Advanced Statistics Business Report

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Problem-1 Salary Data Analysis

Salary is hypothesized to depend on educational qualification and occupation. To understand the dependency, the salaries of 40 individuals [SalaryData.csv] are collected and each person's educational qualification and occupation are noted. Educational qualification is at three levels, High school graduate, Bachelor, and Doctorate. Occupation is at four levels, Administrative and clerical, Sales, Professional or specialty, and Executive or managerial. A different number of observations are in each level of education – occupation combination.

1.1 State the null and the alternate hypothesis for conducting one-way ANOVA for both Education and Occupation individually.

One way ANOVA (Education)
Null Hypothesis H0: The mean salary is the same across all the 3 categories of education (Doctorate,Bachelors, and HS-Grad).
Alternate Hypothesis H1: The mean salary is different in at least one category of education.

One way ANOVA (Occupation)
Null Hypothesis H0: The mean salary is the same across all the 4 categories of occupation (Prof-Specialty,Sales, Adm-clerical,and Exec-Managerial).
Alternate Hypothesis H1: The mean salary is different in at least one category of occupation.

1.2 Perform a one-way ANOVA on Salary with respect to Education. State whether the null hypothesis is accepted or rejected based on the ANOVA results.

One way ANOVA for Education variable.

	df	sum_sq	mean_sq	F	PR(>F)
C(Education	2	1.03E+11	5.13E+10	30.95628	1.26E-08
Residual	37	6.14E+10	1.66E+09	NaN	NaN

At the level of 5% significance, p-value < 0.05, that means we will have to reject the null hypothesis and conclude that there is a significant difference in the mean salaries for at least one category of Education.

1.3 Perform a one-way ANOVA on Salary with respect to Occupation. State whether the null hypothesis is accepted or rejected based on the ANOVA results.

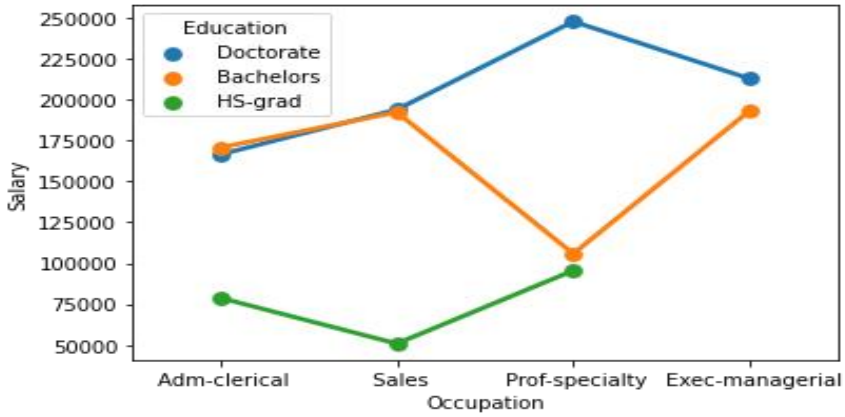
One Way ANOVA for Occupation variable.

	df	sum_sq	mean_sq	F	PR(>F)
C(Education	3	1.13E+10	3.75E+09	0.884144	0.458508
Residual	36	1.53E+11	4.24E+09	NaN	NaN

Since the p value = 0.458508 > 0.05, we fail to reject the null hypothesis and conclude that there is no significant difference in the mean salaries across the 4 categories of occupation.

1.5 What is the interaction between the two treatments? Analyze the effects of one variable on the other (Education and Occupation) with the help of an interaction plot.

We analyze the effects of one variable on the other (Education and Occupation) with the help of an interaction plot.



The interaction plot shows that there is significant amount of interaction between the categorical variables, Education and Occupation.

The following are some of the observations from the interaction plot:

- People with HS-grad education do not reach the position of Exec-managerial and they hold only Adm-clerk, Sales and Prof-Specialty occupations.
- People with education as Bachelors or Doctorate and occupation as Adm-clerical and Sales almost earn the same salaries (salaries ranging from 170000–190000).
- People with education as Bachelors and occupation as Prof-Specialty earn lesser than people with education as
- Bachelors and occupations as Adm-clerical and Sales.
- People with education as Bachelors and occupation Sales earn higher than people with education as Bachelors and occupation Prof-Specialty whereas people with education as Doctorate and occupation Sales earn lesser than people with Doctorate and occupation Prof-Specialty. We see a reversal in this part of the plot.
- Similarly, people with education as Bachelors and occupation as Prof-Specialty earn lesser than people with
- education as Bachelors and occupation Exec-Managerial whereas people with education as Doctorate and
- occupation as Prof-Specialty earn higher than people with education as Doctorate and occupation
- Exec-Managerial. There is a reversal in this part of the plot too.
- Salespeople with Bachelors or Doctorate education earn the same salaries and earn higher than people with
- education as HS-grad.
- Adm clerical people with education as HS-grad earn the lowest salaries when compared to people with education
- as Bachelors or Doctorate.
- Prof-Specialty people with education as Doctorate earn maximum salaries and people with education as HS-Grad
- earn the minimum.
- People with education as HS -Grad earn the minimum salaries.
- There are no people with education as HS -grad who hold Exec-managerial occupation.
- People with education as Bachelors and occupation, Sales and Exec-Managerial earn the same salaries.

1.6 Perform a two-way ANOVA based on the Education and Occupation (along with their interaction Education*Occupation) with the variable 'Salary'. State the null and alternative hypotheses and state Your results. How will you interpret this result?

H0: The effect of the independent variable 'Education' on the mean 'Salary' does not depend on the effect of the other independent variable Occupation' (i.e. there is no interaction effect between the 2 independent variables, education and occupation).

H1: There is an interaction effect between the independent variable 'Education' and the independent variable 'Occupation' on the mean 'Salary'.

Two way ANOVA

	df	sum_sq	mean_sq	F	PR(>F)
C(Education)	2	1.03E+11	5.13E+10	72.211958	5.47E-12
C(Occupation)	3	5.52E+09	1.84E+09	2.587626	0.0721158
C(Education):C(Occupation)	6	3.63E+10	6.06E+09	8.519815	2.23E-05
Residual	29	2.06E+10	7.11E+08	NaN	NaN

From the table, we see that there is a significant amount of interaction between Education and Occupation. As p = 2.232500e-05 < 0.05, we reject the null hypothesis. Thus, we see that there is an interaction effect between education and occupation on the mean salary.

1.7 Explain the business implications of performing ANOVA for this particular case study.

From the above analysis, it is clearly seen that people with education as Doctorate draw the maximum salaries and people with education HS-grad earn the least. Thus, we can conclude that Salary is dependent on educational qualifications and occupation.

Problem-2 Education Data Analysis

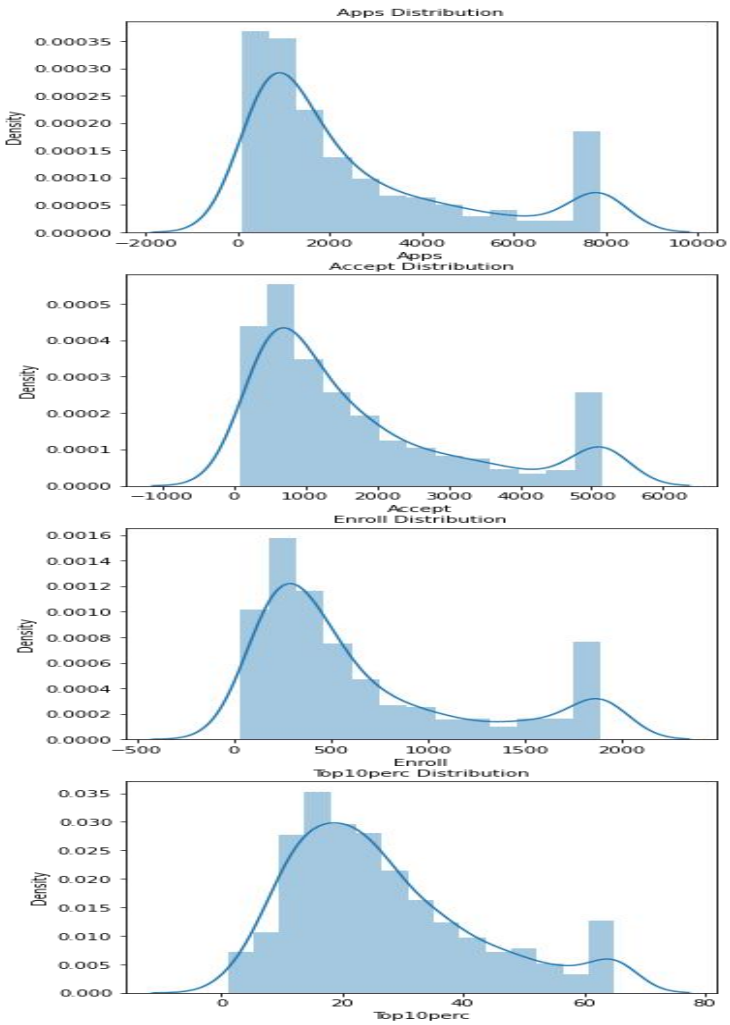
The dataset Education - Post 12th Standard.csv contains information on various colleges. You are expected to do a Principal Component Analysis for this case study according to the instructions given. The data dictionary of the 'Education - Post 12th Standard.csv' can be found in the following file: Data Dictionary.xlsx.

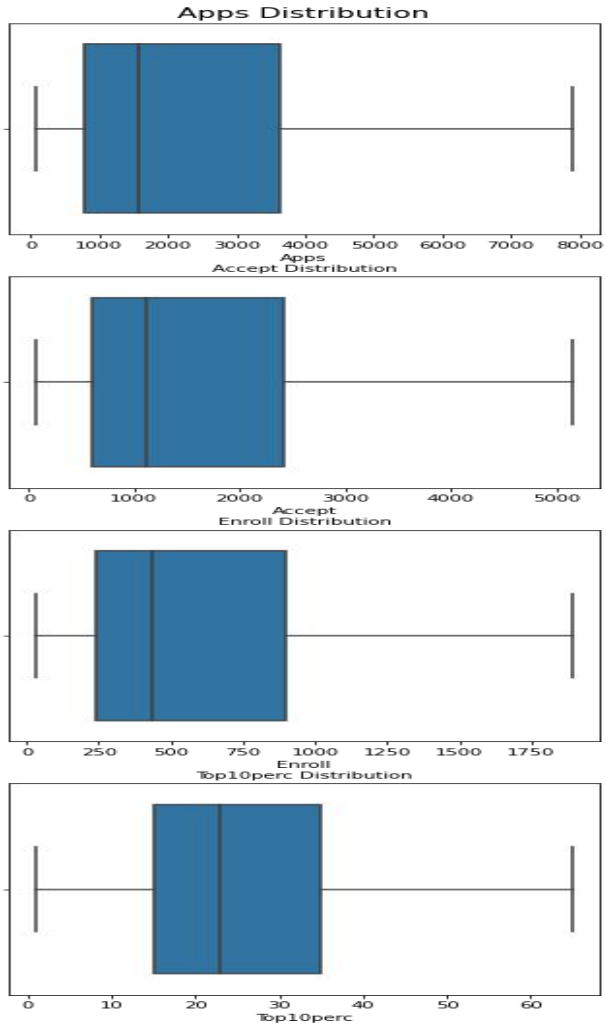
- ✓ The dataset have 777 rows and 18 columns.
- ✓ All the columns have integer or float values except Names which is a categorical value.
- ✓ There are no duplicates in the value
- ✓ There are no null or missing values in the data set

2.1 Perform Exploratory Data Analysis [both univariate and multivariate analysis to be performed]. What insight do you draw from the EDA?

