npa-prediction-model

July 29, 2024

[94]:
```python
import pandas as pd
from sklearn.preprocessing import StandardScaler, MinMaxScaler

# Load the dataset from the specified file path
file_path = "C:/Users/91807/Downloads/MSME Pulse Reports Data - Sheet1 (1).csv"
df = pd.read_csv(file_path)

# Display first few rows of the dataset
print("First few rows of the dataset:")
print(df.head())

# summary of dataset to check data types and missing values
print("\nDataset information:")
print(df.info())

# Check missing values
print("\nMissing values in each column:")
print(df.isnull().sum())

# Remove columns with all missing values
df.dropna(axis=1, how='all', inplace=True)

# Print column names to identify correct target column
print("\nColumn names in the dataset:")
print(df.columns)

# Data Cleaning

# Select numerical columns
numerical_cols = df.select_dtypes(include=['number']).columns

# Fill missing values with the mean for numerical columns
df[numerical_cols] = df[numerical_cols].fillna(df[numerical_cols].mean())

# Drop rows with missing values
df.dropna(inplace=True)
```

```
# Convert data types if not done already
for col in df.columns:
    if df[col].dtype == 'object':  # Convert object columns to categorical if␣
 ↪necessary
        df[col] = df[col].astype('category').cat.codes

# Print first few rows after cleaning
print("\nFirst few rows after cleaning:")
print(df.head())

# Specify the actual target column
target_column = 'Industry (Micro, Small, Medium and Large) - Total NPA %'

# Check if the target column is present
if target_column not in df.columns:
    print(f"\nError: Target column '{target_column}' not found in the dataset.␣
 ↪Please update the target_column variable.")
else:
    # Identify features and target
    features = df.drop(columns=target_column)
    target = df[target_column]

    # Normalize/Scale data
    # 1. Standardization
    scaler_standard = StandardScaler()
    features_standardized = scaler_standard.fit_transform(features)

    # 2. Min-Max Scaling
    scaler_minmax = MinMaxScaler()
    features_minmax_scaled = scaler_minmax.fit_transform(features)

    print("\nFirst few rows of standardized features:")
    print(pd.DataFrame(features_standardized, columns=features.columns).head())

    # display min-max scaled features
    print("\nFirst few rows of Min-Max scaled features:")
    print(pd.DataFrame(features_minmax_scaled, columns=features.columns).head())
```

```
First few rows of the dataset:
   Company code  Name  Year     Months  AR Format  \
0           NaN   NaN  2018      March        NaN
1           NaN   NaN  2018       June        NaN
2           NaN   NaN  2018  September        NaN
3           NaN   NaN  2018   December        NaN
4           NaN   NaN  2019      March        NaN

   Priority Sector - NPA as a % of total advances in that sector  \
```

```
0                                                 8.70
1                                                12.74
2                                                11.29
3                                                 7.38
4                                                  NaN

   Agriculture & Allied activities - Priority Sector NPA %  \
0                                                11.10
1                                                12.82
2                                                 9.49
3                                                 8.70
4                                                  NaN

   Industry (Micro, Small, Medium and Large) - Priority Sector NPA %  \
0                                                  7.7
1                                                 12.0
2                                                 19.2
3                                                 13.4
4                                                  NaN

   Services - Priority Sector NPA %  Personal Loans - Priority Sector NPA %  \
0                              6.20                                    2.20
1                              8.54                                    2.79
2                              8.45                                    2.68
3                              7.50                                    3.20
4                               NaN                                     NaN

   …  \
0  …
1  …
2  …
3  …
4  …

   Industry (Micro, Small, Medium and Large) -  Non - Priority Sector Total
(o/s) Advances  \
0                                           20999975.0
1                                            1189870.0
2                                            1205936.0
3                                            2338400.0
4                                                  NaN

   Services -  Non - Priority Sector Total (o/s) Advances  \
0                                           10944375.0
1                                             322221.0
2                                            1324306.0
3                                             629800.0
4                                                  NaN
```

```
   Personal Loans -  Non - Priority Sector Total (o/s) Advances  \
0                                          3437375.0
1                                           232856.0
