05a_eda

May 26, 2024

1 Exploratory Data Analysis

1.1 Content

1. Data imports
2. exploring the data structure
3. Up and Downsampling
4. data structure after SMOTE Upsampling
5. Regression Coefficient Confidence Intervals
6. Correlation Matrix
7. save to csv

[77]:
```
# imports
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from collections import Counter
from sklearn.metrics import *
from sklearn.utils import resample
import matplotlib.colors as mcolors
from imblearn.over_sampling import SMOTE
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score
from sklearn.decomposition import PCA
```

Data imports

[78]:
```
# import files
df = pd.read_csv("files/fo_swiss.csv")
abilities = pd.read_csv("files/onet_abilities.csv")
skills = pd.read_csv("files/onet_skills.csv")
not_automatable = [item[0] for item in pd.read_csv("files/not_automatable.csv").
 ↪values.tolist()]

print(df.shape[0])
df.head(5)
```

326

[78]:
```
   isco08                                            Name_de  \
0    2655                                       Schauspieler
1    2612                                            Richter
2    3115  Maschinenbautechniker, Techniker im Bereich Sy…
3    2120                 Mathematiker, Aktuare und Statistiker
4    1222  Führungskräfte in Werbung und Öffentlichkeitsa…

   Berufshauptgruppe    s1    s2    s3    s4    s5    s6    s7  …  a45  a46  \
0                  2  0.72  0.72  0.69  0.69  0.50  0.50  0.50  …  0.0  0.0
1                  2  0.81  0.75  0.81  0.72  0.81  0.66  0.56  …  0.0  0.0
2                  3  0.69  0.66  0.66  0.47  0.72  0.53  0.53  …  0.0  0.0
3                  2  0.81  0.72  0.75  0.50  0.81  0.53  0.50  …  0.0  0.0
4                  1  0.69  0.75  0.78  0.75  0.75  0.56  0.63  …  0.0  0.0

    a47   a48   a49   a50   a51  a52  fo_probability  fo_computerisation
0  0.00  0.00  0.00  0.00  0.00  0.0           0.370                  na
1  0.00  0.00  0.00  0.00  0.00  0.0           0.400                  na
2  0.25  0.28  0.19  0.03  0.03  0.0           0.240                  na
3  0.00  0.00  0.00  0.00  0.00  0.0           0.035                  na
4  0.00  0.00  0.00  0.00  0.00  0.0           0.015                  na

[5 rows x 92 columns]
```

Exploring the data structure

[79]:
```
# drop columns
skills = skills.drop(columns=["id"])
abilities = abilities.drop(columns=["id"])
```

[80]:
```
# rename columns
skills = skills.rename(columns={"name": "skill", "description":␣
↪"skill_description"})
abilities = abilities.rename(columns={"name": "ability", "description":␣
↪"ability_description"})
```

[81]:
```
# Add a letter in front of 'id' column
skills['skill_id'] = 's' + skills['skill_id'].astype(str)
abilities['ability_id'] = 'a' + abilities['ability_id'].astype(str)

df.head(2)
```

[81]:
```
   isco08       Name_de  Berufshauptgruppe    s1    s2    s3    s4    s5  \
0    2655  Schauspieler                  2  0.72  0.72  0.69  0.69  0.50
1    2612       Richter                  2  0.81  0.75  0.81  0.72  0.81

     s6    s7  …  a45  a46  a47  a48  a49  a50  a51  a52  fo_probability  \
```

```
0  0.50  0.50  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0              0.37
1  0.66  0.56  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0              0.40

   fo_computerisation
0                 na
1                 na

[2 rows x 92 columns]
```

[82]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 326 entries, 0 to 325
Data columns (total 92 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   isco08              326 non-null    int64
 1   Name_de             326 non-null    object
 2   Berufshauptgruppe   326 non-null    int64
 3   s1                  326 non-null    float64
 4   s2                  326 non-null    float64
 5   s3                  326 non-null    float64
 6   s4                  326 non-null    float64
 7   s5                  326 non-null    float64
 8   s6                  326 non-null    float64
 9   s7                  326 non-null    float64
 10  s8                  326 non-null    float64
 11  s9                  326 non-null    float64
 12  s10                 326 non-null    float64
 13  s11                 326 non-null    float64
 14  s12                 326 non-null    float64
 15  s13                 326 non-null    float64
 16  s14                 326 non-null    float64
 17  s15                 326 non-null    float64
 18  s16                 326 non-null    float64
 19  s17                 326 non-null    float64
 20  s18                 326 non-null    float64
 21  s19                 326 non-null    float64
 22  s20                 326 non-null    float64
 23  s21                 326 non-null    float64
 24  s22                 326 non-null    float64
 25  s23                 326 non-null    float64
 26  s24                 326 non-null    float64
 27  s25                 326 non-null    float64
 28  s26                 326 non-null    float64
 29  s27                 326 non-null    float64
 30  s28                 326 non-null    float64
 31  s29                 326 non-null    float64
```

```
32  s30                    326 non-null    float64
33  s31                    326 non-null    float64
34  s32                    326 non-null    float64
35  s33                    326 non-null    float64
36  s34                    326 non-null    float64
37  s35                    326 non-null    float64
38  a1                     326 non-null    float64
39  a2                     326 non-null    float64
40  a3                     326 non-null    float64
41  a4                     326 non-null    float64
42  a5                     326 non-null    float64
43  a6                     326 non-null    float64
44  a7                     326 non-null    float64
45  a8                     326 non-null    float64
46  a9                     326 non-null    float64
47  a10                    326 non-null    float64
48  a11                    326 non-null    float64
49  a12                    326 non-null    float64
50  a13                    326 non-null    float64
51  a14                    326 non-null    float64
52  a15                    326 non-null    float64
53  a16                    326 non-null    float64
54  a17                    326 non-null    float64
55  a18                    326 non-null    float64
56  a19                    326 non-null    float64
57  a20                    326 non-null    float64
58  a21                    326 non-null    float64
59  a22                    326 non-null    float64
60  a23                    326 non-null    float64
61  a24                    326 non-null    float64
62  a25                    326 non-null    float64
63  a26                    326 non-null    float64
64  a27                    326 non-null    float64
65  a28                    326 non-null    float64
66  a29                    326 non-null    float64
67  a30                    326 non-null    float64
68  a31                    326 non-null    float64
69  a32                    326 non-null    float64
70  a33                    326 non-null    float64
71  a34                    326 non-null    float64
72  a35                    326 non-null    float64
73  a36                    326 non-null    float64
74  a37                    326 non-null    float64
75  a38                    326 non-null    float64
76  a39                    326 non-null    float64
77  a40                    326 non-null    float64
78  a41                    326 non-null    float64
79  a42                    326 non-null    float64
```