Univariate analysis
It helps us to understand the distribution of data in the dataset. With univariate analysis we can find patterns and we can summarize the data.

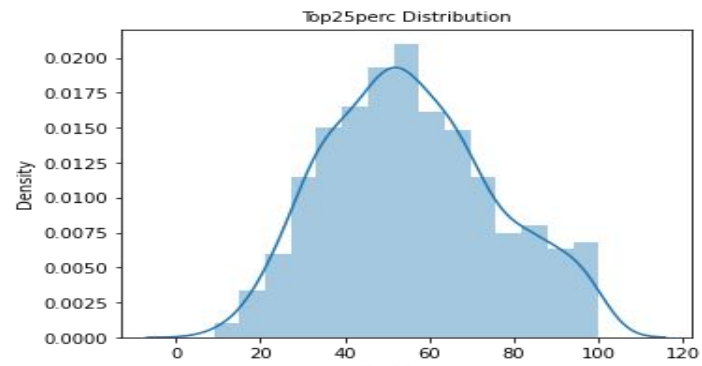
Disruption of the variables

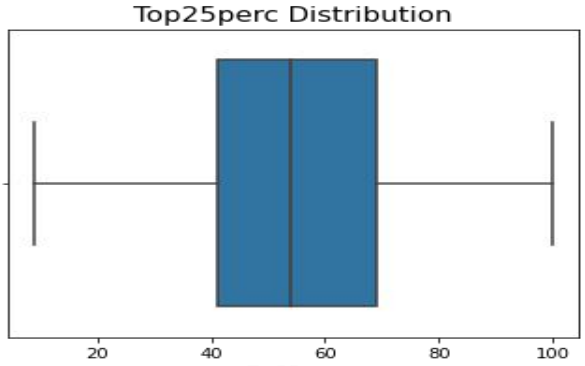


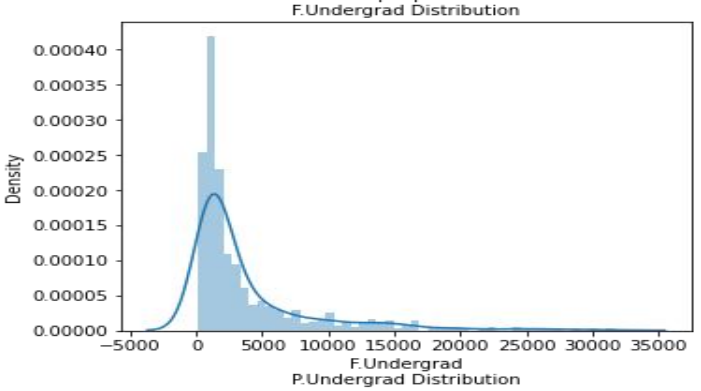


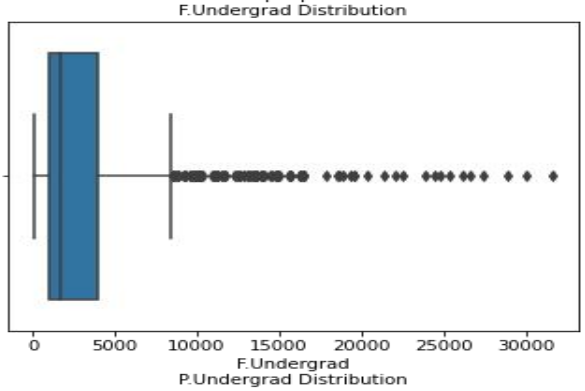
From the above plots, we can state that:

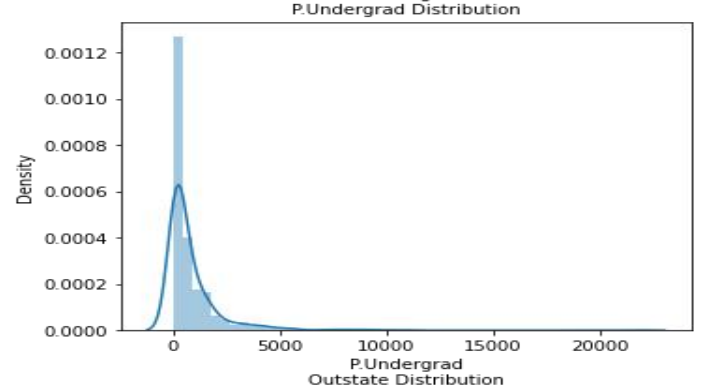
- ➢ All the variables above seem to have Outliers
- ➢ The distribution of the data is Positively skewed
- ➢ The box plot of the students from top 10 % of higher secondary class seems to have outliers. The distribution is also positively skewed.

