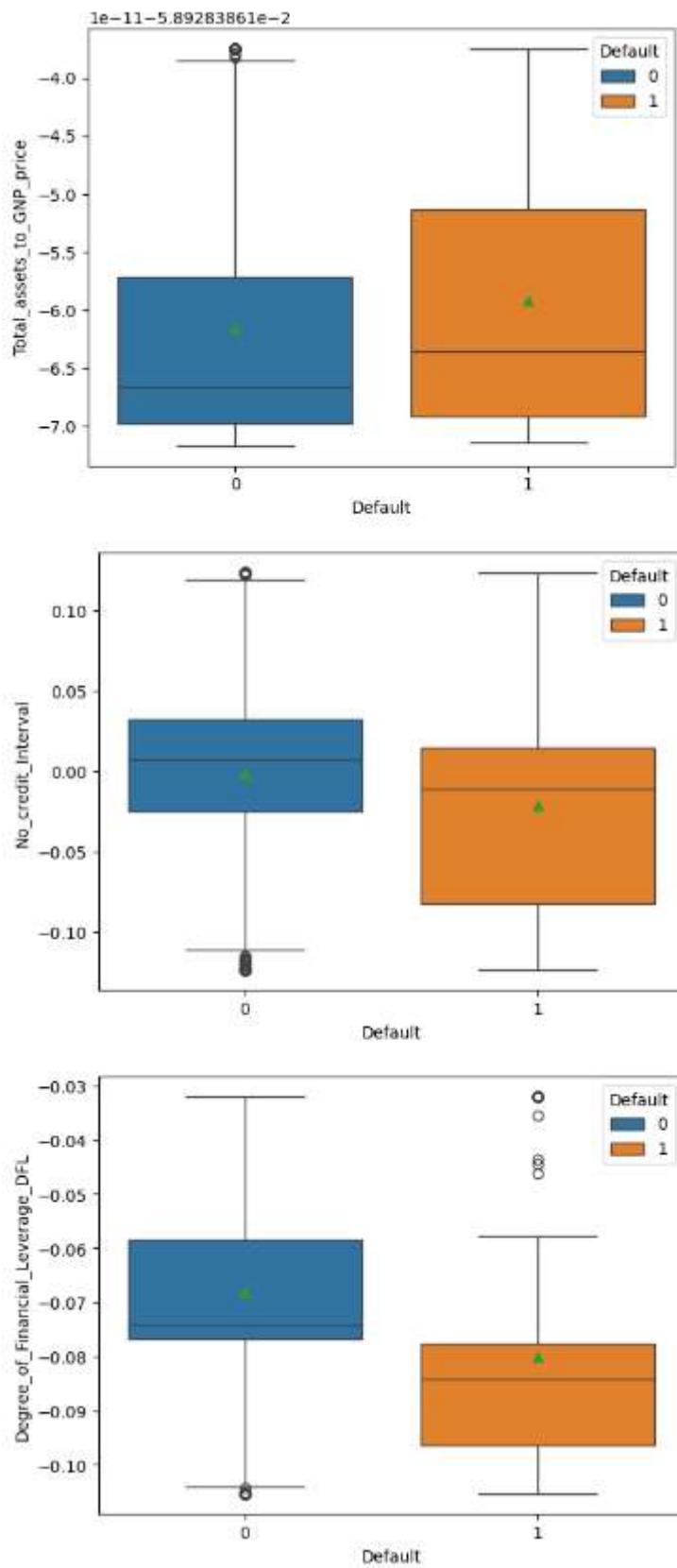


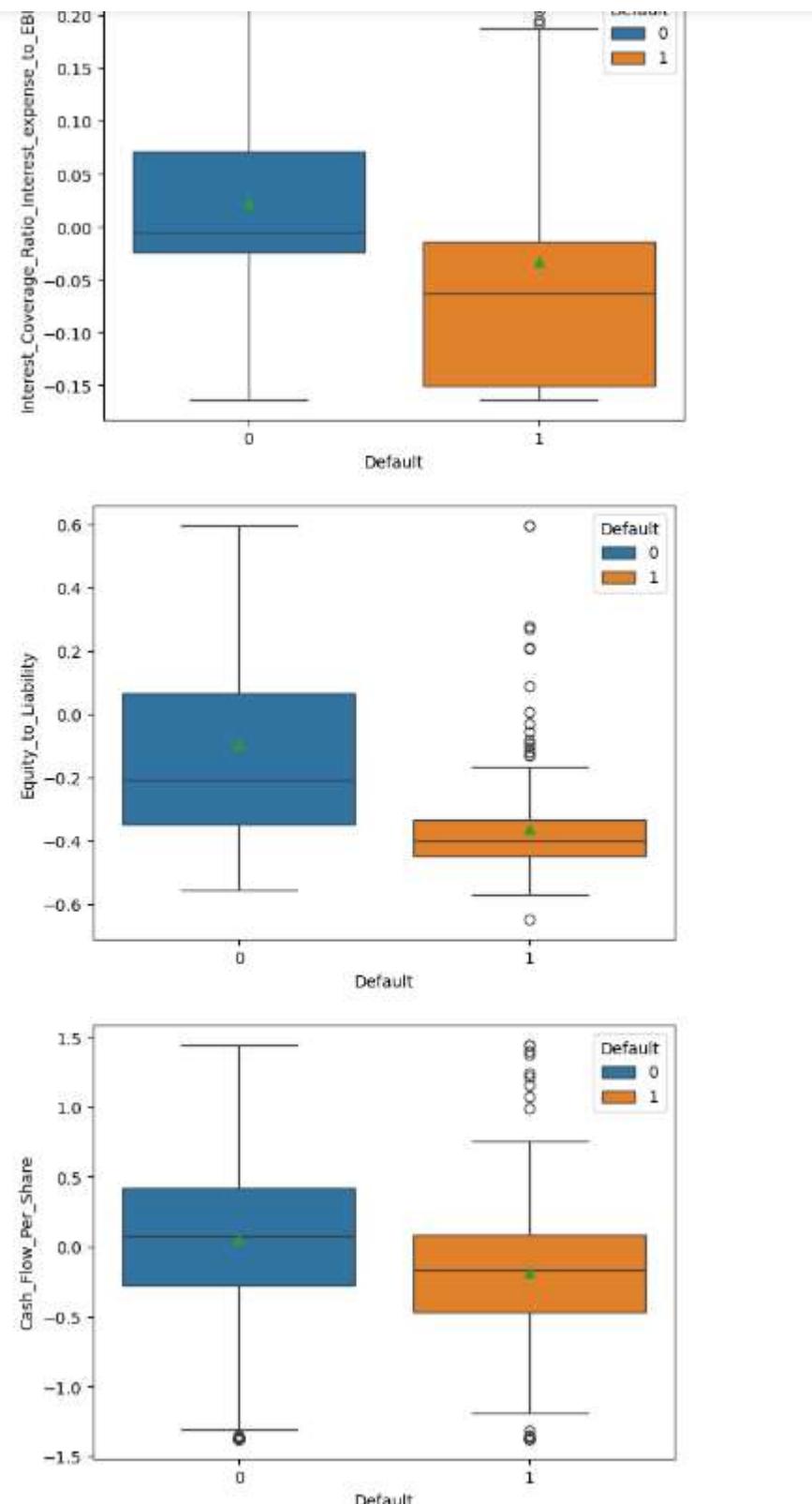












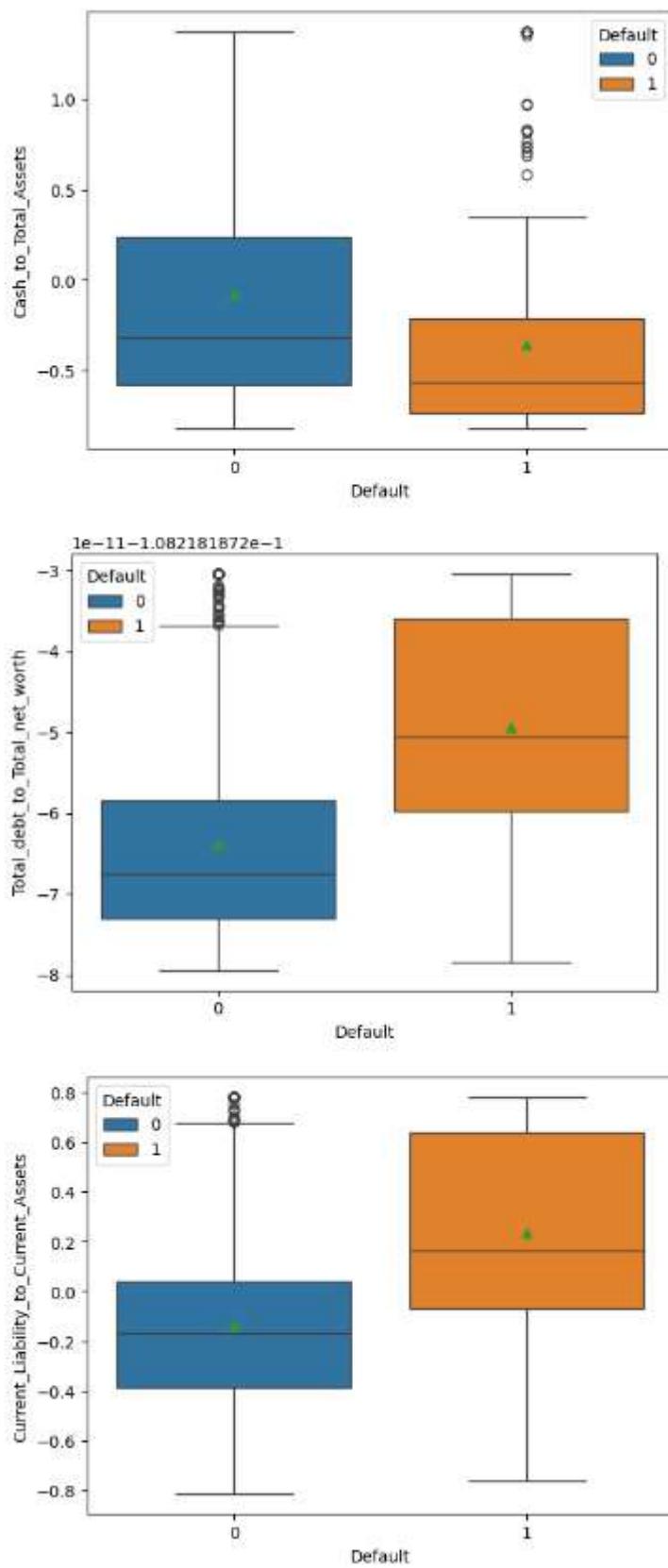


Fig.1.11. Bivariate Analysis- Numerical Variables vs Target Variables

Observations:

- For the defaulters, the mean and the median
 'Research_and_development_expense_rate', 'Average_Collection_Days',
 'Allocation_rate_per_person', 'Long_term_Liability_to_Current_Assets', 'Total_expense_to_Assets',
 'Fixed_Assets_to_Assets', 'Total_assets_to_GNP_price', 'Total_debt_to_Total_net_worth',
 'Current_Liability_to_Current_Assets' are significantly higher compared to non-defaulters
- Also, the mean and median 'Cash_flow_rate', 'Tax_rate_A', 'Per_Share_Net_profit_before_tax_Yuan',
 'Realized_Sales_Gross_Profit_Growth_Rate', 'Operating_Profit_Growth_Rate',
 'Continuous_Net_Profit_Growth_Rate', 'Total_Asset_Growth_Rate',
 'Net_Value_Growth_Rate', 'Total_Asset_Return_Growth_Rate_Ratio', 'Cash_Reinvestment_perc',
 'Current_Ratio', 'Quick_Ratio', 'Interest_Expense_Ratio', 'Long_term_fund_suitability_ratio_A',
 'Net_profit_before_tax_to_Paid_in_capital', 'Total_Asset_Turnover', 'Operating_profit_per_person',
 'Quick_Assets_to_Current_Liability',
 'Cash_to_Current_Liability', 'Operating_Funds_to_Liability', 'Inventory_to_Working_Capital',
 'Inventory_to_Current_Liability', 'Retained_Earnings_to_Total_Assets',
 'Total_income_to_Total_expense', 'Cash_Flow_to_Total_Assets', 'Cash_Flow_to_Liability',
 'CFO_to_Assets', 'Cash_Flow_to_Equity', 'No_credit_Interval',
 'Degree_of_Financial_Leverage_DFL', 'Interest_Coverage_Ratio_Interest_expense_to_EBIT', 'Equity_to_Liability',
 'Cash_Flow_Per_Share', 'Cash_to_Total_Assets' are significantly lower compared to non-defaulters
- The variables have high multicollinearity and there are 55 dimensions. So, in order to reduce dimensionality and reduce multicollinearity, VIF method was used to eliminate the variables that have VIF>5 one after the other

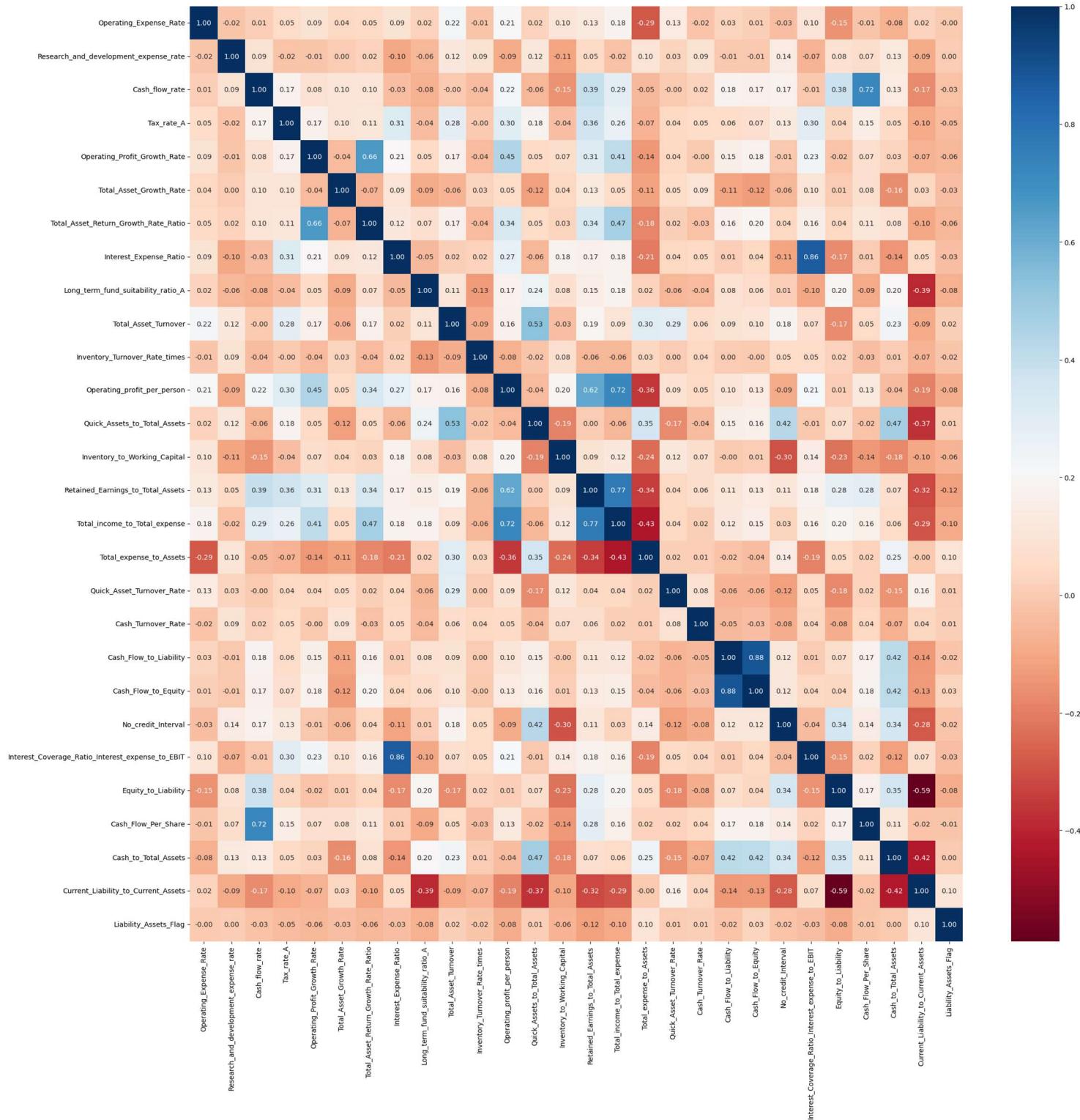


Fig.1.12. Heatmap of correlation between numerical variables after eliminating variables causing high multicollinearity using VIF

4. Train Test Split

Observations:

- The train-test split was done keeping a test size of 0.33, and random state 42

- After the split the shapes of the datasets are,
 - o X_train =(1378,28)
 - o X_test=(680,28)
 - o Y_train=(1378,)
 - o Y_test=(680,)
- On exploring the the y_train dataset, the target variable proportions are:

```
0    1225          0    0.88897
1    153           1    0.11103
Name: Default, dtype: int64   Name: Default, dtype: float64
```

- Thus, a SMOTE balancing was done, after which split the shapes of the datasets are,
 - o X_train =(2450,28)
 - o X_test=(680,28)
 - o Y_train=(2450,)
 - o Y_test=(680,)
- The split of proportion of the target variables for both the classes was 50%.

```
0    1225
1    1225
Name: Default, dtype: int64
```

○

5. Build Logistic Regression Model (using statsmodels library) on most important variables on train dataset and choose the optimum cut-off. Also showcase your model building approach

Approach:

- The logistic regression from statsmodels library was used for model building.
- From the 28 predictor variables, the non-significant variables having p-value>0.05 were eliminated one by one.
- After 16 such iterations, the model was built using the formula:
 - o logit_model16= SM.logit(formula= 'Default ~ Research_and_development_expense_rate + Cash_flow_rate + Tax_rate_A + Total_Asset_Turnover + Operating_profit_per_person + Retained_Earnings_to_Total_Assets + Total_income_to_Total_expense + Quick_Asset_Turnover_Rate + Cash_Turnover_Rate + Cash_Flow_to_Liability + Equity_to_Liability + Cash_to_Total_Assets + Current_Liability_to_Current_Assets ',
data=Default_train).fit()
- Model Summary:

Logit Regression Results

Dep. Variable:	Default	No. Observations:	2450				
Model:	Logit	Df Residuals:	2436				
Method:	MLE	Df Model:	13				
Date:	Sun, 28 Jan 2024	Pseudo R-squ.:	0.5084				
Time:	10:54:39	Log-Likelihood:	-834.84				
converged:	True	LL-Null:	-1698.2				
Covariance Type:	nonrobust	LLR p-value:	0.000				
		coef	std err	z	P> z	[0.025	0.975]
	Intercept	-2.2972	0.188	-12.218	0.000	-2.666	-1.929
Research_and_development_expense_rate	0.7518	0.103	7.281	0.000	0.549	0.954	
Cash_flow_rate	-0.7352	0.330	-2.225	0.026	-1.383	-0.088	
Tax_rate_A	-0.2482	0.087	-2.862	0.004	-0.418	-0.078	
Total_Asset_Turnover	-0.3321	0.099	-3.351	0.001	-0.526	-0.138	
Operating_profit_per_person	2.7425	0.584	4.694	0.000	1.597	3.888	
Retained_Earnings_to_Total_Assets	-2.4425	0.288	-8.490	0.000	-3.006	-1.879	
Total_income_to_Total_expense	-2.0932	0.319	-6.552	0.000	-2.719	-1.467	
Quick_Asset_Turnover_Rate	-0.1658	0.070	-2.356	0.018	-0.304	-0.028	
Cash_Turnover_Rate	-0.3502	0.072	-4.889	0.000	-0.491	-0.210	
Cash_Flow_to_Liability	-2.2604	0.739	-3.060	0.002	-3.708	-0.812	
Equity_to_Liability	-4.5975	0.484	-9.504	0.000	-5.546	-3.649	
Cash_to_Total_Assets	-0.3968	0.159	-2.494	0.013	-0.709	-0.085	
Current_Liability_to_Current_Assets	0.9275	0.233	3.973	0.000	0.470	1.385	

Fig.1.13. Logistic Regression model summary

Train Data Performance

Confusion matrix:

```
[[ 904  321]
 [ 55 1170]]
```

Classification Report

	precision	recall	f1-score	support
0	0.94	0.74	0.83	1225
1	0.78	0.96	0.86	1225
accuracy			0.85	2450
macro avg	0.86	0.85	0.84	2450
weighted avg	0.86	0.85	0.84	2450

Fig.1.14. Logistic Regression- Train data performance

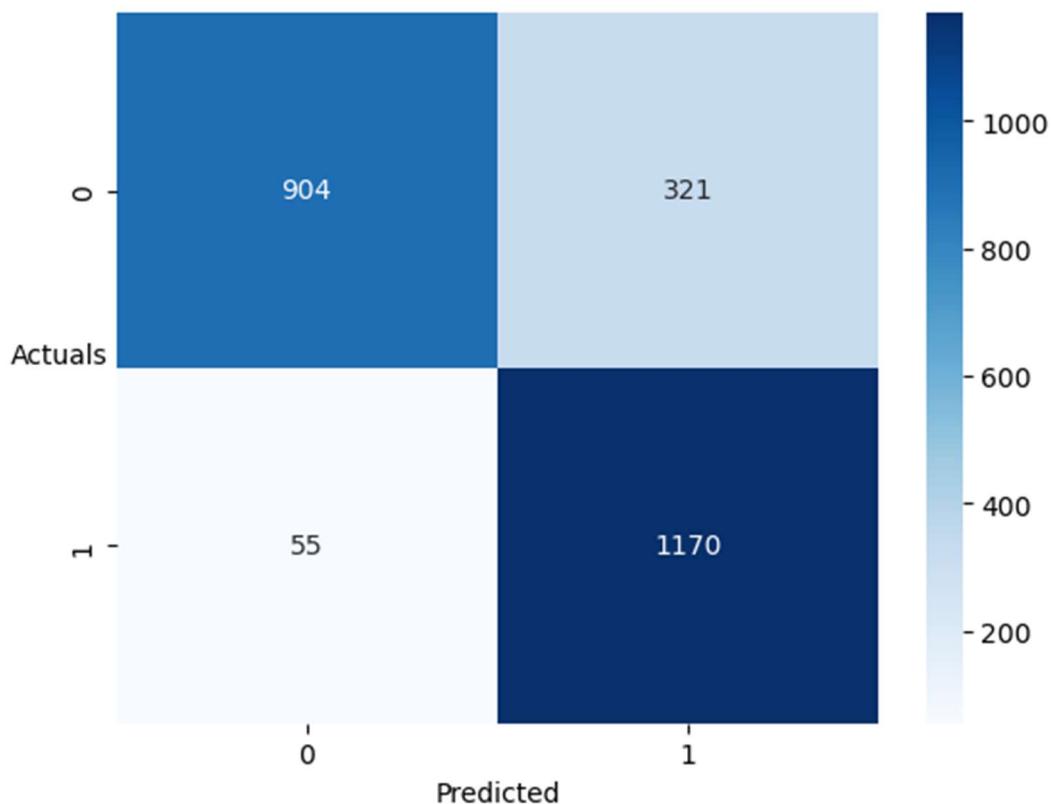


Fig.1.15. Logistic Regression- Confusion matrix- Train Data

6. Validate the Model on Test Dataset and state the performance metrics. Also state interpretation from the model

Logistic Regression Model

test Data Performance

Confusion matrix:

```
[[524 89]
 [13 54]]
```

Classification Report

	precision	recall	f1-score	support
0	0.98	0.85	0.91	613
1	0.38	0.81	0.51	67
accuracy			0.85	680
macro avg	0.68	0.83	0.71	680
weighted avg	0.92	0.85	0.87	680

Fig.1.16. Logistic Regression Model- Test Data Performance

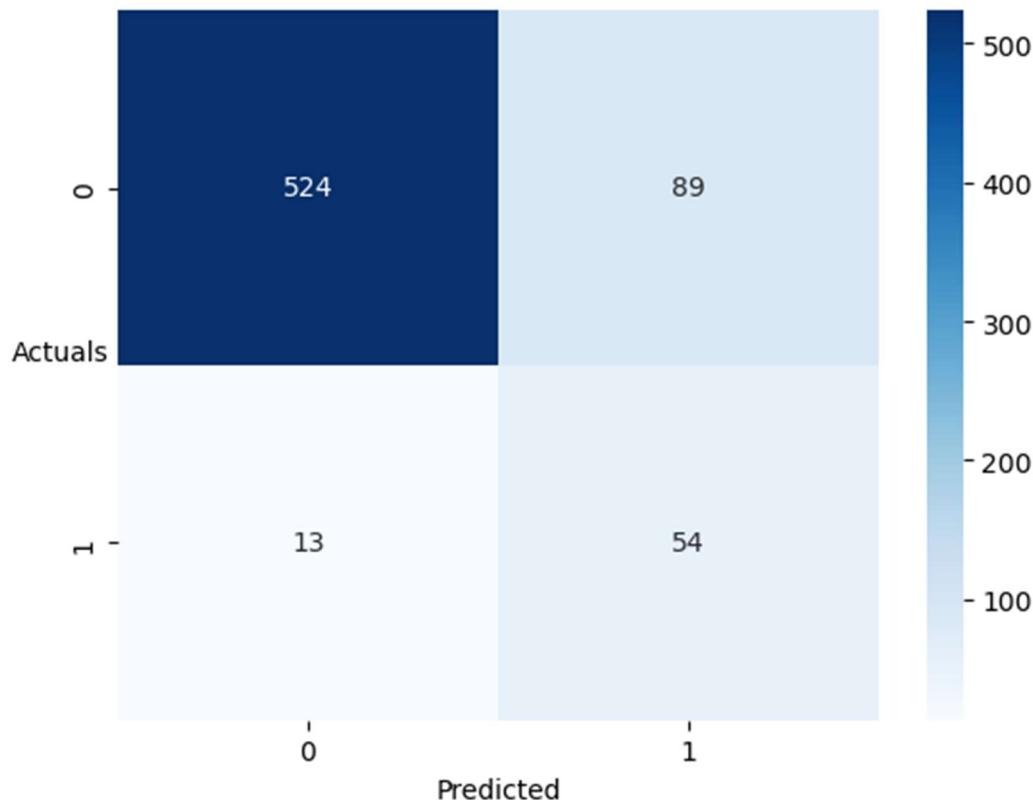


Fig.1.17. Logistic Regression- Confusion Matrix- Test Data

Interpretations:

- The model was overfit in the train set for precision metric.