```
 80  a43                  326 non-null    float64
 81  a44                  326 non-null    float64
 82  a45                  326 non-null    float64
 83  a46                  326 non-null    float64
 84  a47                  326 non-null    float64
 85  a48                  326 non-null    float64
 86  a49                  326 non-null    float64
 87  a50                  326 non-null    float64
 88  a51                  326 non-null    float64
 89  a52                  326 non-null    float64
 90  fo_probability       326 non-null    float64
 91  fo_computerisation   326 non-null    object
dtypes: float64(88), int64(2), object(2)
memory usage: 234.4+ KB
```

[83]:
```
df.describe().round(2)
```

[83]:

	isco08	Berufshauptgruppe	s1	s2	s3	s4	s5
count	326.00	326.00	326.00	326.00	326.00	326.00	326.00
mean	4931.37	4.64	0.59	0.62	0.63	0.53	0.60
std	2580.44	2.59	0.14	0.13	0.12	0.12	0.12
min	1112.00	1.00	0.25	0.28	0.25	0.25	0.31
25%	2634.25	2.00	0.50	0.50	0.50	0.44	0.50
50%	4311.50	4.00	0.56	0.66	0.66	0.50	0.60
75%	7322.75	7.00	0.72	0.75	0.75	0.63	0.72
max	9629.00	9.00	0.94	0.94	0.97	0.81	0.81

\

	s6	s7	s8	…	a44	a45	a46	a47	a48
count	326.00	326.00	326.00	…	326.00	326.00	326.00	326.00	326.00
mean	0.58	0.52	0.53	…	0.39	0.10	0.11	0.23	0.26
std	0.11	0.09	0.13	…	0.15	0.12	0.13	0.20	0.22
min	0.22	0.25	0.22	…	0.00	0.00	0.00	0.00	0.00
25%	0.50	0.47	0.44	…	0.25	0.00	0.00	0.00	0.00
50%	0.53	0.50	0.50	…	0.36	0.03	0.03	0.22	0.25
75%	0.69	0.56	0.63	…	0.50	0.19	0.24	0.41	0.44
max	0.78	0.75	0.78	…	0.91	0.60	0.72	0.78	0.81

\

	a49	a50	a51	a52	fo_probability
count	326.00	326.00	326.00	326.00	326.00
mean	0.21	0.11	0.16	0.14	0.43
std	0.19	0.13	0.15	0.14	0.39
min	0.00	0.00	0.00	0.00	0.00
25%	0.00	0.00	0.00	0.00	0.03
50%	0.19	0.03	0.15	0.13	0.36
75%	0.35	0.22	0.25	0.25	0.84
max	0.97	0.47	0.75	0.63	0.99

```
[8 rows x 90 columns]
```

[84]:
```
# replace na with 0
df["fo_computerisation"] =  pd.to_numeric(df["fo_computerisation"],␣
↪errors='coerce').fillna(0).astype(int)  # this will convert na to 0, which␣
↪is wrong. the issue is solved later on
```

[85]:
```
#Get Number per class
freq = df['fo_computerisation'].value_counts()
print(freq)
```

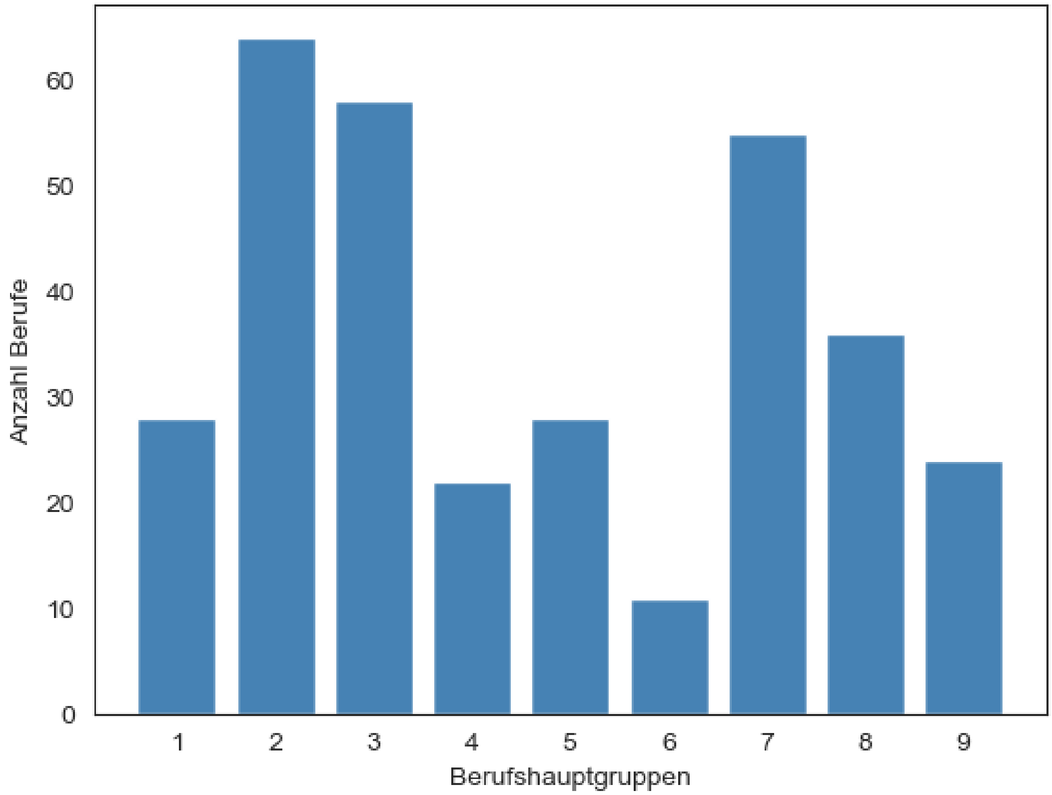
```
fo_computerisation
0    314
1     12
Name: count, dtype: int64
```

[86]:
```
# calculate fo_computerisation based on 'df_probability'
df['fo_computerisation'] = df['fo_probability'].apply(lambda x: 1 if x >= 0.5␣
↪else 0)
```

[87]:
```
#Get Number per class
freq = df['fo_computerisation'].value_counts()
print(freq)
```

```
fo_computerisation
0    178
1    148
Name: count, dtype: int64
```

[88]:
```
# Get number per class and sort by index
freq = df['Berufshauptgruppe'].value_counts().sort_index()

# Create a bar chart
plt.bar(range(len(freq)), freq.values, color="#4682B4")

# Set title, x-label, y-label, and x-ticks
plt.ylabel('Anzahl Berufe', fontsize = 10)
plt.xlabel('Berufshauptgruppen', fontsize = 10)
plt.xticks(range(len(freq)), freq.index)

# Show the figure
plt.show()
```



[89]:
```python
# Select only numeric columns
df_numeric = df.select_dtypes(include=[np.number])