2                                          2071211.0
3                                           992300.0
4                                                NaN

   Other -  Non - Priority Sector Total (o/s) Advances  \
0                                          4658525.0
1                                          1359341.0
2                                          2752802.0
3                                            10500.0
4                                                NaN

   Total - Sector Wise Outstanding (o/s) Advances  \
0                                      56722225.0
1                                      44447107.0
2                                       8988539.0
3                                       5236600.0
4                                     111100000.0

   Agriculture & Allied activities -  Total o/s Advances  \
0                                          3525800.0
1                                           723240.0
2                                           814169.0
3                                           547800.0
4                                                NaN

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances  \
0                                           29286725
1                                            1669266
2                                            1638289
3                                           27588000
4                                           73050000

   Services -  Total o/s Advances  Personal Loans -  Total o/s Advances  \
0                      15422800.0                             4791150.0
1                        517274.0                              252335.0
2                       1602480.0                             2080800.0
3                        919400.0                             1000000.0
4                             NaN                                   NaN

   Other sector -  Total o/s Advances
0                           5740775.0
1                           2284992.0
2                           2852802.0
3                             10600.0
```

```
4                                 NaN

[5 rows x 59 columns]

Dataset information:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 16 entries, 0 to 15
Data columns (total 59 columns):
 #   Column
Non-Null Count  Dtype
---  ------
--------------  -----
 0   Company code
0 non-null      float64
 1   Name
0 non-null      float64
 2   Year
16 non-null     int64
 3   Months
16 non-null     object
 4   AR Format
0 non-null      float64
 5   Priority Sector - NPA as a % of total advances in that sector
4 non-null      float64
 6   Agriculture & Allied activities - Priority Sector NPA %
4 non-null      float64
 7   Industry (Micro, Small, Medium and Large) - Priority Sector NPA %
4 non-null      float64
 8   Services - Priority Sector NPA %
4 non-null      float64
 9   Personal Loans - Priority Sector NPA %
4 non-null      float64
 10  Other - Priority Sector NPA %
3 non-null      float64
 11  Non-Priority Sector - NPA as a % of total advances in that sector
4 non-null      float64
 12  Agriculture & Allied activities - Non-Priority Sector NPA %
4 non-null      float64
 13  Industry (Micro, Small, Medium and Large) - Non-Priority Sector NPA %
4 non-null      float64
 14  Services - Non-Priority Sector NPA %
4 non-null      float64
 15  Personal Loans - Non-Priority Sector NPA %
4 non-null      float64
 16  Other - Non-Priority Sector NPA %
3 non-null      float64
 17  Total - Sector-wise NPA as a % of total advances in that sector
4 non-null      float64
```

```
 18  Agriculture & Allied activities - Total NPA %
4 non-null      float64
 19  Industry (Micro, Small, Medium and Large) - Total NPA %
16 non-null     float64
 20  Services - Total NPA %
4 non-null      float64
 21  Personal Loans - Total NPA %
4 non-null      float64
 22  Other sector - Total NPA %
3 non-null      float64
 23  Priority Sector - Gross NPAs
4 non-null      float64
 24  Agriculture & Allied activities -  Priority Sector Gross NPAs
4 non-null      float64
 25  Industry (Micro, Small, Medium and Large) -  Priority Sector Gross NPAs
4 non-null      float64
 26  Services -  Priority Sector Gross NPAs
4 non-null      float64
 27  Personal Loans -  Priority Sector Gross NPAs
4 non-null      float64
 28  Other -  Priority Sector Gross NPAs
3 non-null      float64
 29  Non-Priority Sector - Gross NPAs
4 non-null      float64
 30  Agriculture & Allied activities -  Non-Priority Sector Gross NPAs
4 non-null      float64
 31  Industry (Micro, Small, Medium and Large) -  Non-Priority Sector Gross NPAs
4 non-null      float64
 32  Services -  Non-Priority Sector Gross NPAs
4 non-null      float64
 33  Personal Loans -  Non-Priority Sector Gross NPAs
4 non-null      float64
 34  Other -  Non-Priority Sector Gross NPAs
3 non-null      float64
 35  Total - Sector Wise Gross NPAs
4 non-null      float64
 36  Agriculture & Allied activities -  Total Gross NPAs
4 non-null      float64
 37  Industry (Micro, Small, Medium and Large) -  Total Gross NPAs
16 non-null     int64
 38  Services -  Total Gross NPAs
4 non-null      float64
 39  Personal Loans -  Total Gross NPAs
4 non-null      float64
 40  Other sector -  Total Gross NPAs
3 non-null      float64