- The performance of the model was consistent in both recall and accuracy across both train and test sets

7. Build a Random Forest Model on Train Dataset. Also showcase your model building approach

Approach:

- The model was built by using grid search for choosing best parameters for optimized results
- Best parameters:

```
{'max_depth': 12,
 'min_samples_leaf': 5,
 'min_samples_split': 10,
 'n_estimators': 50}
```

Random Forest Model

Train Data Performance

Confusion matrix:

```
[[1193  32]
 [ 19 1206]]
```

Classification Report

	precision	recall	f1-score	support
0	0.98	0.97	0.98	1225
1	0.97	0.98	0.98	1225
accuracy			0.98	2450
macro avg	0.98	0.98	0.98	2450
weighted avg	0.98	0.98	0.98	2450

Fig.1.18. Random Forest model- Train Data performance

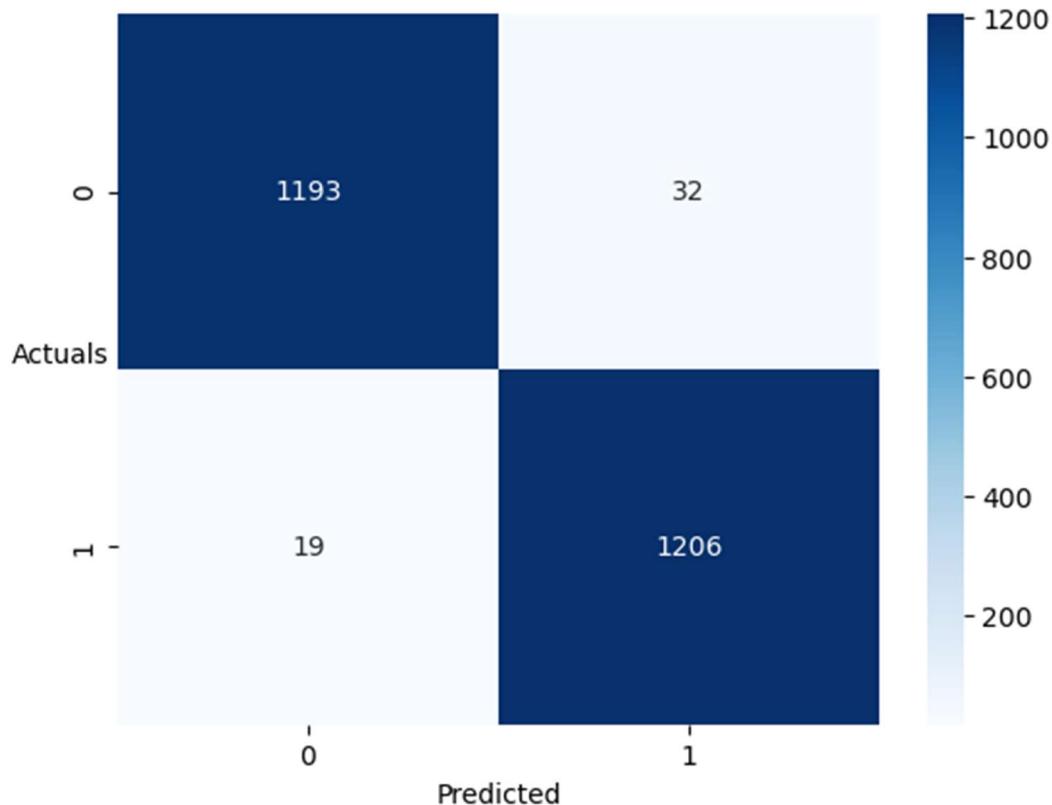


Fig.1.19. Random Forest model- Confusion Matrix- Train Data

- Validate the Random Forest Model on test Dataset and state the performance metrics. Also state interpretation from the model

Random Forest Model

test Data Performance

Confusion matrix:

```
[[563 50]
 [19 48]]
```

Classification Report

	precision	recall	f1-score	support
0	0.97	0.92	0.94	613
1	0.49	0.72	0.58	67
accuracy			0.90	680
macro avg	0.73	0.82	0.76	680
weighted avg	0.92	0.90	0.91	680

Fig.1.20. Random Forest model- Test data performance

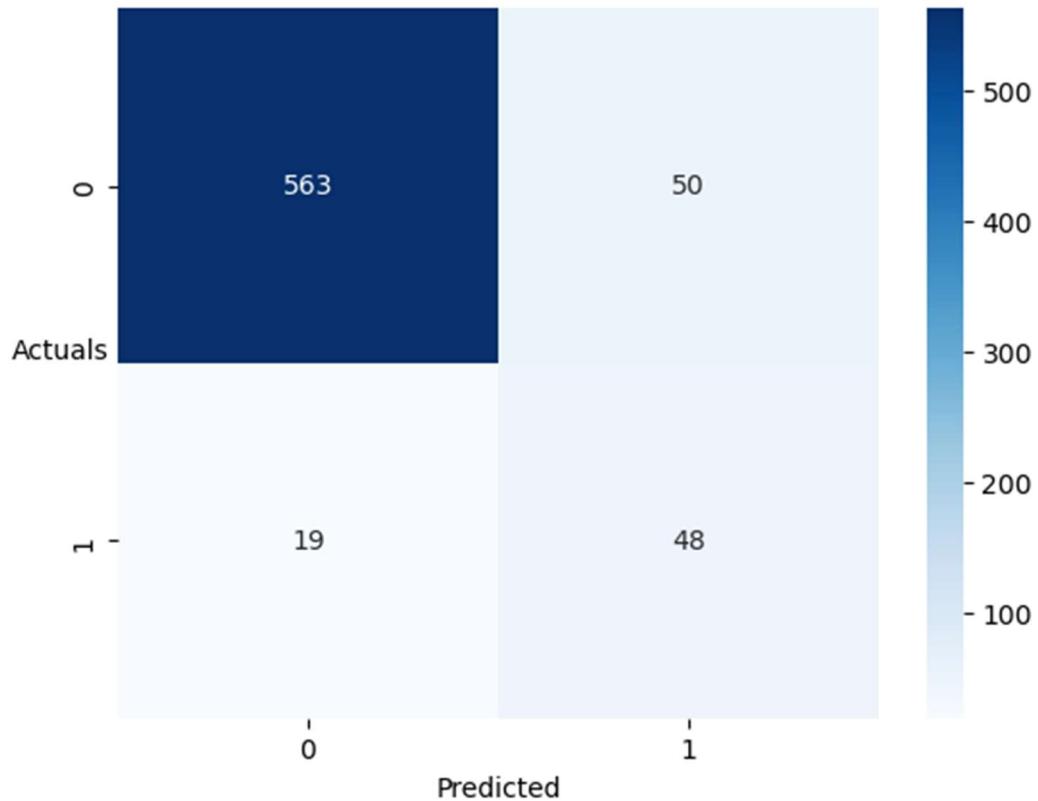


Fig.1.21. Random Forest model-Confusion matrix- test data

Interpretations:

- The model was extremely overfit, as all the scores- precision, recall, accuracy and f1 scores were excellent on train data
- However, on the test data, the model showed a good performance for accuracy, moderate performance for recall and a very poor performance for precision.

9. Build a LDA Model on Train Dataset. Also showcase your model building approach

LDA Model

Train Data Performance

Confusion matrix:

```
[[1033 192]
 [144 1081]]
```

Classification Report

	precision	recall	f1-score	support
0	0.88	0.84	0.86	1225
1	0.85	0.88	0.87	1225
accuracy			0.86	2450
macro avg	0.86	0.86	0.86	2450
weighted avg	0.86	0.86	0.86	2450

Fig.1.22. LDA model- Train data performance

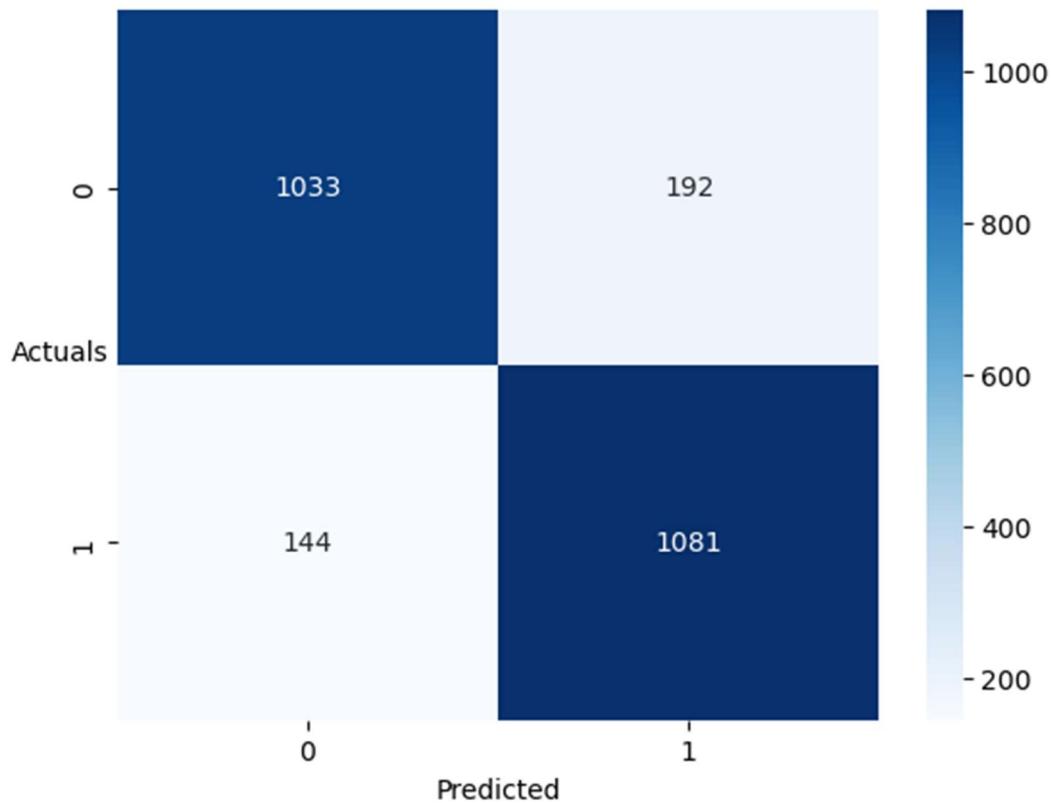


Fig.1.23. LDA model- Confusion Matrix- Train Data

10. Validate the LDA Model on test Dataset and state the performance metrics. Also state interpretation from the model

LDA Model

test Data Performance

Confusion matrix:

```
[[517 96]
 [12 55]]
```

Classification Report

	precision	recall	f1-score	support
0	0.98	0.84	0.91	613
1	0.36	0.82	0.50	67
accuracy			0.84	680
macro avg	0.67	0.83	0.71	680
weighted avg	0.92	0.84	0.87	680