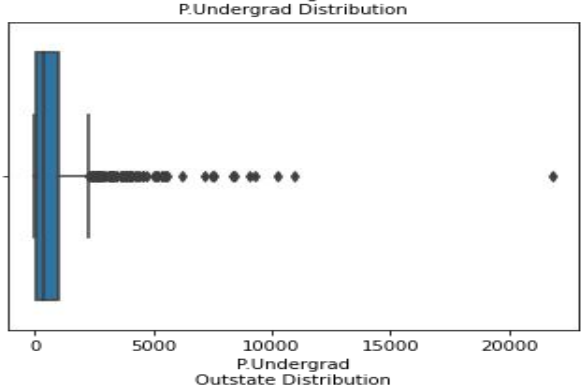


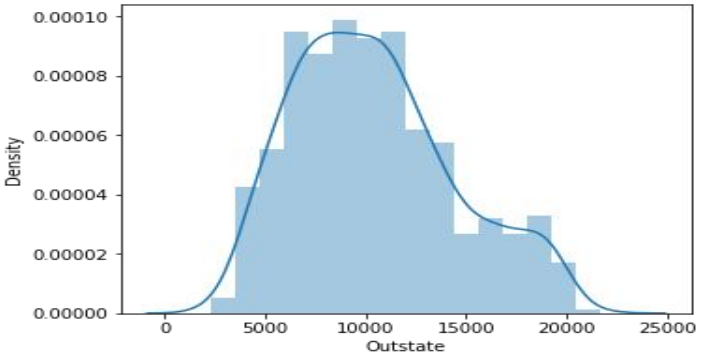


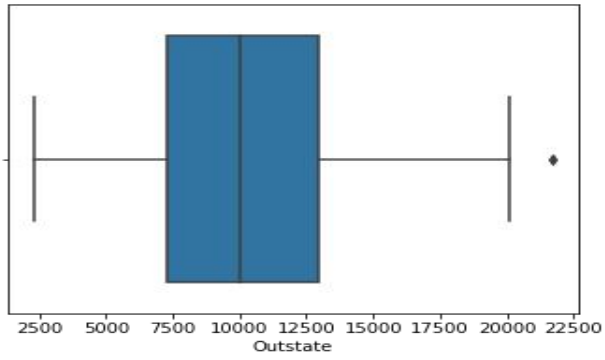




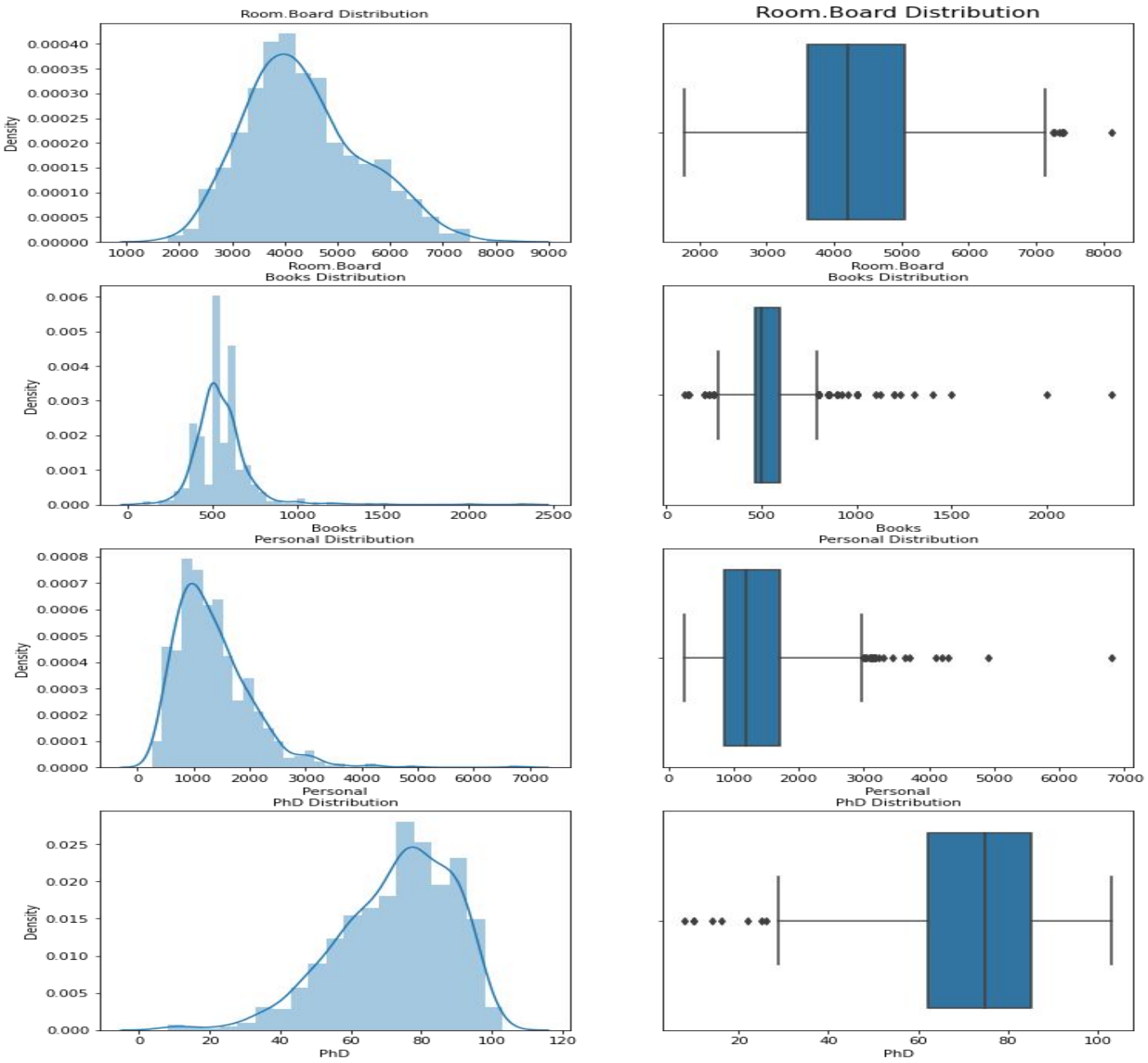




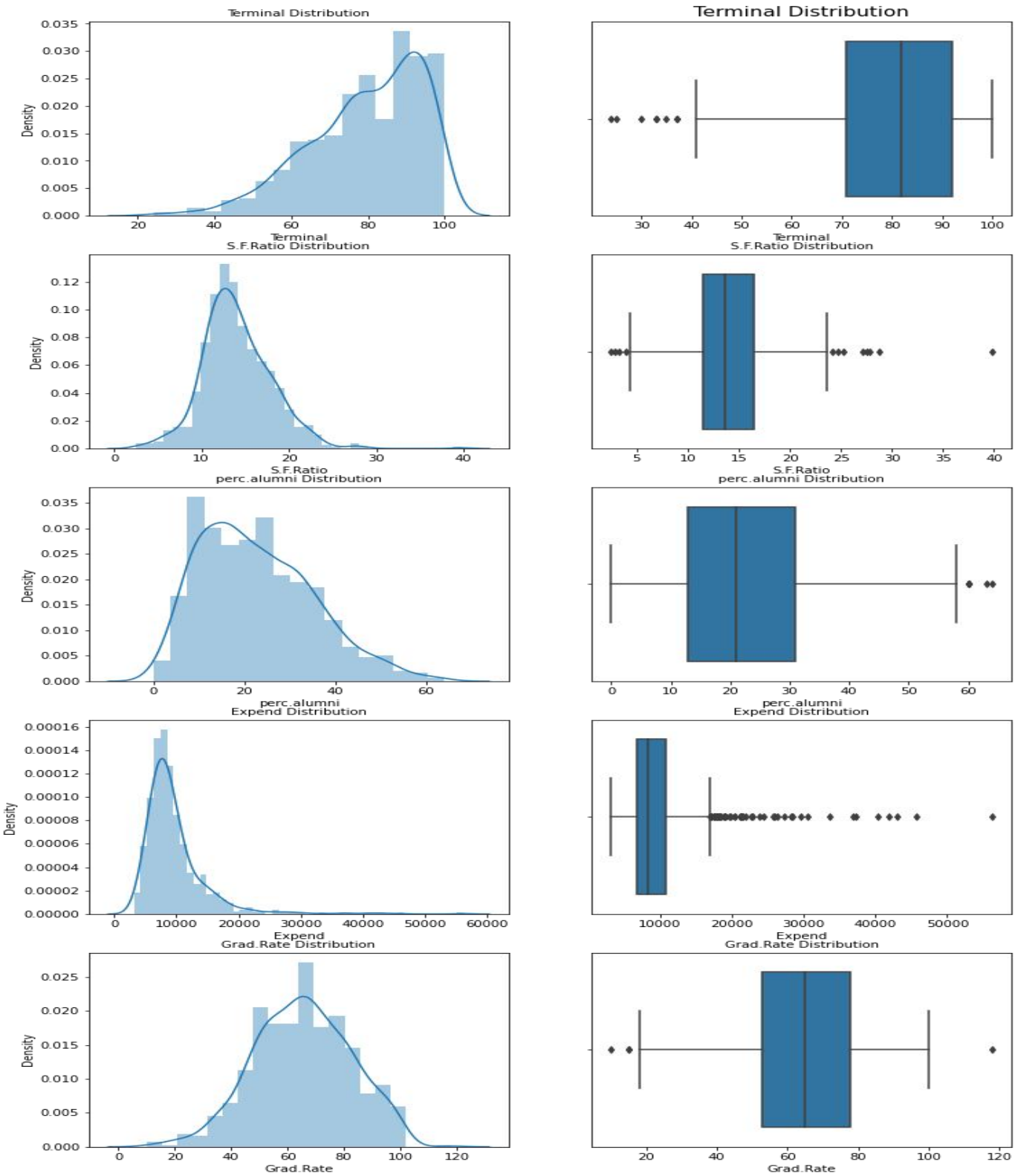




- The box plot for the top 25% has no outliers. The distribution is almost normally distributed.
- Rest, all the variables above seem to have Outliers
- Majority of the students are from top 25% of higher secondary class.
- The box plot of Outstate has only one outlier



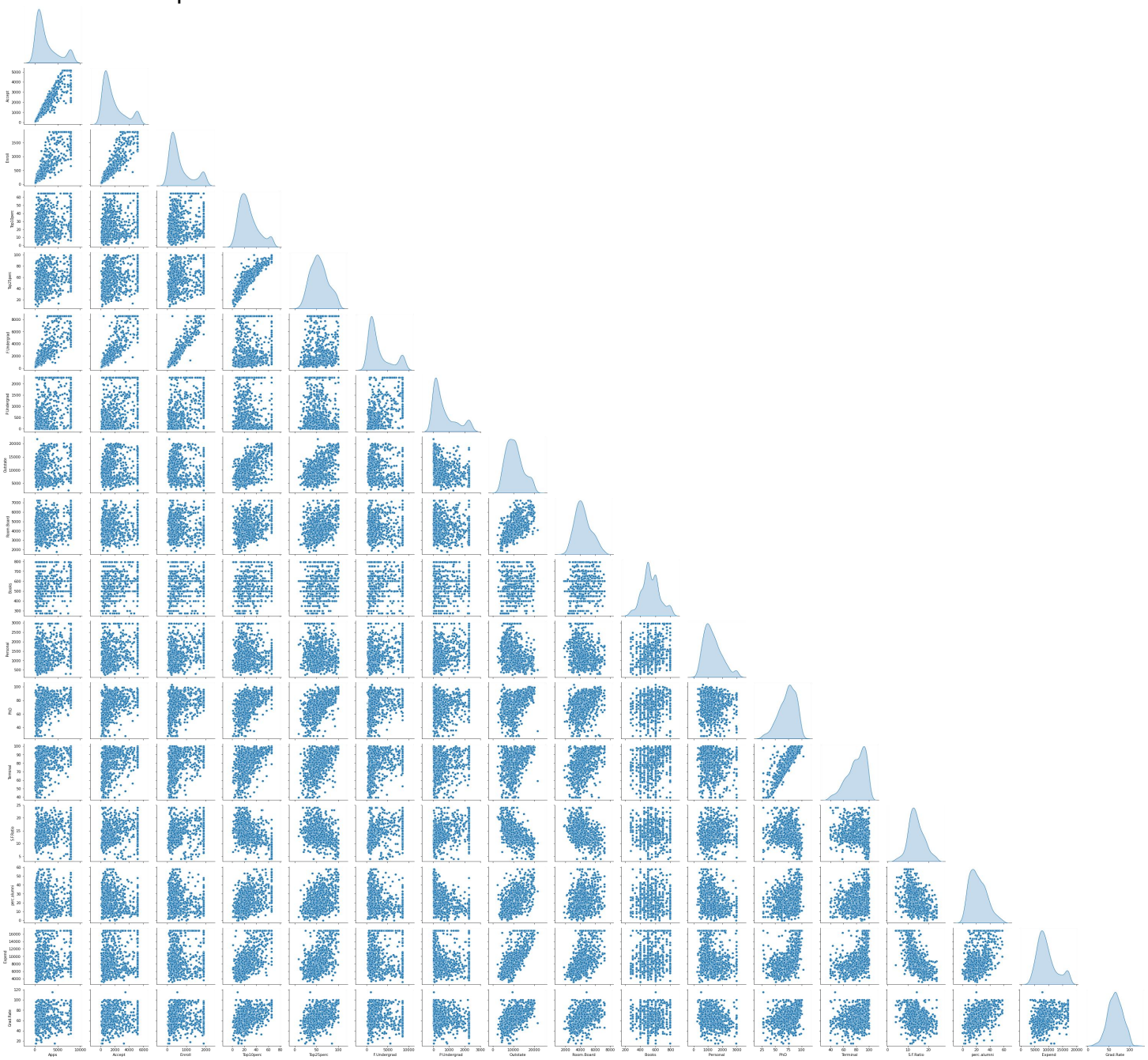
- The Room board has few outliers. The distribution is normally distributed.
- Rest seems to have multiple Outliers
- The distribution seems to be negatively skewed for PHD, while positively skewed for Books and Personal



- All the above variables have Outliers present in it
- The distribution for the terminal is negatively skewed while the expenditure is positively skewed.
- The distribution is almost normally distributed for Alumni, SF Ratio and Grad rate