# Calculate correlation
corr = df_numeric.corr()

# Display the correlation matrix
corr
```

[89]:
```
                     isco08  Berufshauptgruppe        s1        s2        s3  \
isco08             1.000000           0.998287 -0.780094 -0.724832 -0.768921
Berufshauptgruppe  0.998287           1.000000 -0.785612 -0.733018 -0.775674
s1                -0.780094          -0.785612  1.000000  0.789472  0.849349
s2                -0.724832          -0.733018  0.789472  1.000000  0.908991
s3                -0.768921          -0.775674  0.849349  0.908991  1.000000
…                        …                  …         …         …         …
a50                0.557115           0.560632 -0.402196 -0.395728 -0.406229
a51                0.496304           0.501174 -0.384058 -0.337968 -0.367260
a52                0.649642           0.653424 -0.630015 -0.575574 -0.566921
fo_probability     0.510758           0.518262 -0.512661 -0.557475 -0.563570
fo_computerisation 0.494887           0.503570 -0.497289 -0.548277 -0.545791
```

```
                           s4        s5        s6        s7        s8  …  \
isco08              -0.657392 -0.704797 -0.510884 -0.502370 -0.679214  …
Berufshauptgruppe   -0.664497 -0.707131 -0.511340 -0.506091 -0.679665  …
s1                   0.655073  0.836534  0.609810  0.613115  0.781304  …
s2                   0.834895  0.754310  0.599137  0.642778  0.706376  …
s3                   0.789313  0.777944  0.592369  0.637421  0.729087  …
…                           …         …         …         …         …  …
a50                 -0.365147 -0.208847 -0.095499 -0.188122 -0.247600  …
a51                 -0.326187 -0.179069 -0.080187 -0.157205 -0.180893  …
a52                 -0.472795 -0.416801 -0.218547 -0.350913 -0.446690  …
fo_probability      -0.540139 -0.616052 -0.534419 -0.475254 -0.557876  …
fo_computerisation  -0.508542 -0.567065 -0.492861 -0.424156 -0.507713  …

                          a45       a46       a47       a48       a49  \
isco08               0.551850  0.561929  0.676531  0.669807  0.623415
Berufshauptgruppe    0.554762  0.564717  0.683692  0.676154  0.629064
s1                  -0.393883 -0.440090 -0.588218 -0.579570 -0.540124
s2                  -0.361852 -0.393288 -0.630389 -0.606298 -0.535363
s3                  -0.375216 -0.408926 -0.611800 -0.592960 -0.524761
…                           …         …         …         …         …
a50                  0.918138  0.910412  0.759231  0.784532  0.802498
a51                  0.881171  0.912271  0.684001  0.714539  0.774746
a52                  0.665158  0.724730  0.752964  0.787220  0.799037
fo_probability       0.071696  0.103256  0.289879  0.246624  0.204038
fo_computerisation   0.115136  0.141952  0.322163  0.283416  0.239207

                          a50       a51       a52  fo_probability  \
isco08               0.557115  0.496304  0.649642        0.510758
Berufshauptgruppe    0.560632  0.501174  0.653424        0.518262
s1                  -0.402196 -0.384058 -0.630015       -0.512661
s2                  -0.395728 -0.337968 -0.575574       -0.557475
s3                  -0.406229 -0.367260 -0.566921       -0.563570
…                           …         …         …               …
a50                  1.000000  0.835231  0.665827        0.103014
a51                  0.835231  1.000000  0.657659        0.057525
a52                  0.665827  0.657659  1.000000        0.228484
fo_probability       0.103014  0.057525  0.228484        1.000000
fo_computerisation   0.154802  0.092507  0.253942        0.950052

                     fo_computerisation
isco08                         0.494887
Berufshauptgruppe              0.503570
s1                            -0.497289
s2                            -0.548277
s3                            -0.545791
…                                     …
```

```
a50                          0.154802
a51                          0.092507
a52                          0.253942
fo_probability               0.950052
fo_computerisation           1.000000

[91 rows x 91 columns]
```

[90]:

```
cov = df_numeric.cov()
cov
```

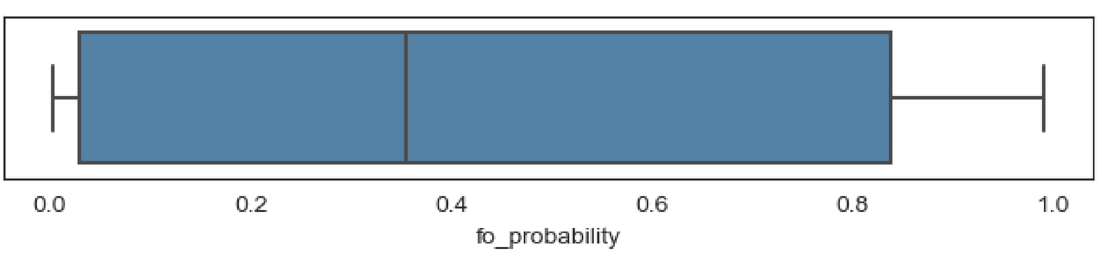
[90]:

```
                          isco08  Berufshauptgruppe          s1          s2  \
isco08              6.658669e+06        6664.048334 -276.964797 -233.957337
Berufshauptgruppe   6.664048e+03           6.692336   -0.279628   -0.237197
s1                 -2.769648e+02          -0.279628    0.018931    0.013587
s2                 -2.339573e+02          -0.237197    0.013587    0.015646
s3                 -2.379457e+02          -0.240641    0.014014    0.013635
…                            …                  …           …           …
a50                 1.797850e+02           0.181377   -0.006920   -0.006190
a51                 1.940292e+02           0.196428   -0.008006   -0.006405
a52                 2.359491e+02           0.237922   -0.012201   -0.010133
fo_probability      5.148128e+02           0.523696   -0.027552   -0.027238
fo_computerisation  6.367815e+02           0.649589   -0.034118   -0.034198

                            s3          s4          s5          s6  \
isco08             -237.945667 -200.748870 -210.191839 -139.673673
Berufshauptgruppe    -0.240641   -0.203431   -0.211420   -0.140151
s1                    0.014014    0.010666    0.013302    0.008889
s2                    0.013635    0.012359    0.010905    0.007940
s3                    0.014382    0.011202    0.010782    0.007526
…                          …           …           …           …
a50                  -0.006092   -0.005404   -0.003019   -0.001265
a51                  -0.006673   -0.005848   -0.003135   -0.001287
a52                  -0.009569   -0.007875   -0.006780   -0.003259
fo_probability       -0.026399   -0.024968   -0.027811   -0.022117
fo_computerisation   -0.032638   -0.030009   -0.032680   -0.026038