Fig.1.24. LDA model- Test Data Performance

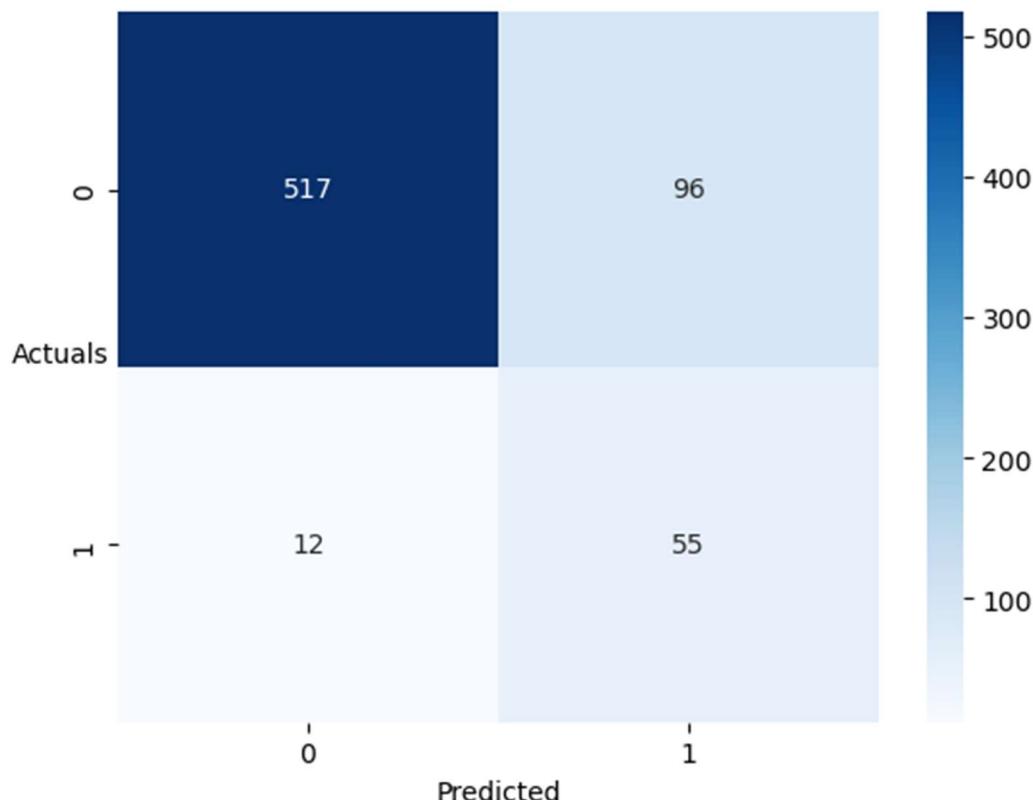


Fig.1.25. LDA model- Confusion Matrix- test data

Interpretations:

- The model had an overfit precision score on the train data

- The recall of the model for the default class was consistent on both the train and test data, as was the accuracy

11. Compare the performances of Logistic Regression, Random Forest, and LDA models (include ROC curve)

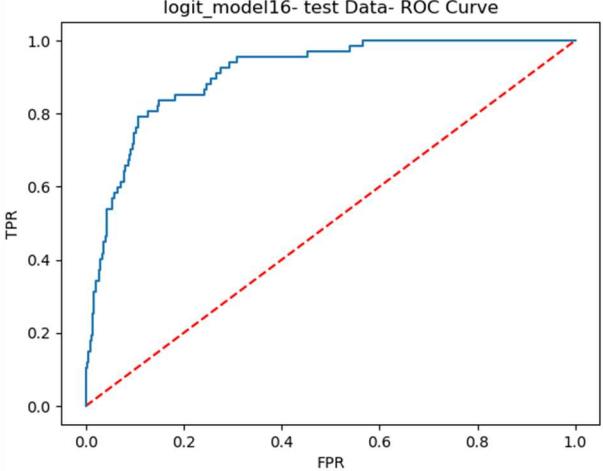
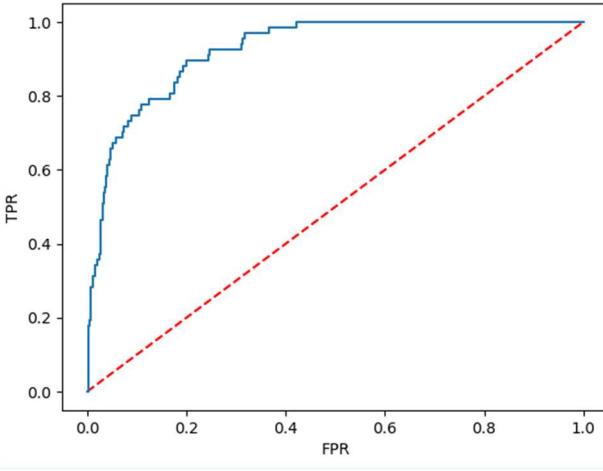
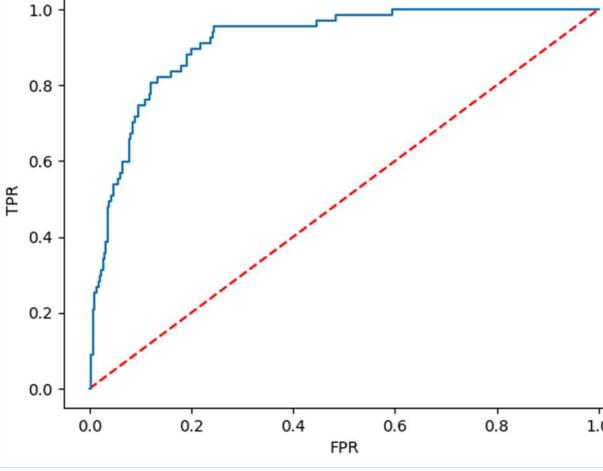
Model Name	Precision	Recall	F1 Score	Accuracy	ROC curve
Logistic Regression	0.38	0.81	0.51	0.82	 <p>logit_model16- test Data- ROC Curve</p> <p>This ROC curve plot shows the True Positive Rate (TPR) on the y-axis against the False Positive Rate (FPR) on the x-axis, both ranging from 0.0 to 1.0. A blue step-line represents the model's performance, starting at (0,0) and rising to approximately (1,1). A red dashed diagonal line represents a random classifier.</p>
Random Forest	0.49	0.72	0.58	0.90	 <p>Random Forest- test Data- ROC Curve</p> <p>This ROC curve plot shows the True Positive Rate (TPR) on the y-axis against the False Positive Rate (FPR) on the x-axis, both ranging from 0.0 to 1.0. A blue step-line represents the model's performance, starting at (0,0) and rising to approximately (1,1). A red dashed diagonal line represents a random classifier.</p>
LDA	0.40	0.82	0.53	0.83	 <p>Linear Discriminant Analysis- test Data- ROC Curve</p> <p>This ROC curve plot shows the True Positive Rate (TPR) on the y-axis against the False Positive Rate (FPR) on the x-axis, both ranging from 0.0 to 1.0. A blue step-line represents the model's performance, starting at (0,0) and rising to approximately (1,1). A red dashed diagonal line represents a random classifier.</p>