Multivariate analysis

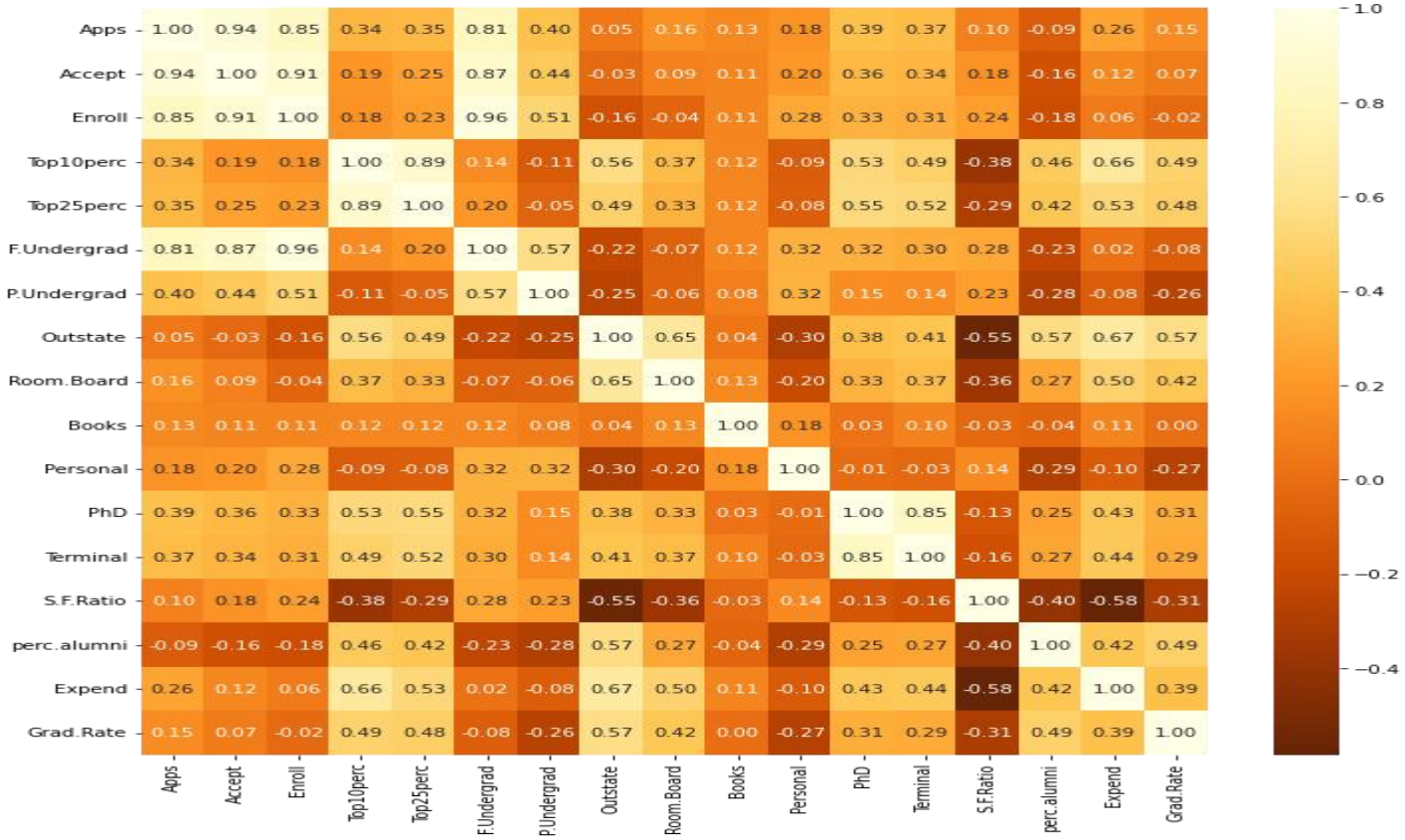
In Multivariate analysis we do a pairplot. Which helps us to understand the relationship between all the numerical values in the dataset. On comparing all the variables with each other we could understand the patterns or trends in the dataset.



Heatmap

Heat map is used to find out the correlation between two numerical values.

- The application variable is highly positively correlated with application accepted, students enrolled and full time graduates. So this relationship gives the insights on when student submits the application it is accepted and the student is enrolled as full time graduate.
- There is negative correlation between application and percentage of alumni. This shows us not all students are part of alumni of their college or university.
- The application with top 10, 25 of higher secondary class, outstate, room board, books, personal, PhD, terminal, S.F ratio, expenditure and Graduation ratio are positively correlated
- Negative correlation is shown between application and percentage of alumni. This indicates us not all students are part of alumni of their college or university.
- The application with top 10, 25 of higher secondary class, outstate, room board, books, personal, PhD, terminal, S.F ratio, expenditure and Graduation ratio are positively correlated



2.2 Is scaling necessary for PCA in this case? Give justification and perform scaling.

- Yes, scaling is very important for PCA because of the way that the principal components are calculated. The PCA calculates a new projection of the data set. And the new axis are based on the standard deviation of the variables.

	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books	Personal	PhD	Terminal	S.F.Ratio	perc.alumni	Expend	Grad.Rate
0	-0.346882	-0.321205	-0.063509	-0.258583	-0.191827	-0.168116	-0.209207	-0.746356	-0.964905	-0.602312	1.270045	-0.163028	-0.115729	1.013776	-0.867574	-0.501910	-0.318252
1	-0.210884	-0.038703	-0.288584	-0.655656	-1.353911	-0.209788	0.244307	0.457496	1.909208	1.215880	0.235515	-2.675646	-3.378176	-0.477704	-0.544572	0.166110	-0.551262
2	-0.406866	-0.376318	-0.478121	-0.315307	-0.292878	-0.549565	-0.497090	0.201305	-0.554317	-0.905344	-0.259582	-1.204845	-0.931341	-0.300749	0.585935	-0.177290	-0.667767
3	-0.668261	-0.681682	-0.692427	1.840231	1.677612	-0.658079	-0.520752	0.626633	0.996791	-0.602312	-0.688173	1.185206	1.175657	-1.615274	1.151188	1.792851	-0.376504
4	-0.726176	-0.764555	-0.780735	-0.655656	-0.596031	-0.711924	0.009005	-0.716508	-0.216723	1.518912	0.235515	0.204672	-0.523535	-0.553542	-1.675079	0.241803	-2.939613

2.3 Comment on the comparison between the covariance and the correlation matrices from this data.[on scaled data]

- Both covariance and correlation measure the relationship and the dependency between two variables.
- Covariance indicates the direction of the linear relationship between variables.
- Correlation measures both the strength and direction of the linear relationship between two variables.
- Correlation values are standardized while Covariance values are not standardized.

- From this data below, we can see variables having high positive and negative correlation. We can also understand the variables which are moderately correlated with each other.
- From the date, we can see that application, acceptance, enrollment and full time graduates are highly positively correlated
- Top 10 % and top 25 % are highly positively correlated

SS of Covariance matrix(Only overview, not complete SS)

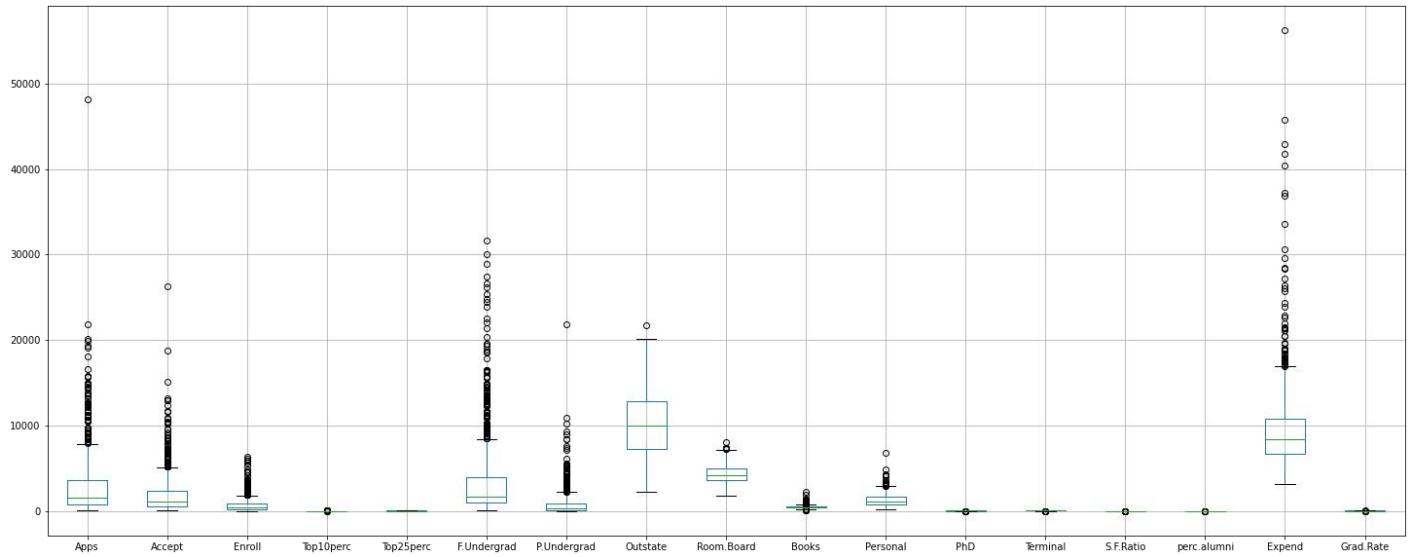
```
Covariance Matrix
%s [[ 1.00128866  0.94466636  0.84791332  0.33927032  0.35209304  0.81554018
   0.3987775   0.05022367  0.16515151  0.13272942  0.17896117  0.39120081
   0.36996762  0.09575627 -0.09034216  0.2599265   0.14694372]
 [ 0.94466636  1.00128866  0.91281145  0.19269493  0.24779465  0.87534985
   0.44183938 -0.02578774  0.09101577  0.11367165  0.20124767  0.35621633
   0.3380184   0.17645611 -0.16019604  0.12487773  0.06739929]
 [ 0.84791332  0.91281145  1.00128866  0.18152715  0.2270373   0.96588274
   0.51372977 -0.1556777  -0.04028353  0.11285614  0.28129148  0.33189629
   0.30867133  0.23757707 -0.18102711  0.06425192 -0.02236983]
 [ 0.33927032  0.19269493  0.18152715  1.00128866  0.89314445  0.1414708
  -0.10549205  0.5630552   0.37195909  0.1190116  -0.09343665  0.53251337
   0.49176793 -0.38537048  0.45607223  0.6617651   0.49562711]
 [ 0.35209304  0.24779465  0.2270373   0.89314445  1.00128866  0.19970167
  -0.05364569  0.49002449  0.33191707  0.115676   -0.08091441  0.54656564
   0.52542506 -0.29500852  0.41840277  0.52812713  0.47789622]
 [ 0.81554018  0.87534985  0.96588274  0.1414708   0.19970167  1.00128866
   0.57124738 -0.21602002 -0.06897917  0.11569867  0.31760831  0.3187472
   0.30040557  0.28006379 -0.22975792  0.01867565 -0.07887464]
 [ 0.3987775   0.44183938  0.51372977 -0.10549205 -0.05364569  0.57124738
   1.00128866 -0.25383901 -0.06140453  0.08130416  0.32029384  0.14930637
   0.14208644  0.23283016 -0.28115421 -0.08367612 -0.25733218]
 [ 0.05022367 -0.02578774 -0.1556777   0.5630552   0.49002449 -0.21602002
  -0.25383901  1.00128866  0.65509951  0.03890494 -0.29947232  0.38347594
   0.40850895 -0.55553625  0.56699214  0.6736456   0.57202613]
 [ 0.16515151  0.09101577 -0.04028353  0.37195909  0.33191707 -0.06897917
  -0.06140453  0.65509951  1.00128866  0.12812787 -0.19968518  0.32962651
   0.3750222  -0.36309504  0.27271444  0.50238599  0.42548915]
 [ 0.13272942  0.11367165  0.11285614  0.1190116   0.115676    0.11569867
   0.08130416  0.03890494  0.12812787  1.00128866  0.17952581  0.0269404
   0.10008351 -0.03197042 -0.04025955  0.11255393  0.00106226]
 [ 0.17896117  0.20124767  0.28129148 -0.09343665 -0.08091441  0.31760831
   0.32029384 -0.29947232 -0.19968518  0.17952581  1.00128866 -0.01094989
  -0.03065256  0.13652054 -0.2863366  -0.09801804 -0.26969106]
 [ 0.39120081  0.35621633  0.33189629  0.53251337  0.54656564  0.3187472
   0.14930637  0.38347594  0.32962651  0.0269404  -0.01094989  1.00128866
   0.85068186 -0.13069832  0.24932955  0.43331936  0.30543094]
 [ 0.36996762  0.3380184   0.30867133  0.49176793  0.52542506  0.30040557
   0.14208644  0.40850895  0.3750222   0.10008351 -0.03065256  0.85068186
   1.00128866 -0.16031027  0.26747453  0.43936469  0.28990033]
```