 41  Priority Sector - Total Outstanding (o/s) Advances
4 non-null      float64
```

```
 42  Agriculture & Allied activities -  Priority Sector Total o/s Advances
4 non-null      float64
 43  Industry (Micro, Small, Medium and Large) -  Priority Sector Total o/s
Advances          4 non-null      float64
 44  Services -  Priority Sector Total o/s Advances
4 non-null      float64
 45  Personal Loans -  Priority Sector Total o/s Advances
4 non-null      float64
 46  Other -  Priority Sector Total o/s Advances
4 non-null      float64
 47  Non-Priority Sector - Outstanding (o/s) Total Advances
4 non-null      float64
 48  Agriculture & Allied activities -  Non - Priority Sector Total (o/s)
Advances            4 non-null      float64
 49  Industry (Micro, Small, Medium and Large) -  Non - Priority Sector Total
(o/s) Advances  4 non-null      float64
 50  Services -  Non - Priority Sector Total (o/s) Advances
4 non-null      float64
 51  Personal Loans -  Non - Priority Sector Total (o/s) Advances
4 non-null      float64
 52  Other -  Non - Priority Sector Total (o/s) Advances
4 non-null      float64
 53  Total - Sector Wise Outstanding (o/s) Advances
7 non-null      float64
 54  Agriculture & Allied activities -  Total o/s Advances
4 non-null      float64
 55  Industry (Micro, Small, Medium and Large) -  Total o/s Advances
16 non-null     int64
 56  Services -  Total o/s Advances
4 non-null      float64
 57  Personal Loans -  Total o/s Advances
4 non-null      float64
 58  Other sector -  Total o/s Advances
4 non-null      float64
dtypes: float64(55), int64(3), object(1)
memory usage: 7.5+ KB
None

Missing values in each column:
Company code
16
Name
16
Year
0
Months
0
AR Format
```

16
Priority Sector - NPA as a % of total advances in that sector
12
Agriculture & Allied activities - Priority Sector NPA %
12
Industry (Micro, Small, Medium and Large) - Priority Sector NPA %
12
Services - Priority Sector NPA %
12
Personal Loans - Priority Sector NPA %
12
Other - Priority Sector NPA %
13
Non-Priority Sector - NPA as a % of total advances in that sector
12
Agriculture & Allied activities - Non-Priority Sector NPA %
12
Industry (Micro, Small, Medium and Large) - Non-Priority Sector NPA %
12
Services - Non-Priority Sector NPA %
12
Personal Loans - Non-Priority Sector NPA %
12
Other - Non-Priority Sector NPA %
13
Total - Sector-wise NPA as a % of total advances in that sector
12
Agriculture & Allied activities - Total NPA %
12
Industry (Micro, Small, Medium and Large) - Total NPA %
0
Services - Total NPA %
12
Personal Loans - Total NPA %
12
Other sector - Total NPA %
13
Priority Sector - Gross NPAs
12
Agriculture & Allied activities - Priority Sector Gross NPAs
12
Industry (Micro, Small, Medium and Large) - Priority Sector Gross NPAs
12
Services - Priority Sector Gross NPAs
12
Personal Loans - Priority Sector Gross NPAs
12
Other - Priority Sector Gross NPAs

13
Non-Priority Sector - Gross NPAs
12
Agriculture & Allied activities - Non-Priority Sector Gross NPAs
12
Industry (Micro, Small, Medium and Large) - Non-Priority Sector Gross NPAs
12
Services - Non-Priority Sector Gross NPAs
12
Personal Loans - Non-Priority Sector Gross NPAs
12
Other - Non-Priority Sector Gross NPAs
13
Total - Sector Wise Gross NPAs
12
Agriculture & Allied activities - Total Gross NPAs
12
Industry (Micro, Small, Medium and Large) - Total Gross NPAs
0
Services - Total Gross NPAs
12
Personal Loans - Total Gross NPAs
12
Other sector - Total Gross NPAs
13
Priority Sector - Total Outstanding (o/s) Advances
12
Agriculture & Allied activities - Priority Sector Total o/s Advances
12
Industry (Micro, Small, Medium and Large) - Priority Sector Total o/s Advances
12
Services - Priority Sector Total o/s Advances
12
Personal Loans - Priority Sector Total o/s Advances
12
Other - Priority Sector Total o/s Advances
12
Non-Priority Sector - Outstanding (o/s) Total Advances
12
Agriculture & Allied activities - Non - Priority Sector Total (o/s) Advances
12
Industry (Micro, Small, Medium and Large) - Non - Priority Sector Total (o/s) Advances 12
Services - Non - Priority Sector Total (o/s) Advances
12
Personal Loans - Non - Priority Sector Total (o/s) Advances
12
Other - Non - Priority Sector Total (o/s) Advances

```
12
Total - Sector Wise Outstanding (o/s) Advances
9
Agriculture & Allied activities -  Total o/s Advances
12
Industry (Micro, Small, Medium and Large) -  Total o/s Advances
0
Services -  Total o/s Advances
12
Personal Loans -  Total o/s Advances
12
Other sector -  Total o/s Advances
12
dtype: int64

Column names in the dataset:
Index(['Year', 'Months',
       'Priority Sector - NPA as a % of total advances in that sector',
       'Agriculture & Allied activities - Priority Sector NPA %',
       'Industry (Micro, Small, Medium and Large) - Priority Sector NPA %',
       'Services - Priority Sector NPA %',
       'Personal Loans - Priority Sector NPA %',
       'Other - Priority Sector NPA %',
       'Non-Priority Sector - NPA as a % of total advances in that sector',
       'Agriculture & Allied activities - Non-Priority Sector NPA %',
       'Industry (Micro, Small, Medium and Large) - Non-Priority Sector NPA %',
       'Services - Non-Priority Sector NPA %',
       'Personal Loans - Non-Priority Sector NPA %',