Table 1.1. Test Data Preformance Comparison

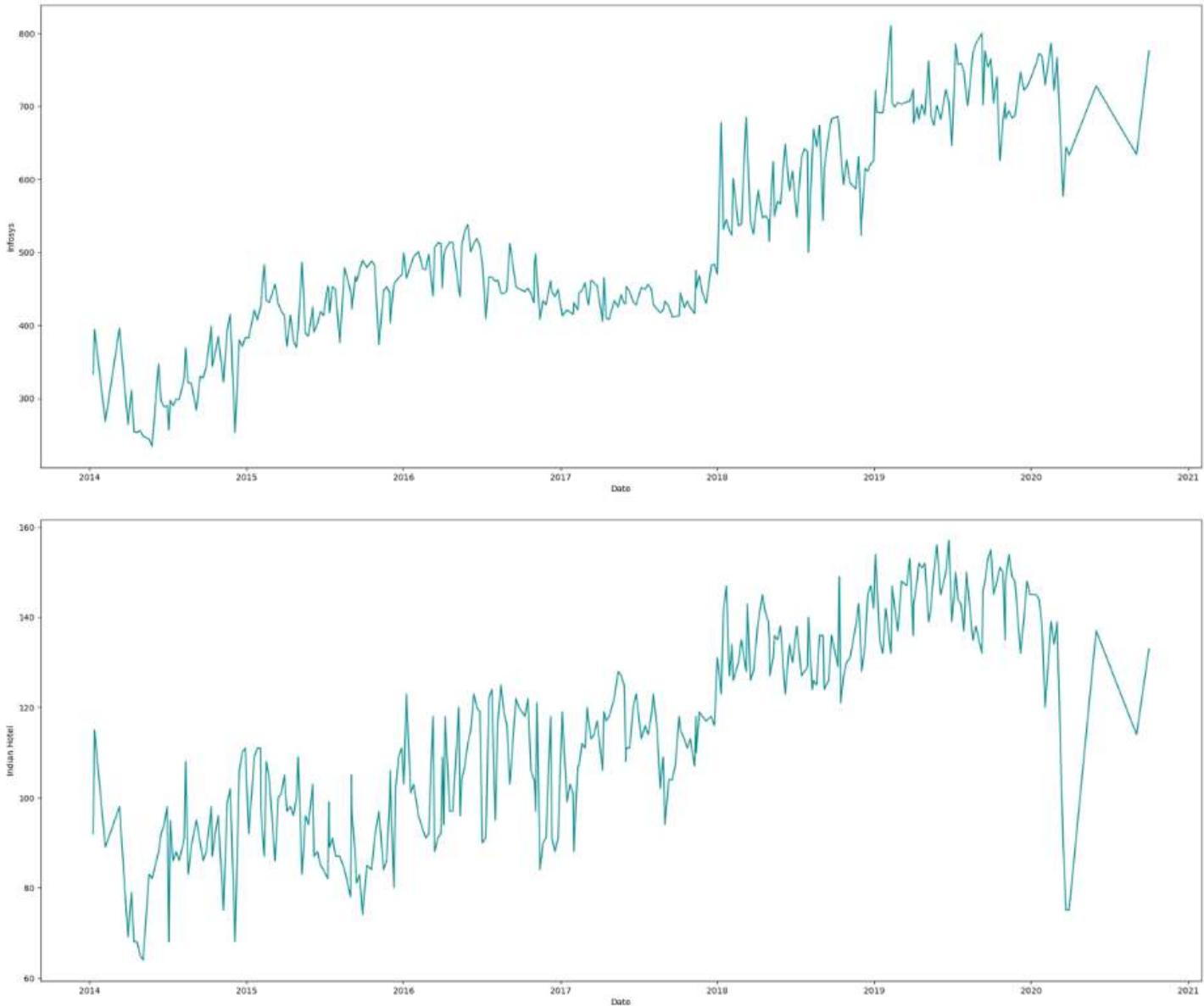
12. Conclusions and Recommendations

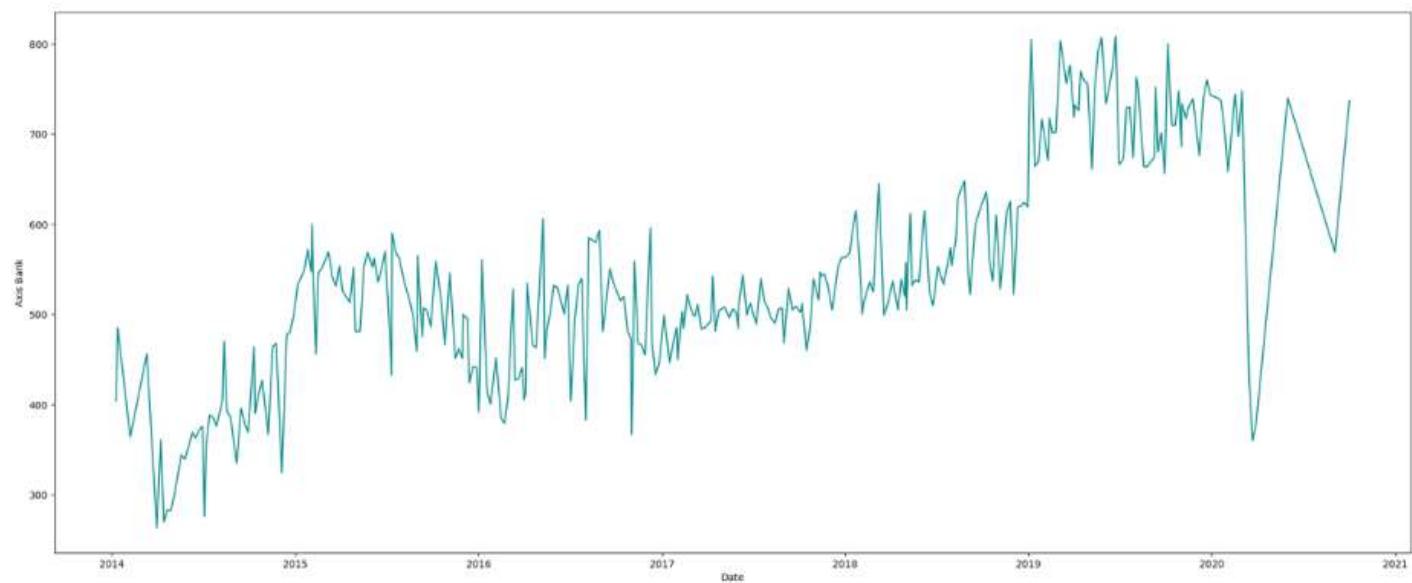
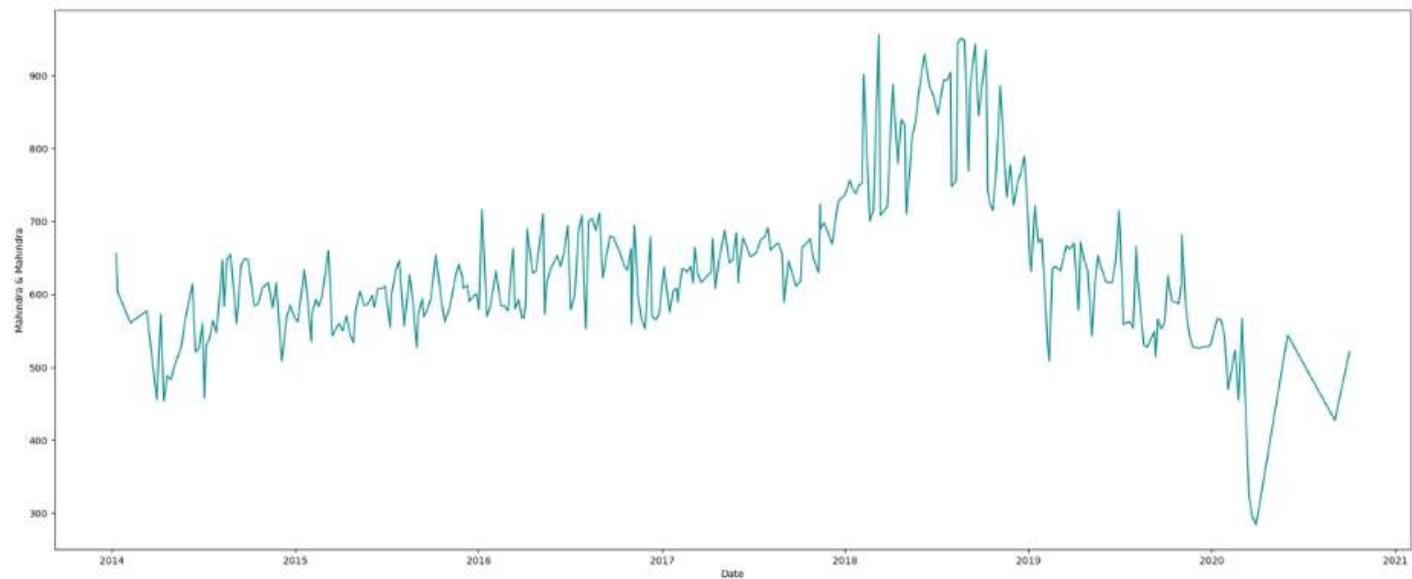
- This exercise was to identify a model for the classification of companies as Defaulter or Non- Defaulter based on certain financial parameters
- As the motive is credit analysis, this assessment will most likely be used to determine whether the companies are eligible for credit facility or not.
- Hence, considering the objective, the most important evaluation parameter would be recall, as it is better to make a misclassification as Defaulter than non-defaulter.
- Thus, based on recall Scores, the LDA model would be the most useful as evident from the table above
- However, the Random Forest model could be chosen for overall performance in all the metrics considered