SS of correlation(complete SS)

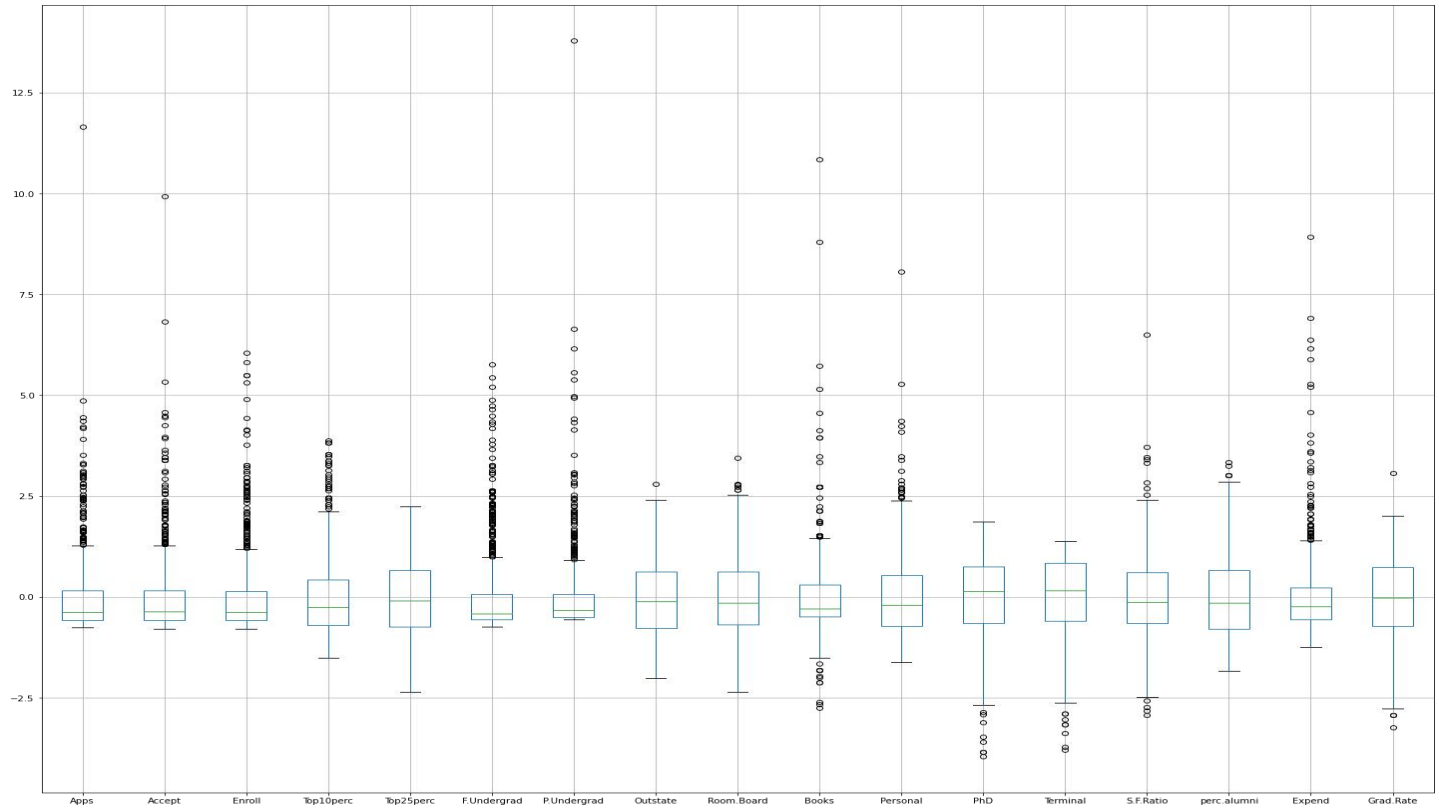
	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books	Personal	PhD	Terminal	S.F.Ratio	perc.alumni	Expend	Grad.Rate
Apps	1.000000	0.943451	0.846822	0.338834	0.351640	0.814491	0.398264	0.050159	0.164939	0.132559	0.178731	0.390697	0.369491	0.095633	-0.090226	0.259592	0.146755
Accept	0.943451	1.000000	0.911637	0.192447	0.247476	0.874223	0.441271	-0.025755	0.090899	0.113525	0.200989	0.355758	0.337583	0.176229	-0.159990	0.124717	0.067313
Enroll	0.846822	0.911637	1.000000	0.181294	0.226745	0.964640	0.513069	-0.155477	-0.040232	0.112711	0.280929	0.331469	0.308274	0.237271	-0.180794	0.064169	-0.022341
Top10perc	0.338834	0.192447	0.181294	1.000000	0.891995	0.141289	-0.105356	0.562331	0.371480	0.118858	-0.093316	0.531828	0.491135	-0.384875	0.455485	0.660913	0.494989
Top25perc	0.351640	0.247476	0.226745	0.891995	1.000000	0.199445	-0.053577	0.489394	0.331490	0.115527	-0.080810	0.545862	0.524749	-0.294629	0.417864	0.527447	0.477281
F.Undergrad	0.814491	0.874223	0.964640	0.141289	0.199445	1.000000	0.570512	-0.215742	-0.068890	0.115550	0.317200	0.318337	0.300019	0.279703	-0.229462	0.018652	-0.078773
P.Undergrad	0.398264	0.441271	0.513069	-0.105356	-0.053577	0.570512	1.000000	-0.253512	-0.061326	0.081200	0.319882	0.149114	0.141904	0.232531	-0.280792	-0.083568	-0.257001
Outstate	0.050159	-0.025755	-0.155477	0.562331	0.489394	-0.215742	-0.253512	1.000000	0.654256	0.038855	-0.299087	0.382982	0.407983	-0.554821	0.566262	0.672779	0.571290
Room.Board	0.164939	0.090899	-0.040232	0.371480	0.331490	-0.068890	-0.061326	0.654256	1.000000	0.127963	-0.199428	0.329202	0.374540	-0.362628	0.272363	0.501739	0.424942
Books	0.132559	0.113525	0.112711	0.118858	0.115527	0.115550	0.081200	0.038855	0.127963	1.000000	0.179295	0.026906	0.099955	-0.031929	-0.040208	0.112409	0.001061
Personal	0.178731	0.200989	0.280929	-0.093316	-0.080810	0.317200	0.319882	-0.299087	-0.199428	0.179295	1.000000	-0.010936	-0.030613	0.136345	-0.285968	-0.097892	-0.269344
PhD	0.390697	0.355758	0.331469	0.531828	0.545862	0.318337	0.149114	0.382982	0.329202	0.026906	-0.010936	1.000000	0.849587	-0.130530	0.249009	0.432762	0.305038
Terminal	0.369491	0.337583	0.308274	0.491135	0.524749	0.300019	0.141904	0.407983	0.374540	0.099955	-0.030613	0.849587	1.000000	-0.160104	0.267130	0.438799	0.289527
S.F.Ratio	0.095633	0.176229	0.237271	-0.384875	-0.294629	0.279703	0.232531	-0.554821	-0.362628	-0.031929	0.136345	-0.130530	-0.160104	1.000000	-0.402929	-0.583832	-0.306710
perc.alumni	-0.090226	-0.159990	-0.180794	0.455485	0.417864	-0.229462	-0.280792	0.566262	0.272363	-0.040208	-0.285968	0.249009	0.267130	-0.402929	1.000000	0.417712	0.490898
Expend	0.259592	0.124717	0.064169	0.660913	0.527447	0.018652	-0.083568	0.672779	0.501739	0.112409	-0.097892	0.432762	0.438799	-0.583832	0.417712	1.000000	0.390343
Grad.Rate	0.146755	0.067313	-0.022341	0.494989	0.477281	-0.078773	-0.257001	0.571290	0.424942	0.001061	-0.269344	0.305038	0.289527	-0.306710	0.490898	0.390343	1.000000