       'Other - Non-Priority Sector NPA %',
       'Total - Sector-wise NPA as a % of total advances in that sector',
       'Agriculture & Allied activities - Total NPA %',
       'Industry (Micro, Small, Medium and Large) - Total NPA %',
       'Services - Total NPA %', 'Personal Loans - Total NPA %',
       'Other sector - Total NPA %', 'Priority Sector - Gross NPAs',
       'Agriculture & Allied activities -  Priority Sector Gross NPAs',
       'Industry (Micro, Small, Medium and Large) -  Priority Sector Gross
NPAs',
       'Services -  Priority Sector Gross NPAs',
       'Personal Loans -  Priority Sector Gross NPAs',
       'Other -  Priority Sector Gross NPAs',
       'Non-Priority Sector - Gross NPAs',
       'Agriculture & Allied activities -  Non-Priority Sector Gross NPAs',
       'Industry (Micro, Small, Medium and Large) -  Non-Priority Sector Gross
NPAs',
       'Services -  Non-Priority Sector Gross NPAs',
       'Personal Loans -  Non-Priority Sector Gross NPAs',
       'Other -  Non-Priority Sector Gross NPAs',
       'Total - Sector Wise Gross NPAs',
```

```
       'Agriculture & Allied activities -  Total Gross NPAs',
       'Industry (Micro, Small, Medium and Large) -  Total Gross NPAs',
       'Services -  Total Gross NPAs', 'Personal Loans -  Total Gross NPAs',
       'Other sector -  Total Gross NPAs',
       'Priority Sector - Total Outstanding (o/s) Advances',
       'Agriculture & Allied activities -  Priority Sector Total o/s Advances',
       'Industry (Micro, Small, Medium and Large) -  Priority Sector Total o/s
Advances',
       'Services -  Priority Sector Total o/s Advances',
       'Personal Loans -  Priority Sector Total o/s Advances',
       'Other -  Priority Sector Total o/s Advances',
       'Non-Priority Sector - Outstanding (o/s) Total Advances',
       'Agriculture & Allied activities -  Non - Priority Sector Total (o/s)
Advances',
       'Industry (Micro, Small, Medium and Large) -  Non - Priority Sector Total
(o/s) Advances',
       'Services -  Non - Priority Sector Total (o/s) Advances',
       'Personal Loans -  Non - Priority Sector Total (o/s) Advances',
       'Other -  Non - Priority Sector Total (o/s) Advances',
       'Total - Sector Wise Outstanding (o/s) Advances',
       'Agriculture & Allied activities -  Total o/s Advances',
       'Industry (Micro, Small, Medium and Large) -  Total o/s Advances',
       'Services -  Total o/s Advances',
       'Personal Loans -  Total o/s Advances',
       'Other sector -  Total o/s Advances'],
      dtype='object')

First few rows after cleaning:
   Year  Months  \
0  2018       6
1  2018       5
2  2018       8
3  2018       2
4  2019       6

   Priority Sector - NPA as a % of total advances in that sector  \
0                                             8.7000
1                                            12.7400
2                                            11.2900
3                                             7.3800
4                                            10.0275

   Agriculture & Allied activities - Priority Sector NPA %  \
0                                            11.1000
1                                            12.8200
2                                             9.4900
3                                             8.7000
4                                            10.5275
```

```
   Industry (Micro, Small, Medium and Large) - Priority Sector NPA %  \
0                                              7.700
1                                             12.000
2                                             19.200
3                                             13.400
4                                             13.075

   Services - Priority Sector NPA %  Personal Loans - Priority Sector NPA %  \
0                            6.2000                                  2.2000
1                            8.5400                                  2.7900
2                            8.4500                                  2.6800
3                            7.5000                                  3.2000
4                            7.6725                                  2.7175

   Other - Priority Sector NPA %  \
0                      10.400000
1                      16.150000
2                      10.216667
3                       4.100000
4                      10.216667

   Non-Priority Sector - NPA as a % of total advances in that sector  \
0                                              5.100
1                                             12.370
2                                              3.910
3                                              4.600
4                                              6.495

   Agriculture & Allied activities - Non-Priority Sector NPA %  …  \
0                                              6.800             …
1                                             13.170             …
2                                              9.710             …
3                                              4.500             …
4                                              8.545             …

   Industry (Micro, Small, Medium and Large) -  Non - Priority Sector Total
(o/s) Advances  \