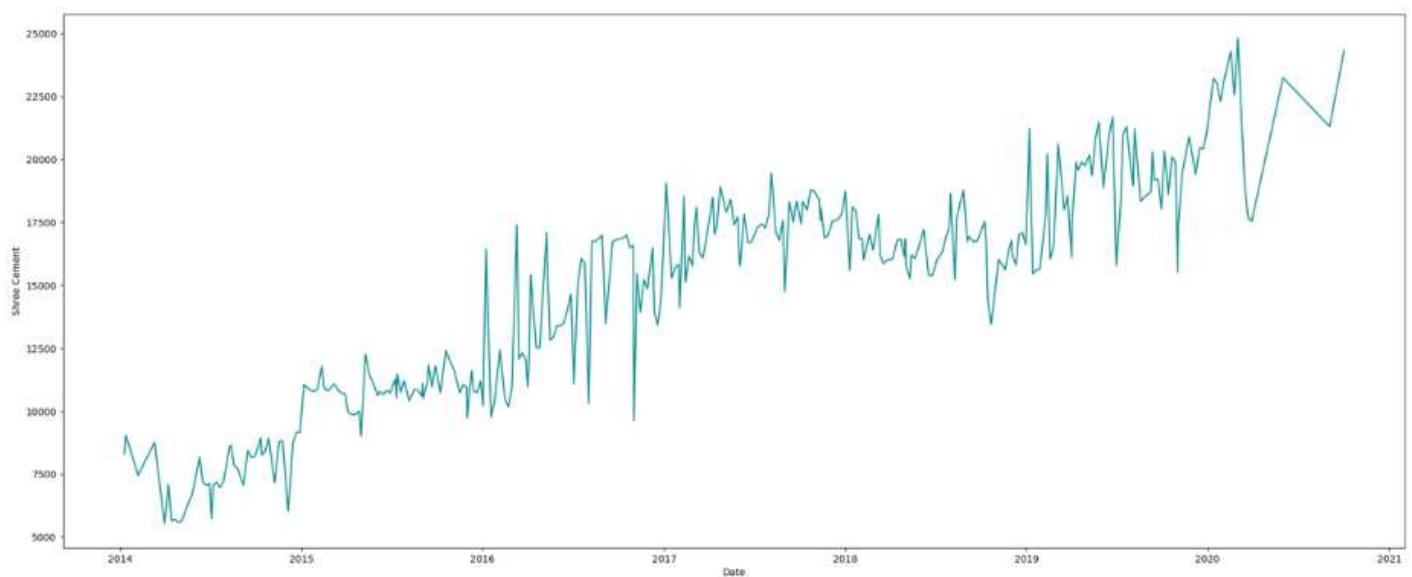
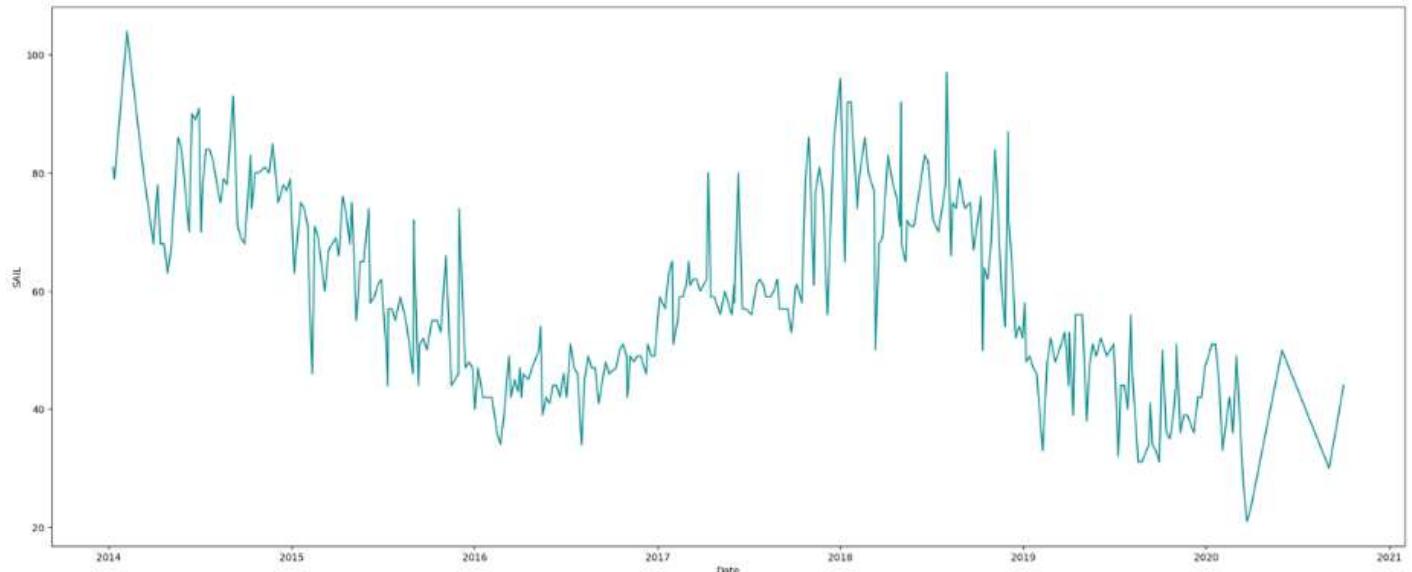
Case 2: Market Risk Analysis

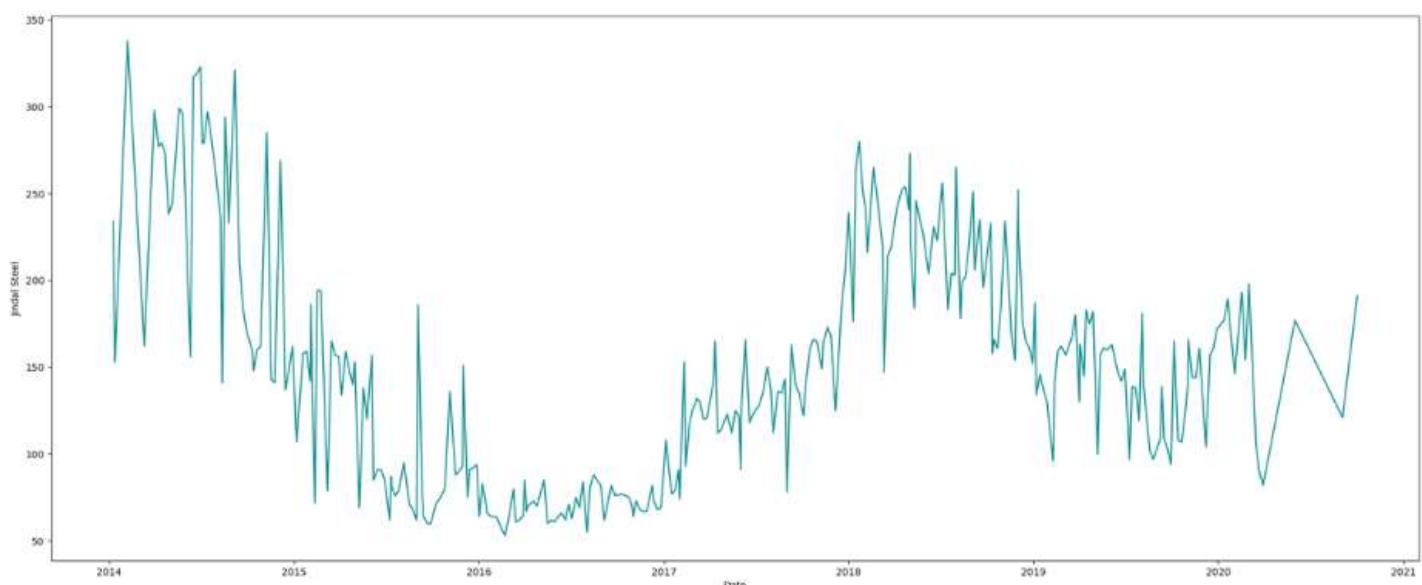
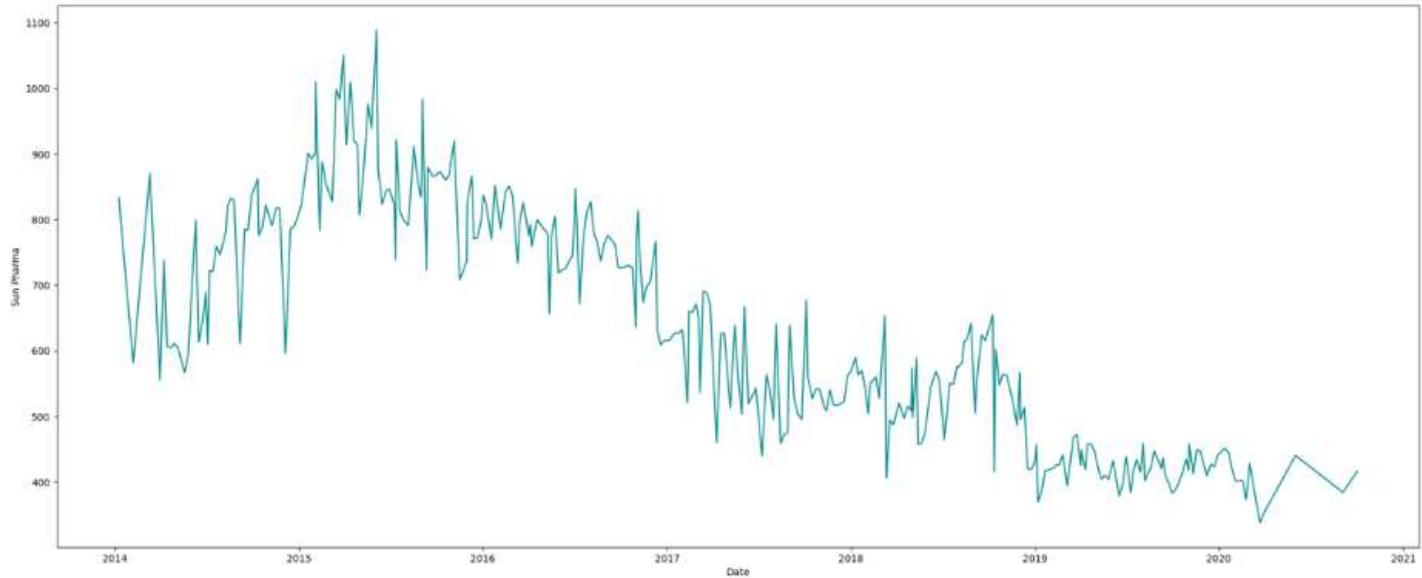
The dataset contains 6 years of information(weekly stock information) on the stock prices of 10 different Indian Stocks. Calculate the mean and standard deviation on the stock returns and share insights. You are expected to do the Market Risk Analysis using Python.