                            s7          s8  …         a45         a46  \
isco08             -122.864516 -222.716112  …  164.895488  189.837509
Berufshauptgruppe    -0.124087   -0.223426  …    0.166184    0.191261
s1                    0.007995    0.013660  …   -0.006275   -0.007927
s2                    0.007620    0.011228  …   -0.005241   -0.006441
s3                    0.007245    0.011110  …   -0.005210   -0.006420
…                          …           …  …           …           …
a50                  -0.002230   -0.003935  …    0.013296    0.014906
a51                  -0.002257   -0.003483  …    0.015459    0.018095
a52                  -0.004681   -0.007989  …    0.010841    0.013355
```

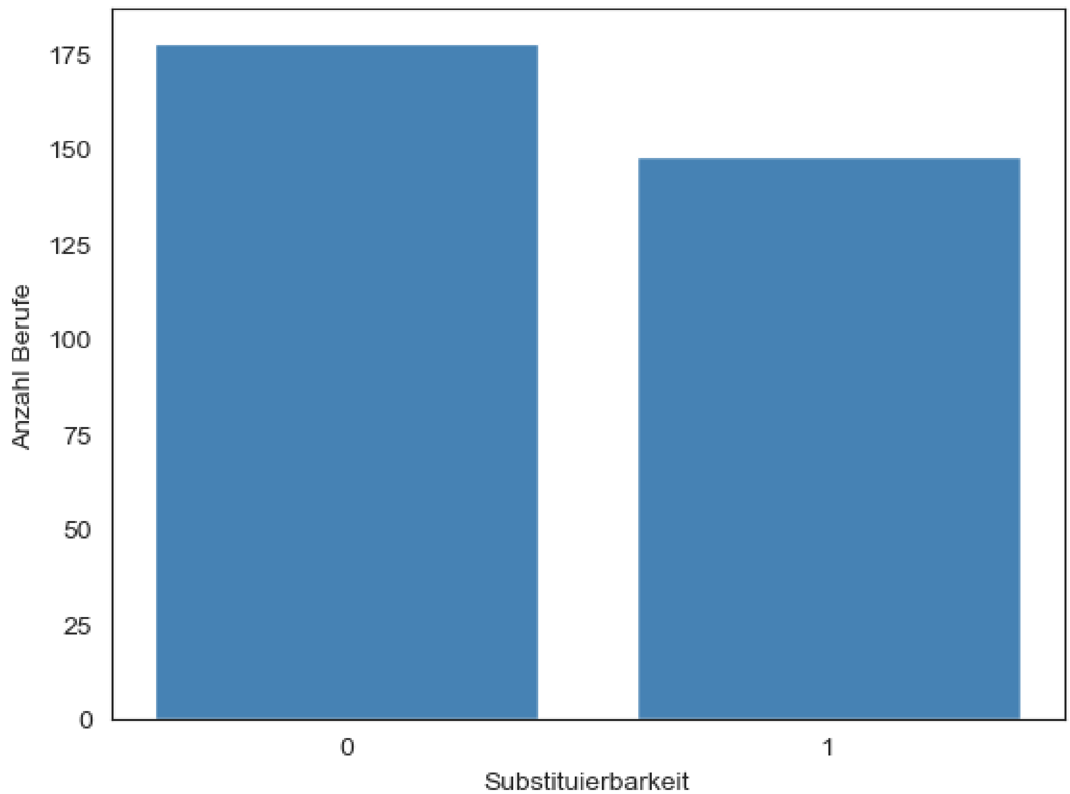
```
fo_probability        -0.017594   -0.027690  …    0.003243    0.005280
fo_computerisation    -0.020046   -0.032171  …    0.006648    0.009267

                           a47         a48         a49         a50  \
isco08              356.604117  382.399647  298.976780  179.784959
Berufshauptgruppe     0.361289    0.386998    0.302447    0.181377
s1                   -0.016532   -0.017643   -0.013812   -0.006920
s2                   -0.016107   -0.016779   -0.012446   -0.006190
s3                   -0.014987   -0.015733   -0.011696   -0.006092
…                          …          …          …          …
a50                   0.019395    0.021707    0.018652    0.015640
a51                   0.021168    0.023951    0.021815    0.015825
a52                   0.021649    0.024514    0.020902    0.011720
fo_probability        0.023129    0.021313    0.014812    0.005032
fo_computerisation    0.032815    0.031267    0.022168    0.009653

                           a51         a52  fo_probability  fo_computerisation
isco08              194.029221  235.949105      514.812848          636.781463
Berufshauptgruppe     0.196428    0.237922        0.523696            0.649589
s1                   -0.008006   -0.012201       -0.027552           -0.034118
s2                   -0.006405   -0.010133       -0.027238           -0.034198
s3                   -0.006673   -0.009569       -0.026399           -0.032638
…                          …          …              …                  …
a50                   0.015825    0.011720        0.005032            0.009653
a51                   0.022954    0.014024        0.003404            0.006989
a52                   0.014024    0.019811        0.012562            0.017823
fo_probability        0.003404    0.012562        0.152574            0.185046
fo_computerisation    0.006989    0.017823        0.185046            0.248646

[91 rows x 91 columns]
```

[91]:
```python
# boxplot of probabilities of computerisation
plt.figure(figsize=(8,1.2))
sns.set_style("white")
sns.boxplot(x=df['fo_probability'], color="#4682B4")
```

[91]: <Axes: xlabel='fo_probability'>



[92]:
```
# Get number per class
freq = df['fo_computerisation'].value_counts()

# Create a bar chart
plt.bar(freq.index, freq.values, color="#4682B4")
# plt.title('Substituierbarkeit nach Osborne and Frey (2013)')
plt.ylabel('Anzahl Berufe', fontsize = 10)
plt.xticks(freq.index)
plt.xlabel('Substituierbarkeit', fontsize = 10)
plt.show()
```



Up and Downsampling

[93]:
```
df_numeric = df.drop(columns=['Name_de'])
```

[94]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(df_numeric.
 ↪drop('fo_computerisation', axis=1), df_numeric['fo_computerisation'],␣
 ↪test_size=0.2, random_state=42)

# Fit a logistic regression model
```

```
model = LogisticRegression(max_iter=1000)
model.fit(X_train, y_train)

# Predict probabilities for the test set
y_pred_prob = model.predict_proba(X_test)[:, 1]

# Calculate AUC
auc = roc_auc_score(y_test, y_pred_prob)
print('AUC: %.2f' % auc)
```

```
AUC: 1.00
```

1.1.1 calculate minority and majority class automaitcally

[95]:
```
# Get the counts of each class
class_counts = df_numeric['fo_computerisation'].value_counts()

# Identify majority and minority classes
majority_class = class_counts.idxmax()
minority_class = class_counts.idxmin()

# Separate majority and minority classes
df_majority = df_numeric[df['fo_computerisation'] == majority_class]
df_minority = df_numeric[df['fo_computerisation'] == minority_class]
```