2.4 Check the dataset for outliers before and after scaling. What insight do you derive here?

Dataset before Scaling

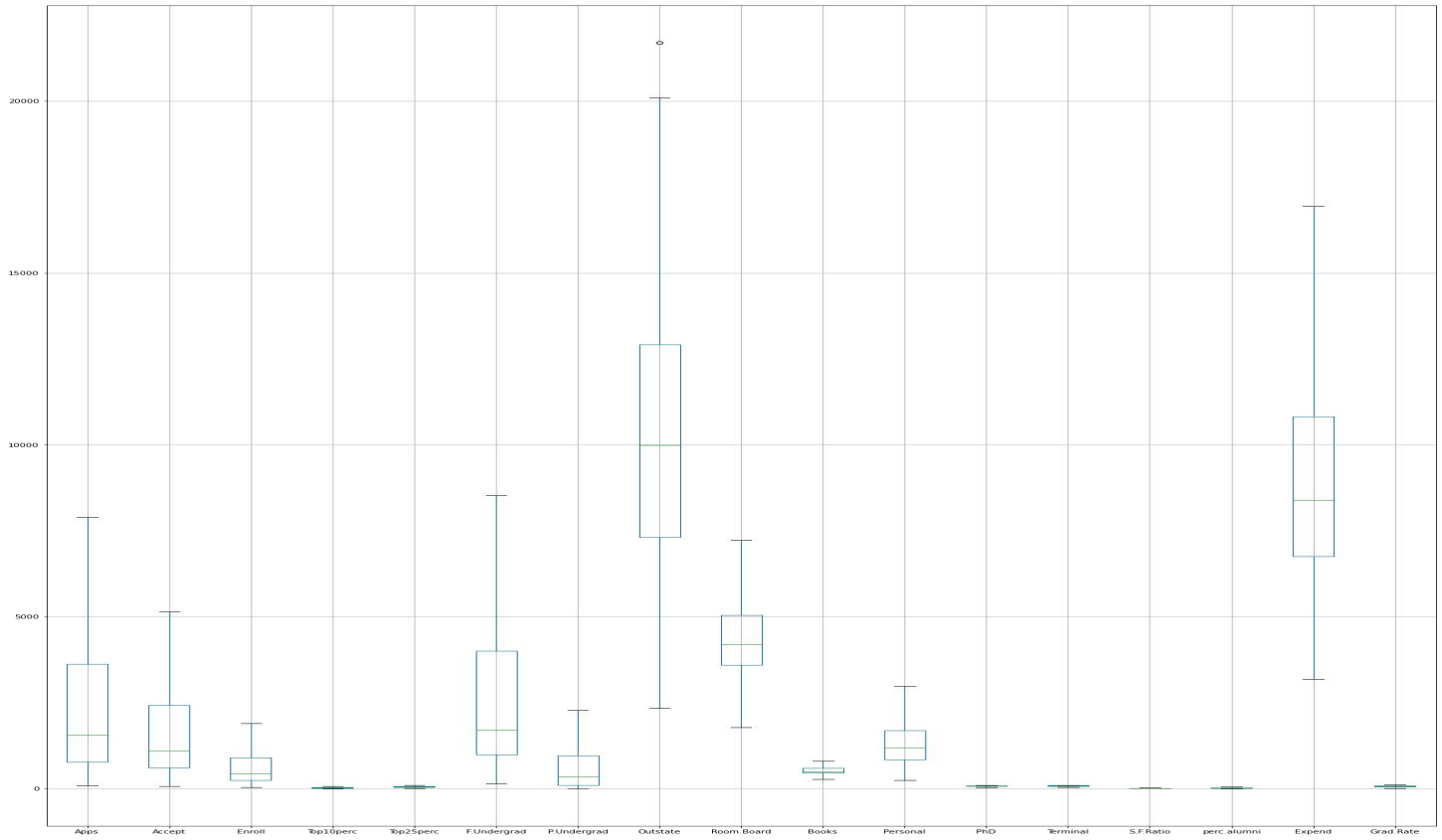


Dataset after Scaling



The outliers are still present in dataset after scaling.

Reason: scaling does not remove outliers. It scales the values on a Z score distribution. We can treat outliers by remove or impute them with IQR values. PFB the boxplots after removing Outliers.



2.5 Extract the eigenvalues and eigenvectors. [Using Sklearn PCA Print Both]

To get the Eigenvalues & Eigenvectors, we will first need to get the covariance matrix

Covariance Matrix %s [[1.00128866 0.94466636 0.84791332 0.33927032 0.35209304 0.81554018 0.3987775 0.05022367 0.16515151 0.13272942 0.17896117 0.39120081 0.36996762 0.09575627 -0.09034216 0.2599265 0.14694372] [0.94466636 1.00128866 0.91281145 0.19269493 0.24779465 0.87534985 0.44183938 -0.02578774 0.09101577 0.11367165 0.20124767 0.35621633 0.3380184 0.17645611 -0.16019604 0.12487773 0.06739929] [0.84791332 0.91281145 1.00128866 0.18152715 0.2270373 0.96588274 0.51372977 -0.1556777 -0.04028353 0.11285614 0.28129148 0.33189629 0.30867133 0.23757707 -0.18102711 0.06425192 -0.02236983] [0.33927032 0.19269493 0.18152715 1.00128866 0.89314445 0.1414708 -0.10549205 0.5630552 0.37195909 0.1190116 -0.09343665 0.53251337 0.49176793 -0.38537048 0.45607223 0.6617651 0.49562711] [0.35209304 0.24779465 0.2270373 0.89314445 1.00128866 0.19970167 -0.05364569 0.49002449 0.33191707 0.115676 -0.08091441 0.54656564 0.52542506 -0.29500852 0.41840277 0.52812713 0.47789622] [0.81554018 0.87534985 0.96588274 0.1414708 0.19970167 1.00128866 0.57124738 -0.21602002 -0.06897917 0.11569867 0.31760831 0.3187472 0.30040557 0.28006379 -0.22975792 0.01867565 -0.07887464] [0.3987775 0.44183938 0.51372977 -0.10549205 -0.05364569 0.57124738 1.00128866 -0.25383901 -0.06140453 0.08130416 0.32029384 0.14930637 0.14208644 0.23283016 -0.28115421 -0.08367612 -0.25733218] [0.05022367 -0.02578774 -0.1556777 0.5630552 0.49002449 -0.21602002 -0.25383901 1.00128866 0.65509951 0.03890494 -0.29947232 0.38347594 0.40850895 -0.55553625 0.56699214 0.6736456 0.57202613] [0.16515151 0.09101577 -0.04028353 0.37195909 0.33191707 -0.06897917 -0.06140453 0.65509951 1.00128866 0.12812787 -0.19968518 0.32962651 0.3750222 -0.36309504 0.27271444 0.50238599 0.42548915] [0.13272942 0.11367165 0.11285614 0.1190116 0.115676 0.11569867 0.08130416 0.03890494 0.12812787 1.00128866 0.17952581 0.0269404 0.10008351 -0.03197042 -0.04025955 0.11255393 0.00106226] [0.17896117 0.20124767 0.28129148 -0.09343665 -0.08091441 0.31760831 0.32029384 -0.29947232 -0.19968518 0.17952581 1.00128866 -0.01094989 -0.03065256 0.13652054 -0.2863366 -0.09801804 -0.26969106] [0.39120081 0.35621633 0.33189629 0.53251337 0.54656564 0.3187472 0.14930637 0.38347594 0.32962651 0.0269404 -0.01094989 1.00128866 0.85068186 -0.13069832 0.24932955 0.43331936 0.30543094] [0.36996762 0.3380184 0.30867133 0.49176793 0.52542506 0.30040557 0.14208644 0.40850895 0.3750222 0.10008351 -0.03065256 0.85068186 1.00128866 -0.16031027 0.26747453 0.43936469 0.28990033] [0.09575627 0.17645611 0.23757707 -0.38537048 -0.29500852 0.28006379 0.23283016 -0.55553625 -0.36309504 -0.03197042 0.13652054 -0.13069832 -0.16031027 1.00128866 -0.4034484 -0.5845844 -0.30710565] [-0.09034216 -0.16019604 -0.18102711 0.45607223 0.41840277 -0.22975792 -0.28115421 0.56699214 0.27271444 -0.04025955 -0.2863366 0.24932955 0.26747453 -0.4034484 1.00128866 0.41825001 0.49153016] [0.2599265 0.12487773 0.06425192 0.6617651 0.52812713 0.01867565 -0.08367612 0.6736456 0.50238599 0.11255393 -0.09801804 0.43331936 0.43936469 -0.5845844 0.41825001 1.00128866 0.39084571] [0.14694372 0.06739929 -0.02236983 0.49562711 0.47789622 -0.07887464 -0.25733218 0.57202613 0.42548915 0.00106226 -0.26969106 0.30543094 0.28990033 -0.30710565 0.49153016 0.39084571 1.00128866]]

Eigen Vectors

%s [[-2.48765602e-01 3.31598227e-01 6.30921033e-02 -2.81310530e-01
5.74140964e-03 1.62374420e-02 4.24863486e-02 1.03090398e-01
9.02270802e-02 -5.25098025e-02 3.58970400e-01 -4.59139498e-01
4.30462074e-02 -1.33405806e-01 8.06328039e-02 -5.95830975e-01
2.40709086e-02]
[-2.07601502e-01 3.72116750e-01 1.01249056e-01 -2.67817346e-01
5.57860920e-02 -7.53468452e-03 1.29497196e-02 5.62709623e-02
1.77864814e-01 -4.11400844e-02 -5.43427250e-01 5.18568789e-01
-5.84055850e-02 1.45497511e-01 3.34674281e-02 -2.92642398e-01
-1.45102446e-01]
[-1.76303592e-01 4.03724252e-01 8.29855709e-02 -1.61826771e-01
-5.56936353e-02 4.25579803e-02 2.76928937e-02 -5.86623552e-02
1.28560713e-01 -3.44879147e-02 6.09651110e-01 4.04318439e-01
-6.93988831e-02 -2.95896092e-02 -8.56967180e-02 4.44638207e-01
1.11431545e-02]
[-3.54273947e-01 -8.24118211e-02 -3.50555339e-02 5.15472524e-02
-3.95434345e-01 5.26927980e-02 1.61332069e-01 1.22678028e-01
-3.41099863e-01 -6.40257785e-02 -1.44986329e-01 1.48738723e-01
-8.10481404e-03 -6.97722522e-01 -1.07828189e-01 -1.02303616e-03
3.85543001e-02]
[-3.44001279e-01 -4.47786551e-02 2.41479376e-02 1.09766541e-01
-4.26533594e-01 -3.30915896e-02 1.18485556e-01 1.02491967e-01
-4.03711989e-01 -1.45492289e-02 8.03478445e-02 -5.18683400e-02
-2.73128469e-01 6.17274818e-01 1.51742110e-01 -2.18838802e-02

```
 -8.93515563e-02]
[-1.54640962e-01  4.17673774e-01  6.13929764e-02 -1.00412335e-01
 -4.34543659e-02  4.34542349e-02  2.50763629e-02 -7.88896442e-02
  5.94419181e-02 -2.08471834e-02 -4.14705279e-01 -5.60363054e-01
 -8.11578181e-02 -9.91640992e-03 -5.63728817e-02  5.23622267e-01
  5.61767721e-02]
[-2.64425045e-02  3.15087830e-01 -1.39681716e-01  1.58558487e-01
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  4.57332880e-03 -1.86675363e-01  5.08995918e-02 -1.01594830e-01
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 -8.23443779e-01]
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  3.54559731e-01]
[-6.47575181e-02  5.63418434e-02 -6.77411649e-01 -8.70892205e-02
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  1.33663353e-01  8.20292186e-02  7.72631963e-04 -2.88282896e-03
  3.19400370e-02  9.43887925e-03 -6.68494643e-02 -1.14379958e-02
 -2.81593679e-02]
[ 4.25285386e-02  2.19929218e-01 -4.99721120e-01  2.30710568e-01
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  9.44688900e-02 -1.36027616e-01 -1.11433396e-03  1.28904022e-02
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 -3.92640266e-02]
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  1.85181525e-01  1.23452200e-01  1.38133366e-02 -2.98075465e-02
  4.03723253e-02  1.12055599e-01 -6.91126145e-01 -1.27696382e-01
  2.32224316e-02]
[-3.17056016e-01  4.64294477e-02  6.60375454e-02  5.19443019e-01
  2.04719730e-01 -1.54927646e-01  2.84770105e-02  1.21613297e-02
  2.54938198e-01  8.85784627e-02  6.20932749e-03  2.70759809e-02
 -5.89734026e-02 -1.58909651e-01  6.71008607e-01  5.83134662e-02
  1.64850420e-02]
[ 1.76957895e-01  2.46665277e-01  2.89848401e-01  1.61189487e-01
 -7.93882496e-02 -4.87045875e-01 -2.19259358e-01  8.36048735e-02
 -2.74544380e-01 -4.72045249e-01 -2.22215182e-03  2.12476294e-02
  4.45000727e-01  2.08991284e-02  4.13740967e-02  1.77152700e-02
 -1.10262122e-02]
[-2.05082369e-01 -2.46595274e-01  1.46989274e-01 -1.73142230e-02
 -2.16297411e-01  4.73400144e-02 -2.43321156e-01 -6.78523654e-01
  2.55334907e-01 -4.22999706e-01 -1.91869743e-02 -3.33406243e-03
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  1.82660654e-01]
[-3.18908750e-01 -1.31689865e-01 -2.26743985e-01 -7.92734946e-02
  7.59581203e-02  2.98118619e-01  2.26584481e-01  5.41593771e-02
  4.91388809e-02 -1.32286331e-01 -3.53098218e-02  4.38803230e-02
  6.92088870e-01  2.27742017e-01  7.31225166e-02  9.37464497e-02
  3.25982295e-01]
[-2.52315654e-01 -1.69240532e-01  2.08064649e-01 -2.69129066e-01
 -1.09267913e-01 -2.16163313e-01 -5.59943937e-01  5.33553891e-03
 -4.19043052e-02  5.90271067e-01 -1.30710024e-02  5.00844705e-03
  2.19839000e-01  3.39433604e-03  3.64767385e-02  6.91969778e-02
  1.22106697e-01]]
```