0                                        20999975.00
1                                         1189870.00
2                                         1205936.00
3                                         2338400.00
4                                         6433545.25

   Services -  Non - Priority Sector Total (o/s) Advances  \
0                                         10944375.0
1                                           322221.0
2                                          1324306.0
```

```
3                                           629800.0
4                                          3305175.5

   Personal Loans -  Non - Priority Sector Total (o/s) Advances  \
0                                          3437375.0
1                                           232856.0
2                                          2071211.0
3                                           992300.0
4                                          1683435.5

   Other -  Non - Priority Sector Total (o/s) Advances  \
0                                          4658525.0
1                                          1359341.0
2                                          2752802.0
3                                            10500.0
4                                          2195292.0

   Total - Sector Wise Outstanding (o/s) Advances  \
0                                      56722225.0
1                                      44447107.0
2                                       8988539.0
3                                       5236600.0
4                                     111100000.0

   Agriculture & Allied activities -  Total o/s Advances  \
0                                         3525800.00
1                                          723240.00
2                                          814169.00
3                                          547800.00
4                                         1402752.25

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances  \
0                                           29286725
1                                            1669266
2                                            1638289
3                                           27588000
4                                           73050000

   Services -  Total o/s Advances  Personal Loans -  Total o/s Advances  \
0                      15422800.0                            4791150.00
1                        517274.0                             252335.00
2                       1602480.0                            2080800.00
3                        919400.0                            1000000.00
4                       4615488.5                            2031071.25

   Other sector -  Total o/s Advances
0                          5740775.00
1                          2284992.00
```

```
2                          2852802.00
3                            10600.00
4                          2722292.25

[5 rows x 56 columns]

First few rows of standardized features:
       Year    Months  \
0 -1.144622  0.721863
1 -1.144622  0.294092
2 -1.144622  1.577405
3 -1.144622 -0.989220
4 -0.621366  0.721863

   Priority Sector - NPA as a % of total advances in that sector  \
0                                          -1.261319
1                                           2.577272
2                                           1.199560
3                                          -2.515512
4                                           0.000000

   Agriculture & Allied activities - Priority Sector NPA %  \
0                                           0.724181
1                                           2.899885
2                                          -1.312380
3                                          -2.311686
4                                           0.000000

   Industry (Micro, Small, Medium and Large) - Priority Sector NPA %  \
0                                          -2.613656
1                                          -0.522731
2                                           2.978352
3                                           0.158035
4                                           0.000000

   Services - Priority Sector NPA %  Personal Loans - Priority Sector NPA %  \
0                         -3.123855                               -2.906355
1                          1.840370                                0.407170
2                          1.649438                               -0.210605
3                         -0.365952                                2.709790
4                          0.000000                                0.000000

   Other - Priority Sector NPA %  \
0                       0.086036
1                       2.784428
2                       0.000000
3                      -2.870463
4                       0.000000
```

```
   Non-Priority Sector - NPA as a % of total advances in that sector  \
0                                          -0.816232
1                                           3.437536
2                                          -1.512516
3                                          -1.108788
4                                           0.000000

   Agriculture & Allied activities - Non-Priority Sector NPA %  …  \
0                                      -1.075057e+00            …