1.1.2 SMOTE

[96]:
```
# define independent and target values
X = df_numeric.select_dtypes(include=[np.number]).drop('fo_computerisation',␣
↪axis=1)
y = df_numeric['fo_computerisation']

# Upsample minority class
oversample = SMOTE(random_state=42)
X, y = oversample.fit_resample(X, y)

counter = Counter(y)
print(counter)

df_smote = pd.concat([pd.DataFrame(X), pd.DataFrame(y,␣
↪columns=['fo_computerisation'])], axis=1)
```

```
Counter({0: 178, 1: 178})
```

[97]:
```
# calculate "fo_computerisation" based on 'df_probability' to make sure SMOTE␣
↪didn't mess this up
df_smote['fo_computerisation'] = df_smote['fo_probability'].apply(lambda x: 1␣
↪if x >= 0.5 else 0)
```

[98]:
```
# Get Amount per class
freq = df_smote['fo_computerisation'].value_counts()
print(freq)
```

```
fo_computerisation
0    178
1    178
Name: count, dtype: int64
```

[99]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(df_smote.
 ↪drop('fo_computerisation', axis=1), df_smote['fo_computerisation'],␣
 ↪test_size=0.2, random_state=42)

# Fit a logistic regression model
model = LogisticRegression(max_iter=1000)
model.fit(X_train, y_train)

# Predict probabilities for the test set
y_pred_prob = model.predict_proba(X_test)[:, 1]

# Calculate AUC
auc = roc_auc_score(y_test, y_pred_prob)
print('AUC: %.2f' % auc)
```

```
AUC: 1.00
```

1.1.3 Upsampling

[100]:
```
# Upsample minority class
df_minority_upsampled = resample(df_minority,
                                 replace=True,     # sample with replacement
                                 n_samples=df_majority.shape[0],    # to match␣
 ↪majority class
                                 random_state=53) # reproducible results

# Combine majority class with upsampled minority class
df_upsampled = pd.concat([df_majority, df_minority_upsampled])

# Display new class counts
df_upsampled.fo_computerisation.value_counts()
```

[100]:
```
fo_computerisation
0    178
1    178
Name: count, dtype: int64
```

[101]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(df_upsampled.
 ↪drop('fo_computerisation', axis=1), df_upsampled['fo_computerisation'],␣
 ↪test_size=0.2, random_state=42)

# Fit a logistic regression model
model = LogisticRegression(max_iter=1000)
model.fit(X_train, y_train)

# Predict probabilities for the test set
y_pred_prob = model.predict_proba(X_test)[:, 1]

# Calculate AUC
auc = roc_auc_score(y_test, y_pred_prob)
print('AUC: %.2f' % auc)
```

```
AUC: 0.99
```

1.1.4 Downsampling

[102]:
```
# Downsample majority class
df_majority_downsampled = resample(df_majority,
                                   replace=False,    # sample without␣
 ↪replacement
                                   n_samples=df_minority.shape[0],  # to match␣
 ↪minority class
                                   random_state=42) # reproducible results

# Combine minority class with downsampled majority class
df_downsampled = pd.concat([df_majority_downsampled, df_minority])

# Display new class counts
df_downsampled.fo_computerisation.value_counts()
```

[102]:
```
fo_computerisation
0    148
1    148
Name: count, dtype: int64
```

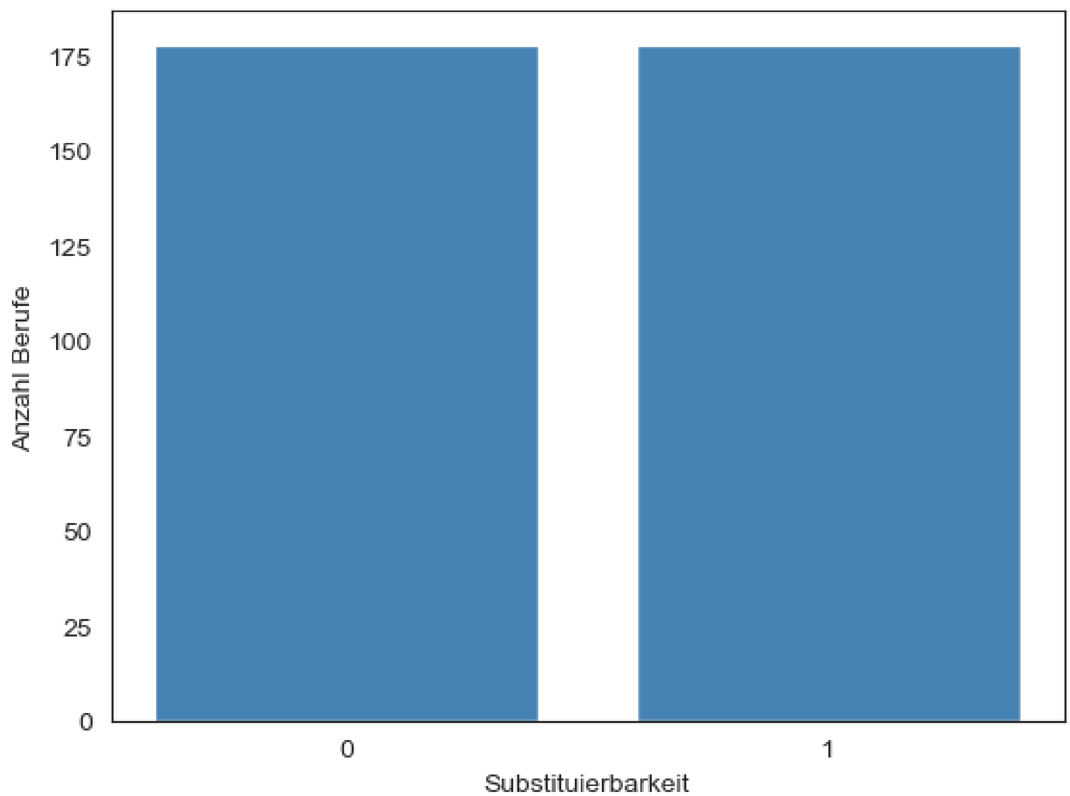
[103]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(df_downsampled.
 ↪drop('fo_computerisation', axis=1), df_downsampled['fo_computerisation'],␣
 ↪test_size=0.2, random_state=53)

# Fit a logistic regression model
model = LogisticRegression(max_iter=1000)
model.fit(X_train, y_train)
```

```
# Predict probabilities for the test set
y_pred_prob = model.predict_proba(X_test)[:, 1]