Eigen Values

```
%s [5.45052162 4.48360686 1.17466761 1.00820573 0.93423123 0.84849117
 0.6057878  0.58787222 0.53061262 0.4043029  0.02302787 0.03672545
 0.31344588 0.08802464 0.1439785  0.16779415 0.22061096]
```

2.6 Perform PCA and export the data of the Principal Component (eigenvectors) into a data frame with the original features

Data of the Principal Component(basis the steps followed above for calculating PCs)

array([[2.48765602e-01, 2.07601502e-01, 1.76303592e-01, 3.54273947e-01, 3.44001279e-01, 1.54640962e-01, 2.64425045e-02, 2.94736419e-01, 2.49030449e-01, 6.47575181e-02, -4.25285386e-02, 3.18312875e-01, 3.17056016e-01, -1.76957895e-01, 2.05082369e-01, 3.18908750e-01, 2.52315654e-01], [3.31598227e-01, 3.72116750e-01, 4.03724252e-01, -8.24118211e-02, -4.47786551e-02, 4.17673774e-01, 3.15087830e-01, -2.49643522e-01, -1.37808883e-01, 5.63418434e-02, 2.19929218e-01, 5.83113174e-02, 4.64294477e-02, 2.46665277e-01, -2.46595274e-01, -1.31689865e-01, -1.69240532e-01], [-6.30921033e-02, -1.01249056e-01, -8.29855709e-02, 3.50555339e-02, -2.41479376e-02, -6.13929764e-02, 1.39681716e-01, 4.65988731e-02, 1.48967389e-01, 6.77411649e-01, 4.99721120e-01, -1.27028371e-01, -6.60375454e-02, -2.89848401e-01, -1.46989274e-01, 2.26743985e-01, -2.08064649e-01], [2.81310530e-01, 2.67817346e-01, 1.61826771e-01, -5.15472524e-02, -1.09766541e-01, 1.00412335e-01, -1.58558487e-01, 1.31291364e-01, 1.84995991e-01, 8.70892205e-02, -2.30710568e-01, -5.34724832e-01, -5.19443019e-01, -1.61189487e-01, 1.73142230e-02, 7.92734946e-02, 2.69129066e-01], [5.74140964e-03, 5.57860920e-02, -5.56936353e-02, -3.95434345e-01, -4.26533594e-01, -4.34543659e-02, 3.02385408e-01, 2.22532003e-01, 5.60919470e-01, -1.27288825e-01, -2.22311021e-01, 1.40166326e-01, 2.04719730e-01, -7.93882496e-02, -2.16297411e-01, 7.59581203e-02, -1.09267913e-01], [-1.62374420e-02, 7.53468452e-03, -4.25579803e-02, -5.26927980e-02, 3.30915896e-02, -4.34542349e-02, -1.91198583e-01, -3.00003910e-02, 1.62755446e-01, 6.41054950e-01, -3.31398003e-01, 9.12555212e-02, 1.54927646e-01, 4.87045875e-01, -4.73400144e-02, -2.98118619e-01, 2.16163313e-01], [-4.24863486e-02, -1.29497196e-02, -2.76928937e-02, -1.61332069e-01, -1.18485556e-01, -2.50763629e-02, 6.10423460e-02, 1.08528966e-01, 2.09744235e-01, -1.49692034e-01, 6.33790064e-01, -1.09641298e-03, -2.84770105e-02, 2.19259358e-01, 2.43321156e-01, -2.26584481e-01, 5.59943937e-01], [-1.03090398e-01, -5.62709623e-02, 5.86623552e-02, -1.22678028e-01, -1.02491967e-01, 7.88896442e-02, 5.70783816e-01, 9.84599754e-03, -2.21453442e-01, 2.13293009e-01, -2.32660840e-01, -7.70400002e-02, -1.21613297e-02, -8.36048735e-02, 6.78523654e-01, -5.41593771e-02, -5.33553891e-03], [-9.02270802e-02, -1.77864814e-01, -1.28560713e-01, 3.41099863e-01, 4.03711989e-01, -5.94419181e-02, 5.60672902e-01, -4.57332880e-03, 2.75022548e-01, -1.33663353e-01, -9.44688900e-02, -1.85181525e-01, -2.54938198e-01, 2.74544380e-01, -2.55334907e-01, -4.91388809e-02, 4.19043052e-02], [5.25098025e-02, 4.11400844e-02, 3.44879147e-02, 6.40257785e-02, 1.45492289e-02, 2.08471834e-02, -2.23105808e-01, 1.86675363e-01, 2.98324237e-01, -8.20292186e-02, 1.36027616e-01, -1.23452200e-01, -8.85784627e-02, 4.72045249e-01, 4.22999706e-

01, 1.32286331e-01, -5.90271067e-01], [4.30462074e-02, -5.84055850e-02, -6.93988831e-02, -8.10481404e-03, -2.73128469e-01, -8.11578181e-02, 1.00693324e-01, 1.43220673e-01, -3.59321731e-01, 3.19400370e-02, -1.85784733e-02, 4.03723253e-02, -5.89734026e-02, 4.45000727e-01, -1.30727978e-01, 6.92088870e-01, 2.19839000e-01], [2.40709086e-02, -1.45102446e-01, 1.11431545e-02, 3.85543001e-02, -8.93515563e-02, 5.61767721e-02, -6.35360730e-02, -8.23443779e-01, 3.54559731e-01, -2.81593679e-02, -3.92640266e-02, 2.32224316e-02, 1.64850420e-02, -1.10262122e-02, 1.82660654e-01, 3.25982295e-01, 1.22106697e-01], [5.95830975e-01, 2.92642398e-01, -4.44638207e-01, 1.02303616e-03, 2.18838802e-02, -5.23622267e-01, 1.25997650e-01, -1.41856014e-01, -6.97485854e-02, 1.14379958e-02, 3.94547417e-02, 1.27696382e-01, -5.83134662e-02, -1.77152700e-02, 1.04088088e-01, -9.37464497e-02, -6.91969778e-02], [8.06328039e-02, 3.34674281e-02, -8.56967180e-02, -1.07828189e-01, 1.51742110e-01, -5.63728817e-02, 1.92857500e-02, -3.40115407e-02, -5.84289756e-02, -6.68494643e-02, 2.75286207e-02, -6.91126145e-01, 6.71008607e-01, 4.13740967e-02, -2.71542091e-02, 7.31225166e-02, 3.64767385e-02], [1.33405806e-01, -1.45497511e-01, 2.95896092e-02, 6.97722522e-01, -6.17274818e-01, 9.91640992e-03, 2.09515982e-02, 3.83544794e-02, 3.40197083e-03, -9.43887925e-03, -3.09001353e-03, -1.12055599e-01, 1.58909651e-01, -2.08991284e-02, -8.41789410e-03, -2.27742017e-01, -3.39433604e-03], [4.59139498e-01, -5.18568789e-01, -4.04318439e-01, -1.48738723e-01, 5.18683400e-02, 5.60363054e-01, -5.27313042e-02, 1.01594830e-01, -2.59293381e-02, 2.88282896e-03, -1.28904022e-02, 2.98075465e-02, -2.70759809e-02, -2.12476294e-02, 3.33406243e-03, -4.38803230e-02, -5.00844705e-03], [3.58970400e-01, -5.43427250e-01, 6.09651110e-01, -1.44986329e-01, 8.03478445e-02, -4.14705279e-01, 9.01788964e-03, 5.08995918e-02, 1.14639620e-03, 7.72631963e-04, -1.11433396e-03, 1.38133366e-02, 6.20932749e-03, -2.22215182e-03, -1.91869743e-02, -3.53098218e-02, -1.30710024e-02]])

2.7 Write down the explicit form of the first PC (in terms of the eigenvectors. Use values with two places of decimals only). [hint: write the linear equation of PC in terms of eigenvectors and corresponding features]

The first PC can be represented using linear combination of features and its coefficients/weights
PC1=c11 * X1+c12 * X2+c13 * X3+c14 * X4.....

where X1,X2,X3,X4... are original variables/features before transformation.