1                                       2.849362e+00            …
2                                       7.177313e-01            …
3                                      -2.492037e+00            …
4                                      -1.094375e-15            …

   Industry (Micro, Small, Medium and Large) -  Non - Priority Sector Total
(o/s) Advances  \
0                                           3.458804
1                                          -1.245113
2                                          -1.241298
3                                          -0.972394
4                                           0.000000

   Services -  Non - Priority Sector Total (o/s) Advances  \
0                                           3.452429
1                                          -1.348104
2                                          -0.895226
3                                          -1.209098
4                                           0.000000

   Personal Loans -  Non - Priority Sector Total (o/s) Advances  \
0                                           2.910997
1                                          -2.407513
2                                           0.643587
3                                          -1.147071
4                                           0.000000

   Other -  Non - Priority Sector Total (o/s) Advances  \
0                                           2.862186
1                                          -0.971344
2                                           0.647806
3                                          -2.538648
4                                           0.000000

   Total - Sector Wise Outstanding (o/s) Advances  \
0                                        -0.127758
1                                        -0.575664
2                                        -1.869509
```

```
3                                        -2.006413
4                                         1.856429

   Agriculture & Allied activities -  Total o/s Advances  \
0                                           3.453582
1                                          -1.105369
2                                          -0.957454
3                                          -1.390759
4                                           0.000000

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances  \
0                                          -0.588462
1                                          -1.681137
2                                          -1.682363
3                                          -0.655671
4                                           1.143018

   Services -  Total o/s Advances  Personal Loans -  Total o/s Advances  \
0                        3.457426                              3.207508
1                       -1.311082                             -2.067083
2                       -0.963908                              0.057790
3                       -1.182436                             -1.198216
4                        0.000000                              0.000000

   Other sector -  Total o/s Advances
0                            2.956955
1                           -0.428386
2                            0.127849
3                           -2.656418
4                            0.000000

[5 rows x 55 columns]

First few rows of Min-Max scaled features:
       Year  Months  \
0  0.000000   0.750
1  0.000000   0.625
2  0.000000   1.000
3  0.000000   0.250
4  0.166667   0.750

   Priority Sector - NPA as a % of total advances in that sector  \
0                                           0.246269
1                                           1.000000
2                                           0.729478
3                                           0.000000
4                                           0.493937
```

```
   Agriculture & Allied activities - Priority Sector NPA %  \
0                                           0.582524
1                                           1.000000
2                                           0.191748
3                                           0.000000
4                                           0.443568

   Industry (Micro, Small, Medium and Large) - Priority Sector NPA %  \
0                                           0.000000
1                                           0.373913
2                                           1.000000
3                                           0.495652
4                                           0.467391

   Services - Priority Sector NPA %  Personal Loans - Priority Sector NPA %  \
0                          0.000000                                 0.0000
1                          1.000000                                 0.5900
2                          0.961538                                 0.4800
3                          0.555556                                 1.0000
4                          0.629274                                 0.5175

   Other - Priority Sector NPA %  \
0                       0.522822
1                       1.000000
2                       0.507607
3                       0.000000
4                       0.507607

   Non-Priority Sector - NPA as a % of total advances in that sector  \
0                                           0.140662