# Calculate AUC
auc = roc_auc_score(y_test, y_pred_prob)
print('AUC: %.2f' % auc)
```

```
AUC: 1.00
```

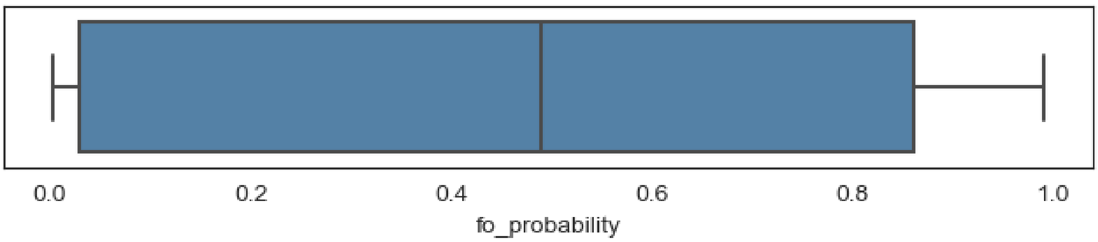
Data structure after SMOTE Upsampling

[104]:
```
# Get number per class
freq = df_smote['fo_computerisation'].value_counts()

# Create a bar chart
plt.bar(freq.index, freq.values, color="#4682B4")
plt.ylabel('Anzahl Berufe', fontsize = 10)
plt.xticks(freq.index)
plt.xlabel('Substituierbarkeit', fontsize = 10)
plt.show()
```

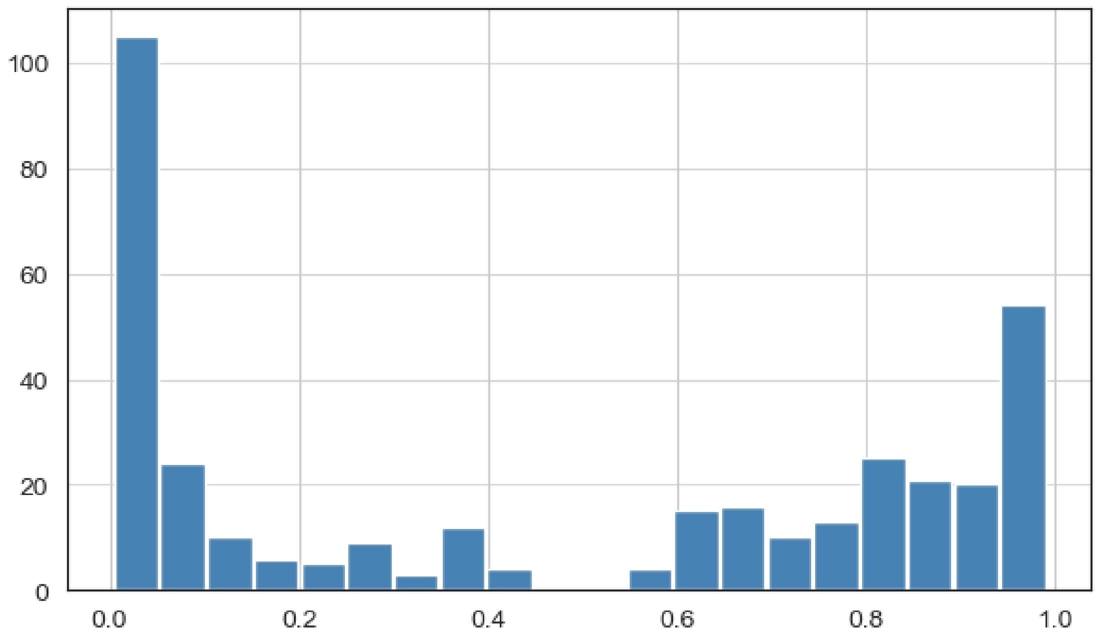


[105]:
```
# boxplot of probabilities of computerisation
plt.figure(figsize=(8,1.2))
sns.set_style("white")
sns.boxplot(x=df_smote['fo_probability'], color="#4682B4")
```

[105]: <Axes: xlabel='fo_probability'>



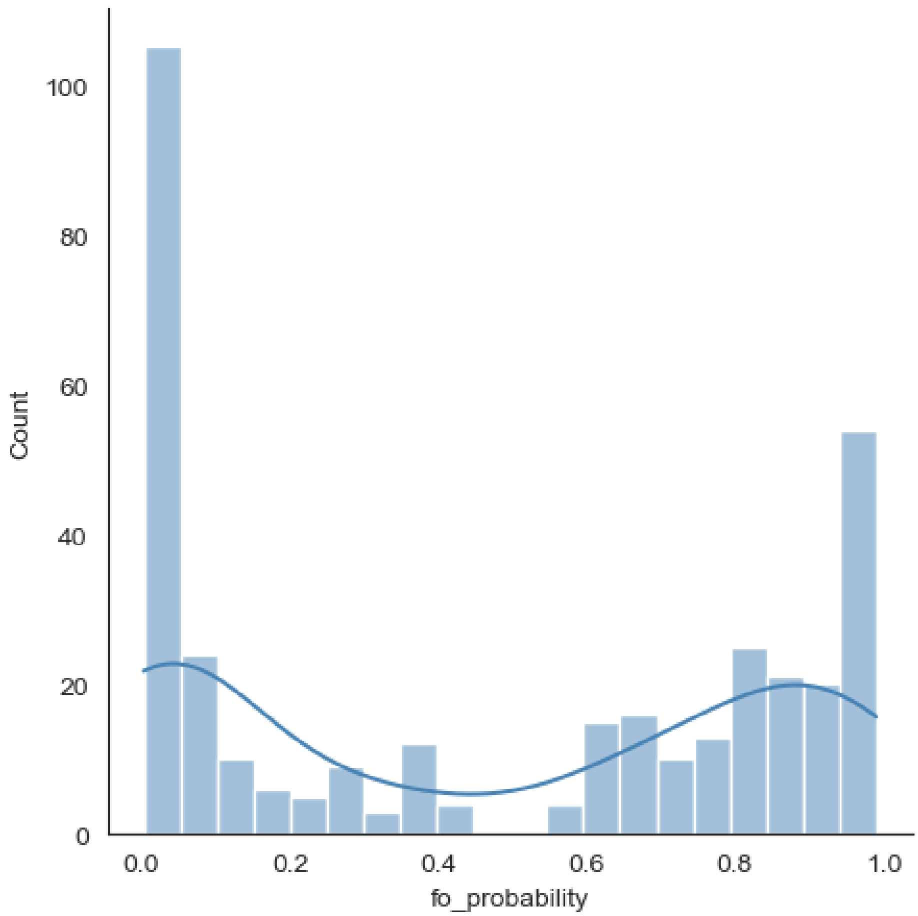
[106]:
```
# Plot Histogram
fig = plt.figure(figsize=(7,4))
plt.xticks(fontsize=14, rotation=0)
plt.yticks(fontsize=14, rotation=0)
n, bins, patches = plt.hist(x=df_smote['fo_probability'],
                            bins=20,
                            color="#4682B4",
                            rwidth=0.95
                   )
plt.grid(True)
plt.ticklabel_format(style='plain')
plt.grid(axis='y', alpha=0.75)

plt.show()
```



[107]:
```
sns.displot(df_smote['fo_probability'], bins=20, color="#4682B4", kde=True)
```