In this scenario PC1 can be represented as linear combination of below components

[c11 c12 c13 c14....c117]= [[-2.62171542e-01 3.14136258e-01 8.10177245e-02 -9.87761685e-02
-2.19898081e-01 2.18800617e-03 -2.83715076e-02 -8.99498102e-02
1.30566998e-01 -1.56464458e-01 -8.62132843e-02 1.82169814e-01
-5.99137640e-01 8.99775288e-02 8.88697944e-02 5.49428396e-01
5.41453698e-03]

[X1 X2 X3.....X17]=['Apps' 'Accept' 'Enroll' 'Top10Perc' 'Top25Perc' 'F.Undergrad' 'P.Undergrad' 'Outstate'
'Room.Board' 'Books' 'Personal' 'PhD' 'Terminal' 'S.F.Ratio' 'perc.alumni' 'Expend'
'Grad.rate']

The Linear eq of 1st component
0.25 * Apps + 0.21 * Accept + 0.18 * Enroll + 0.35 * Top10perc + 0.34 * Top25perc + 0.15 * F.Undergrad + 0.03 * P.Undergrad + 0.29 * Outstate + 0.25 * Room.Board + 0.06 * Books + -0.04 * Personal + 0.32 * PhD + 0.32 * Terminal + -0.18 * S.F.Ratio + 0.21 * perc.alumni + 0.32 * Expend + 0.25 * Grad.Rate

2.8 Consider the cumulative values of the eigenvalues. How does it help you to decide on the optimum number of principal components? What do the eigenvectors indicate?

```
tot = sum(eig_vals)
var_exp = [( i /tot ) * 100 for i in sorted(eig_vals, reverse=True)]
cum_var_exp = np.cumsum(var_exp)
cum_var_exp
```

```
array([ 32.0206282 ,  58.36084263,  65.26175919,  71.18474841,
        76.67315352,  81.65785448,  85.21672597,  88.67034731,
        91.78758099,  94.16277251,  96.00419883,  97.30024023,
        98.28599436,  99.13183669,  99.64896227,  99.86471628,
       100.        ])
```

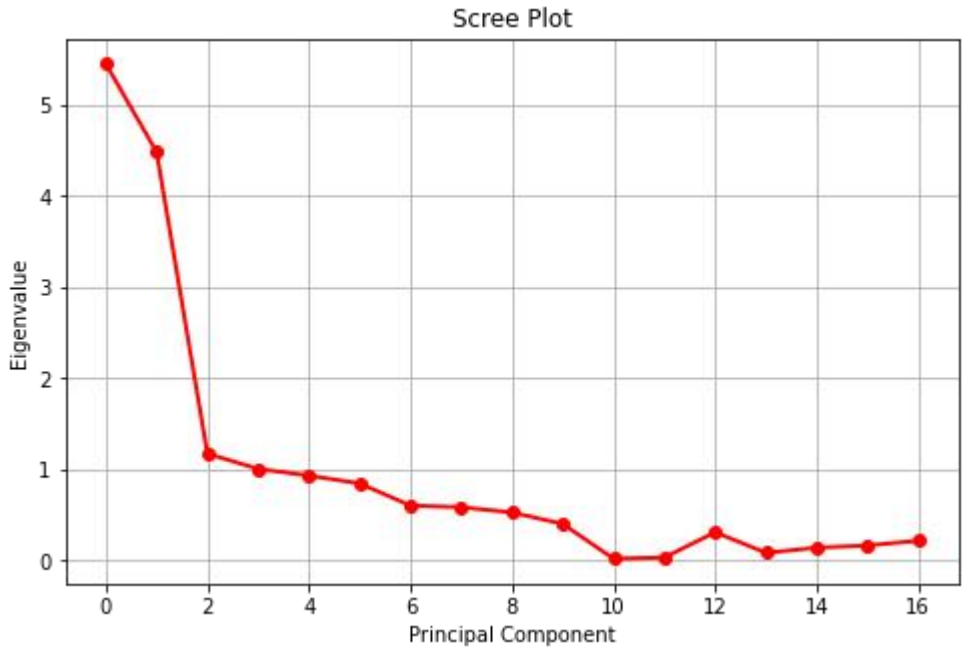
```
pca.components_
```

```
array([[ 0.2487656 ,  0.2076015 ,  0.17630359,  0.35427395,  0.34400128,
         0.15464096,  0.0264425 ,  0.29473642,  0.24903045,  0.06475752,
        -0.04252854,  0.31831287,  0.31705602, -0.17695789,  0.20508237,
         0.31890875,  0.25231565],
       [ 0.33159823,  0.37211675,  0.40372425, -0.08241182, -0.04477866,
         0.41767377,  0.31508783, -0.24964352, -0.13780888,  0.05634184,
         0.21992922,  0.05831132,  0.04642945,  0.24666528, -0.24659527,
        -0.13168986, -0.16924053],
       [-0.06309209, -0.10124907, -0.08298558,  0.03505553, -0.02414793,
        -0.06139296,  0.13968171,  0.04659888,  0.14896739,  0.67741165,
         0.49972112, -0.12702837, -0.06603755, -0.2898484 , -0.14698927,
         0.22674398, -0.20806465],
       [ 0.28131043,  0.26781746,  0.16182686, -0.0515472 , -0.10976657,
         0.10041221, -0.15855847,  0.13129134,  0.184996  ,  0.08708922,
        -0.23071057, -0.53472484, -0.51944301, -0.16118948,  0.01731422,
         0.0792735 ,  0.26912907],
       [ 0.0057413 ,  0.05578622, -0.05569353, -0.39543429, -0.42653362,
        -0.04345451,  0.30238542,  0.22253198,  0.56091948, -0.12728883,
        -0.22231102,  0.14016631,  0.20471975, -0.07938824, -0.21629741,
         0.07595813, -0.10926791]])
```

To decide the optimum number of principal components

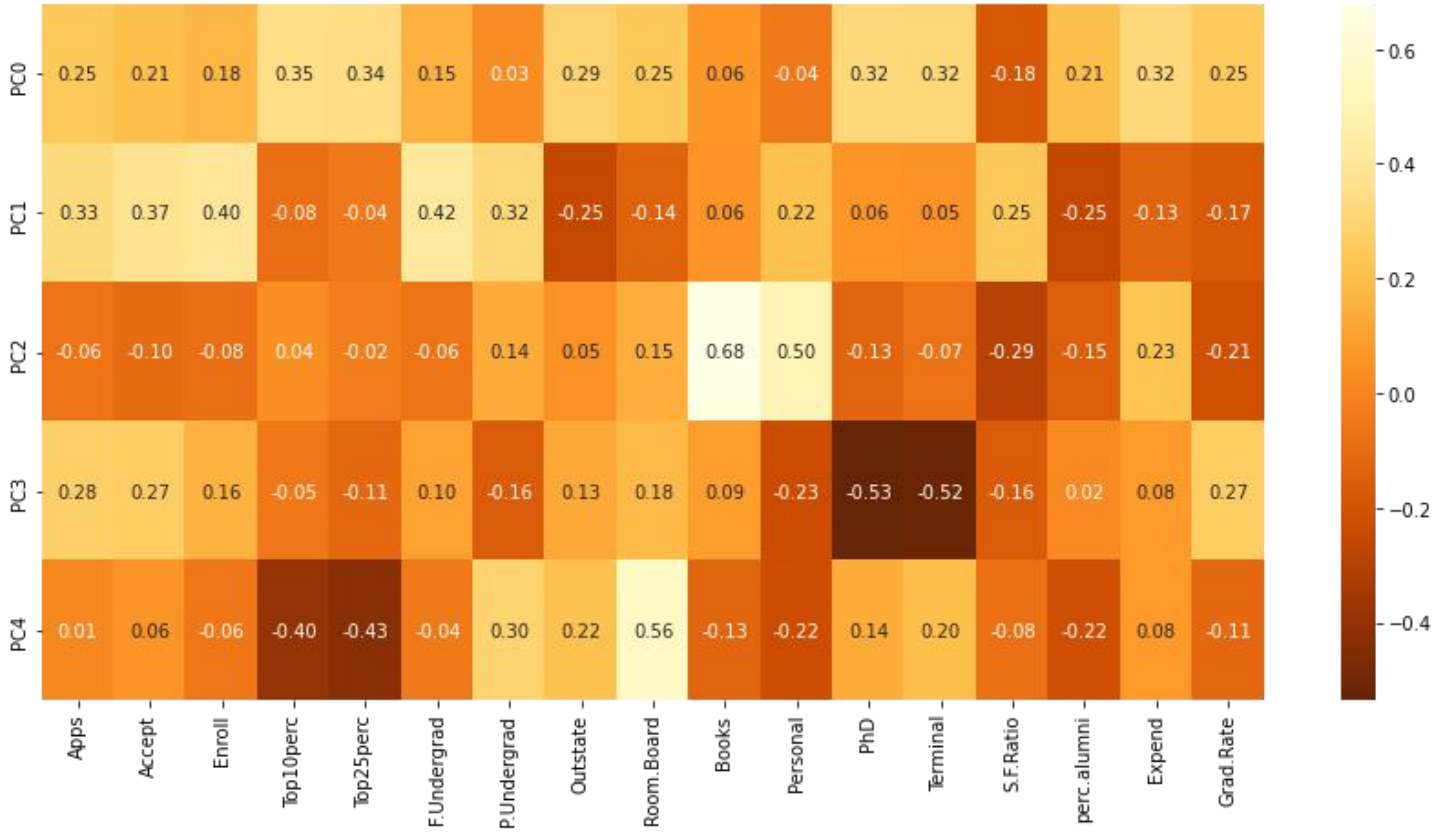
- Check for cumulative variance up to 90%, check the corresponding associated with 90%
- The incremental value between the components should not be less than five percent. So basis on this we can decide the optimum number of principal components as 6, because after this the incremental value between the is less than 5%.
- So, we can select 5 principal components here

- The first components explain 32.02% variance in data & first two explains 58.36% variance in data
- Similarly on checking first five components, these explains 76.67% variance in data



PCA is performed and it is exported into a data frame. After PCA the multi-collinearity is highly reduced.

	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	Outstate	Room.Board	Books	Personal	PhD	Terminal	S.F.Ratio	perc.alumni	Expend	Grad.Rate
0	0.248766	0.207602	0.176304	0.354274	0.344001	0.154641	0.026443	0.294736	0.249030	0.064758	-0.042529	0.318313	0.317056	-0.176958	0.205082	0.318909	0.252316
1	0.331598	0.372117	0.403724	-0.082412	-0.044779	0.417674	0.315088	-0.249644	-0.137809	0.056342	0.219929	0.058311	0.046429	0.246665	-0.246595	-0.131690	-0.169241
2	-0.063092	-0.101249	-0.082986	0.035056	-0.024148	-0.061393	0.139682	0.046599	0.148967	0.677412	0.499721	-0.127028	-0.066038	-0.289848	-0.146989	0.226744	-0.208065
3	0.281310	0.267817	0.161827	-0.051547	-0.109767	0.100412	-0.158558	0.131291	0.184996	0.087089	-0.230711	-0.534725	-0.519443	-0.161189	0.017314	0.079273	0.269129
4	0.005741	0.055786	-0.055694	-0.395434	-0.426534	-0.043455	0.302385	0.222532	0.560919	-0.127289	-0.222311	0.140166	0.204720	-0.079388	-0.216297	0.075958	-0.109268



2.9 Explain the business implication of using the Principal Component Analysis for this case study. How may PCs help in the further analysis? [Hint: Write Interpretations of the Principal Components Obtained]

- Depending on the variance of the dataset we can reduce the PCA components. The PCA components for this business case is 5 where we could see the maximum variance of the dataset.
- Component 5 looks more related to books.
- PC1 could be labeled with Top10Perc,Top25Perc
- Depending on relationsship, we can go ahead and label relationship with features

----------End of Report----------