1. Draw Stock Price Graph(Stock Price vs Time) for any 2 given stocks with inference









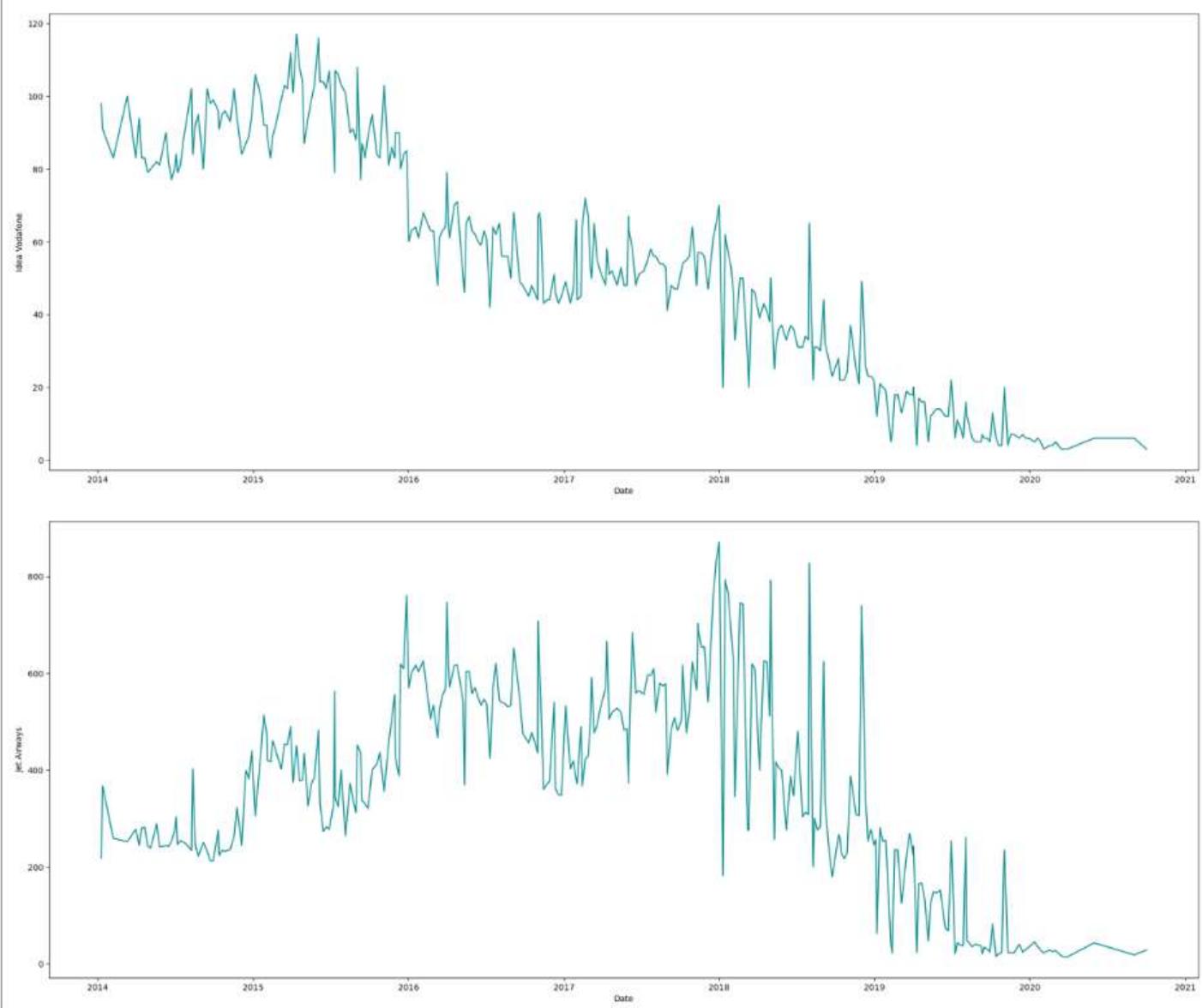


Fig.2.1. Price Vs time plots for stocks

Observations:

- Infosys, Indian Bank, Axis Bank and Shree Cement have a rising trend
- Mahindra & Mahindra , SAIL, Sun Pharma, Jindal Steel, Idea Vodafone , Jet Airways all show a declining trend
- Just within the scope of this data and from this preliminary analysis, bank and IT stocks seemed to have fared better

2. Calculate Returns for all stocks with inference

	count	mean	std	min	25%	50%	75%	max
Infosys	313.0	0.002794	0.035070	-0.167300	-0.014514	0.004376	0.024553	0.135666
Indian Hotel	313.0	0.000266	0.047131	-0.236389	-0.023530	0.000000	0.027909	0.199333
Mahindra & Mahindra	313.0	-0.001506	0.040169	-0.285343	-0.020884	0.001526	0.019894	0.089407
Axis Bank	313.0	0.001167	0.045828	-0.284757	-0.022473	0.001614	0.028522	0.127461
SAIL	313.0	-0.003463	0.062188	-0.251314	-0.040822	0.000000	0.032790	0.309005
Shree Cement	313.0	0.003681	0.039917	-0.129215	-0.019546	0.003173	0.029873	0.152329
Sun Pharma	313.0	-0.001455	0.045033	-0.179855	-0.020699	0.001530	0.023257	0.166604
Jindal Steel	313.0	-0.004123	0.075108	-0.283768	-0.049700	0.000000	0.037179	0.243978
Idea Vodafone	313.0	-0.010608	0.104315	-0.693147	-0.045120	0.000000	0.024391	0.693147
Jet Airways	313.0	-0.009548	0.097972	-0.458575	-0.052644	-0.005780	0.036368	0.300249

Fig.2.2. Market returns- Data Description

Observations:

- Infosys, Indian Hotel, Axis Bank, Shree Cement all have positive mean returns
- The rest have negative mean returns.
- These are consistent with the observations from the plots

3. Calculate Stock Means and Standard Deviation for all stocks with inference

	Returns	Volatility
Infosys	0.002794	0.035070
Indian Hotel	0.000266	0.047131
Mahindra & Mahindra	-0.001506	0.040169
Axis Bank	0.001167	0.045828
SAIL	-0.003463	0.062188
Shree Cement	0.003681	0.039917
Sun Pharma	-0.001455	0.045033
Jindal Steel	-0.004123	0.075108
Idea Vodafone	-0.010608	0.104315
Jet Airways	-0.009548	0.097972

Fig.2.3. Stocks- Returns and Volatility (Std deviation)

4. Draw a plot of Stock Means vs Standard Deviation and state your inference

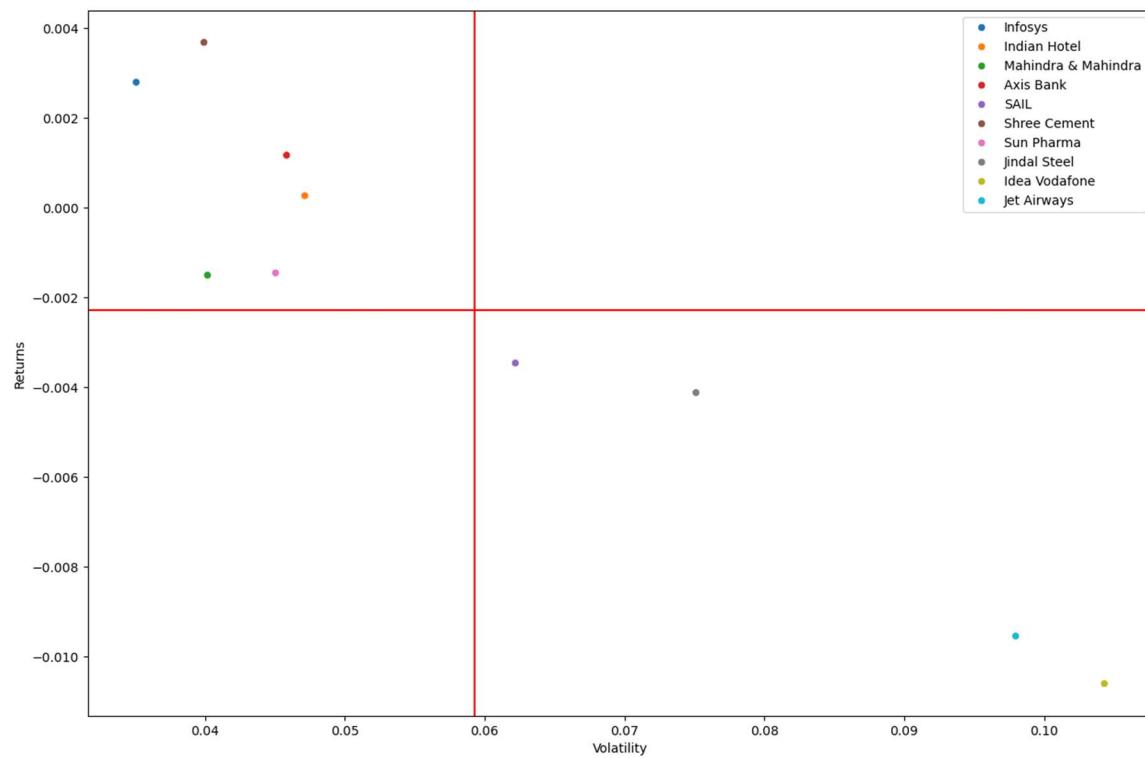


Fig.2.4. Returns vs Volatility

Observations:

- Infosys and Shree Cement are the best stocks, with high returns and low volatility
- Idea Vodafone and Jet Airways are the worst performing stocks, with low returns and high volatility
- Shree Cement has the highest returns and Idea Vodafone has the lowest returns
- Infosys has the lowest volatility and Idea Vodafone has the highest volatility

5. Conclusions and Recommendations

- The performance of Infosys and Shree Cement have been really good compared to other stocks, hence a buy or hold call is advised
- Idea Vodafone is the worst of all. Hence, a hold or sell call is advised
- Bank stock and IT stocks seem to be performing better overall.