```
/opt/anaconda3/envs/bachelorarbeit/lib/python3.11/site-
packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is
deprecated and will be removed in a future version. Convert inf values to NaN
before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
```

[107]:
```
<seaborn.axisgrid.FacetGrid at 0x16c420050>
```

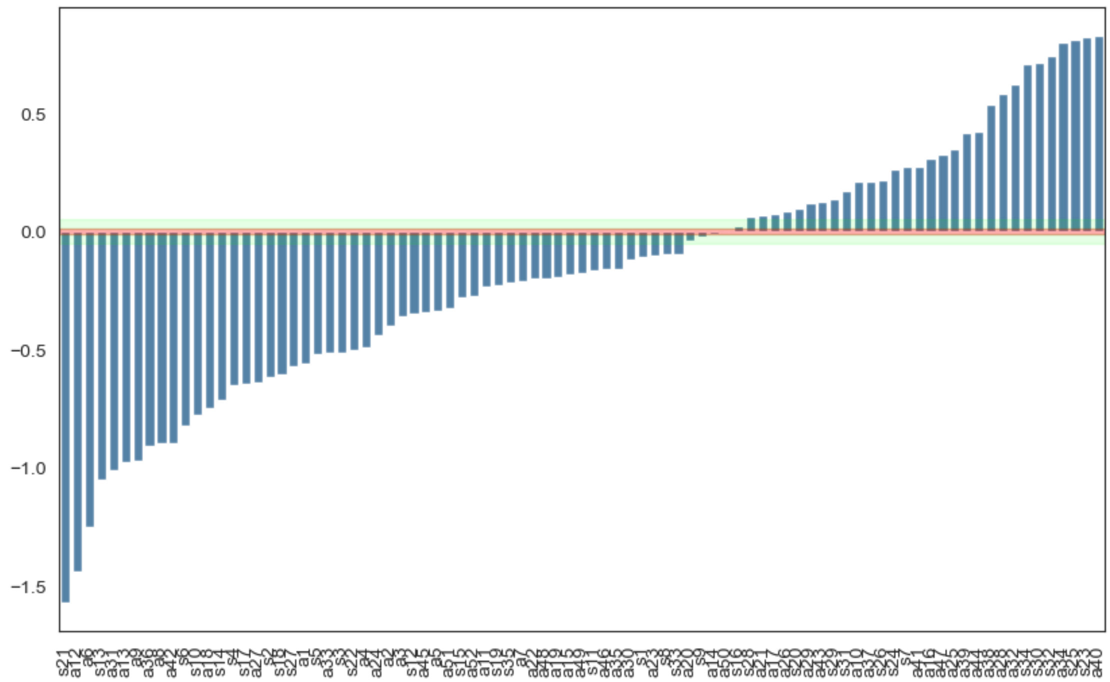


Regression Coefficient / Confidence Intervals

[108]:
```
# Select columns that start with 's' or 'a' and the 'fo_probability' column
df_selected = df_smote.filter(regex='^(s|a|fo_computerisation)')

# Define the dependent variable
y = df_selected['fo_computerisation']

# Define the independent variables
X = df_selected.drop('fo_computerisation', axis=1)

# Fit the model
model = LogisticRegression()
model.fit(X, y)

intercept = model.intercept_

# Get the regression coefficients
```

```python
coefficients = pd.Series(model.coef_[0], index=X.columns)

# Sort the coefficients
coefficients = coefficients.sort_values()

# Create a bar chart
plt.figure(figsize=(10,6))
sns.barplot(x=coefficients.index, y=coefficients.values, color="#4682B4")
plt.xticks(rotation=90)  # Rotate x-axis labels for better visibility

# Konfidenzintervall 99%
plt.axhspan(-0.01, 0.01, color='#ff0000', alpha=0.3, edgecolor='none')

# Konfidenzintervall 95%
plt.axhspan(0.011, 0.05, color='#00FF00', alpha=0.1, edgecolor='none')
plt.axhspan(-0.05, -0.011, color='#00FF00', alpha=0.1, edgecolor='none')

plt.show()
```

```
/var/folders/ms/0wqr6tr506lfp142wmz0qph40000gn/T/ipykernel_3937/1369965362.py:28
: UserWarning: Setting the 'color' property will override the edgecolor or
facecolor properties.
  plt.axhspan(-0.01, 0.01, color='#ff0000', alpha=0.3, edgecolor='none')
/var/folders/ms/0wqr6tr506lfp142wmz0qph40000gn/T/ipykernel_3937/1369965362.py:31
: UserWarning: Setting the 'color' property will override the edgecolor or
facecolor properties.
  plt.axhspan(0.011, 0.05, color='#00FF00', alpha=0.1, edgecolor='none')
/var/folders/ms/0wqr6tr506lfp142wmz0qph40000gn/T/ipykernel_3937/1369965362.py:32
: UserWarning: Setting the 'color' property will override the edgecolor or
facecolor properties.
  plt.axhspan(-0.05, -0.011, color='#00FF00', alpha=0.1, edgecolor='none')
```



Save to csv

[109]:
```python
# Extract coefficients outside the 95% confidence interval
coefficients_outside_95 = coefficients[(coefficients < -0.05) | (coefficients > 0.05)].round(4)

# Extract coefficients outside the 99% confidence interval
coefficients_outside_99 = coefficients[(coefficients < -0.01) | (coefficients > 0.01)].round(4)
```

[110]:
```python
# Create a dataframe from the coefficients outside the 95% and 99% confidence intervals with headers
coefficients_outside_95 = pd.DataFrame(list(coefficients_outside_95.items()), columns=['id', 'coefficient'])
coefficients_outside_99 = pd.DataFrame(list(coefficients_outside_99.items()), columns=['id', 'coefficient'])

# Merge skills dataframe with coefficients
coefficients_outside_95 = coefficients_outside_95.merge(skills, left_on='id', right_on='skill_id', how='left')
coefficients_outside_99 = coefficients_outside_99.merge(skills, left_on='id', right_on='skill_id', how='left')

# Merge abilities dataframe with coefficients
```

```
coefficients_outside_95 = coefficients_outside_95.merge(abilities,␣
↪left_on='id', right_on='ability_id', how='left')
coefficients_outside_99 = coefficients_outside_99.merge(abilities,␣
↪left_on='id', right_on='ability_id', how='left')

# remove unnecessary columns
coefficients_outside_95 = coefficients_outside_95.drop(columns=['skill_id',␣
↪'ability_id'])
coefficients_outside_99 = coefficients_outside_99.drop(columns=['skill_id',␣
↪'ability_id'])
```

[111]:
```
# Merge skill and skill description
coefficients_outside_95['skill'] = coefficients_outside_95['skill'].
↪fillna(coefficients_outside_95['ability'])
coefficients_outside_95["skill_description"] =␣
↪coefficients_outside_95["skill_description"].
↪fillna(coefficients_outside_95["ability_description"])

coefficients_outside_99['skill'] = coefficients_outside_99['skill'].
↪fillna(coefficients_outside_99['ability'])
coefficients_outside_99["skill_description"] =␣
↪coefficients_outside_99["skill_description"].
↪fillna(coefficients_outside_99["ability_description"])