1                                           1.000000
2                                           0.000000
3                                           0.081560
4                                           0.305556

   Agriculture & Allied activities - Non-Priority Sector NPA %  …  \
0                                           0.265283            …
1                                           1.000000            …
2                                           0.600923            …
3                                           0.000000            …
4                                           0.466551            …

   Industry (Micro, Small, Medium and Large) -  Non - Priority Sector Total
(o/s) Advances  \
0                                           1.000000
1                                           0.000000
2                                           0.000811
3                                           0.057977
```

```
4                                         0.264697

   Services -  Non - Priority Sector Total (o/s) Advances  \
0                                         1.000000
1                                         0.000000
2                                         0.094339
3                                         0.028956
4                                         0.280824

   Personal Loans -  Non - Priority Sector Total (o/s) Advances  \
0                                         1.000000
1                                         0.000000
2                                         0.573676
3                                         0.236992
4                                         0.452667

   Other -  Non - Priority Sector Total (o/s) Advances  \
0                                         1.000000
1                                         0.290197
2                                         0.589993
3                                         0.000000
4                                         0.470047

   Total - Sector Wise Outstanding (o/s) Advances  \
0                                      0.461906
1                                      0.351779
2                                      0.033661
3                                      0.000000
4                                      0.949759

   Agriculture & Allied activities -  Total o/s Advances  \
0                                         1.000000
1                                         0.058912
2                                         0.089446
3                                         0.000000
4                                         0.287089

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances  \
0                                         0.380195
1                                         0.000426
2                                         0.000000
3                                         0.356836
4                                         0.981986

   Services -  Total o/s Advances  Personal Loans -  Total o/s Advances  \
0                        1.000000                           1.000000
1                        0.000000                           0.000000
2                        0.072806                           0.402851
```

```
3                        0.026978                                      0.164727
4                        0.274946                                      0.391894

   Other sector -  Total o/s Advances
0                            1.000000
1                            0.396915
2                            0.496006
3                            0.000000
4                            0.473230

[5 rows x 55 columns]
```

[96]:

```
#Applying on the dataset with no empty cells beforehand, focusing on only few␣
↪columns
import pandas as pd
from sklearn.preprocessing import StandardScaler, MinMaxScaler

# Load the dataset from the specified file path
file_path = "C:/Users/91807/Downloads/MSME Pulse Reports Data-Filtered - Sheet1.
↪csv"
df = pd.read_csv(file_path)

# Display first few rows of the dataset
print("First few rows of the dataset:")
print(df.head())

# Display summary of the dataset to check data types and missing values
print("\nDataset information:")
print(df.info())

# Check for missing values
print("\nMissing values in each column:")
print(df.isnull().sum())

# Remove columns with all missing values
df.dropna(axis=1, how='all', inplace=True)

# Print column names to identify correct target column
print("\nColumn names in the dataset:")
print(df.columns)

# Data Cleaning

# Select numerical columns
numerical_cols = df.select_dtypes(include=['number']).columns

# Fill missing values with the mean for numerical columns
```

```
df[numerical_cols] = df[numerical_cols].fillna(df[numerical_cols].mean())

# Drop rows with missing values
df.dropna(inplace=True)

# Convert data types if necessary
for col in df.columns:
    if df[col].dtype == 'object':  # Convert object columns to categorical if␣
↪necessary
        df[col] = df[col].astype('category').cat.codes


print("\nFirst few rows after cleaning:")
print(df.head())

target_column = 'Industry (Micro, Small, Medium and Large) - Total NPA %'


if target_column not in df.columns:
    print(f"\nError: Target column '{target_column}' not found in the dataset.␣
↪Please update the target_column variable.")