# Now you can drop the abilities
coefficients_outside_95 = coefficients_outside_95.
↪drop(columns=['ability_description', 'ability'])
coefficients_outside_99 = coefficients_outside_99.
↪drop(columns=['ability_description', 'ability'])
```

[112]:
```
# Save the dataframes to csv files
coefficients_outside_95.reset_index().rename(columns={'index': 'Variable', 0:␣
↪'Coefficient'}).sort_values('coefficient').drop(columns=["Variable"]).
↪to_csv('files/coefficients_outside_95.csv', index=False)
coefficients_outside_99.reset_index().rename(columns={'index': 'Variable', 0:␣
↪'Coefficient'}).sort_values('coefficient').drop(columns=["Variable"]).
↪to_csv('files/coefficients_outside_99.csv', index=False)
df_smote.to_csv('files/fo_smote.csv', index=False)
pd.DataFrame([intercept], columns=['intercept']).to_csv('files/
↪intercept_not_normalized.csv', index=False)
```

[113]:
```
cols_to_keep = not_automatable
cols_to_keep.extend(['fo_probability', 'fo_computerisation'])

# Drop the other columns
df_smote = df_smote[cols_to_keep]
```

```python
# Display the first few rows of the DataFrame
df_smote.head(5)
```

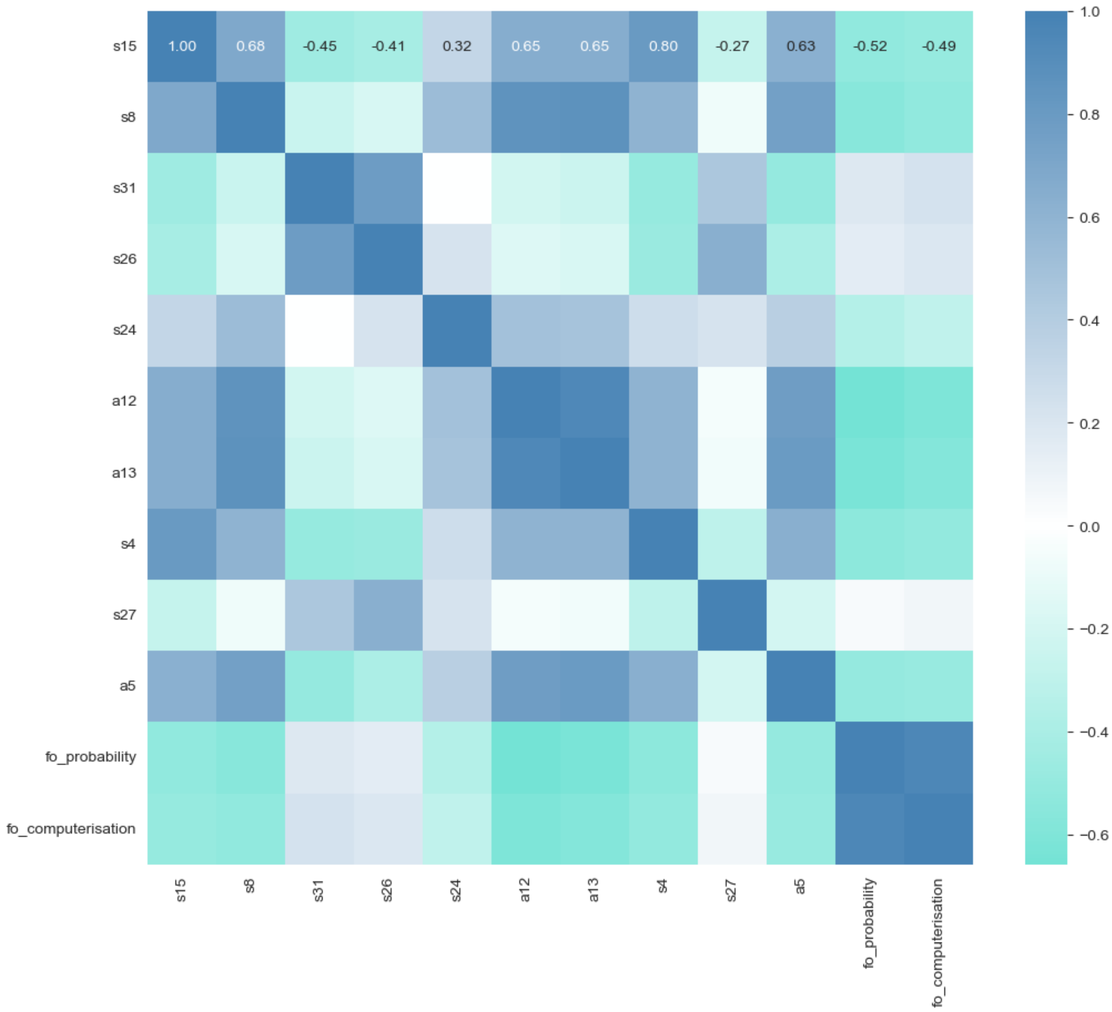
[113]:

```
    s15    s8  s31   s26   s24   a12   a13    s4   s27    a5  fo_probability  \
0  0.38  0.47  0.0  0.00  0.06  0.47  0.47  0.69  0.00  0.72           0.370
1  0.56  0.72  0.0  0.00  0.19  0.78  0.81  0.72  0.00  0.81           0.400
2  0.38  0.63  0.5  0.41  0.28  0.72  0.72  0.47  0.28  0.75           0.240
3  0.44  0.75  0.0  0.00  0.22  0.75  0.78  0.50  0.00  0.75           0.035
4  0.53  0.63  0.0  0.03  0.19  0.72  0.63  0.75  0.00  0.75           0.015

   fo_computerisation
0                   0
1                   0
2                   0
3                   0
4                   0
```

Correlation Matrix

[114]:

```python
# Calculate the correlation matrix
corr_matrix = df_smote.corr()

# Create a custom colormap
cmap = mcolors.LinearSegmentedColormap.from_list("custom", ["#2dd4bf", "white",␣
  ↪"#4682B4"])

# Create a heatmap
plt.figure(figsize=(12, 10))
sns.heatmap(corr_matrix, annot=True, fmt=".2f", cmap=cmap, center=0)

# Show the plot
plt.show()
```



s15
s8
s31
s26
s24
a12
a13
s4
s27
a5
fo_probability
fo_computerisation
1.00
0.68
-0.45
-0.41
0.32
0.65
0.65
0.80
-0.27
0.63
-0.52
-0.49
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6