else:
    # Identify features and target
    features = df.drop(columns=target_column)
    target = df[target_column]

    # Normalize/Scale data

    #Standardization
    scaler_standard = StandardScaler()
    features_standardized = scaler_standard.fit_transform(features)

    # Min-Max Scaling
scaler_minmax = MinMaxScaler()
features_minmax_scaled = scaler_minmax.fit_transform(features)

    # Print first few rows of standardized features
print("\nFirst few rows of standardized features:")
print(pd.DataFrame(features_standardized, columns=features.columns).head())

    # Min-Max scaled features
print("\nFirst few rows of Min-Max scaled features:")
print(pd.DataFrame(features_minmax_scaled, columns=features.columns).head())
```

```
First few rows of the dataset:
   Year     Months  Industry (Micro, Small, Medium and Large) - Total NPA %  \
0  2018      March                                                 6.10
```

```
1  2018       June                                                  12.00
2  2018  September                                                  17.89
3  2018   December                                                  21.10
4  2019      March                                                  16.70

   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                            1584025
1                                             227976
2                                             249018
3                                             840100
4                                           12199500

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)
0                                           29286725
1                                            1669266
2                                            1638289
3                                           27588000
4                                           73050000

Dataset information:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 16 entries, 0 to 15
Data columns (total 5 columns):
 #   Column
Non-Null Count  Dtype
---  ------
--------------  -----
 0   Year
16 non-null     int64
 1   Months
16 non-null     object
 2   Industry (Micro, Small, Medium and Large) - Total NPA %
16 non-null     float64
 3   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)    16 non-null     int64
 4   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  16 non-null     int64
dtypes: float64(1), int64(3), object(1)
memory usage: 772.0+ bytes
None

Missing values in each column:
Year
0
Months
0
```

```
Industry (Micro, Small, Medium and Large) - Total NPA %
0
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      0
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    0
dtype: int64

Column names in the dataset:
Index(['Year', 'Months',
       'Industry (Micro, Small, Medium and Large) - Total NPA %',
       'Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in
million rupees)',
       'Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in
million rupees)'],
      dtype='object')

First few rows after cleaning:
   Year  Months  Industry (Micro, Small, Medium and Large) - Total NPA %  \
0  2018       6                                               6.10
1  2018       5                                              12.00
2  2018       8                                              17.89
3  2018       2                                              21.10
4  2019       6                                              16.70

   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                            1584025
1                                             227976
2                                             249018
3                                             840100
4                                           12199500

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)
0                                           29286725
1                                            1669266
2                                            1638289
3                                           27588000
4                                           73050000

First few rows of standardized features:
       Year    Months  \
0 -1.144622  0.721863
1 -1.144622  0.294092
2 -1.144622  1.577405
3 -1.144622 -0.989220
4 -0.621366  0.721863
```

```
   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                           -0.953501
1                                           -1.246877
2                                           -1.242325
3                                           -1.114446
4                                            1.343120

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)
0                                           -0.588462
1                                           -1.681137
2                                           -1.682363
3                                           -0.655671
4                                            1.143018

First few rows of Min-Max scaled features:
       Year  Months  \
0  0.000000   0.750
1  0.000000   0.625
2  0.000000   1.000
3  0.000000   0.250
4  0.166667   0.750

   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                            0.113273
1                                            0.000000
2                                            0.001758
3                                            0.051132
4                                            1.000000

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)
0                                            0.380195
1                                            0.000426
2                                            0.000000
3                                            0.356836
4                                            0.981986
```

[98]:

```python
correlation_matrix = df.corr()
print(correlation_matrix['Industry (Micro, Small, Medium and Large) - Total NPA␣
 ↪%'].sort_values(ascending=False))
```

```
Industry (Micro, Small, Medium and Large) - Total NPA %
1.000000
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
```

```
rupees)      0.419523
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    0.270004
Months
0.110044
Year
-0.564020
Name: Industry (Micro, Small, Medium and Large) - Total NPA %, dtype: float64
```

[19]:
```
from sklearn.feature_selection import chi2
from sklearn.preprocessing import LabelEncoder

label_encoder = LabelEncoder()
encoded_target = label_encoder.fit_transform(df['Industry (Micro, Small, Medium␣
↪and Large) - Total NPA %'])

chi2_scores, p_values = chi2(features, encoded_target)
print(pd.Series(chi2_scores, index=features.columns).
↪sort_values(ascending=False))
```

```
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    2.013578e+08
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      5.357988e+07
Months
2.015942e+01
Year
2.768926e-02
dtype: float64
```

[100]:
```
from sklearn.ensemble import RandomForestRegressor
import pandas as pd

model = RandomForestRegressor()
model.fit(features, target)

importance = model.feature_importances_
feature_importance = pd.Series(importance, index=features.columns).
↪sort_values(ascending=False)

print("Feature Importances:")
print(feature_importance)
```

```
Feature Importances:
Year
0.397688
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      0.374926
```

```
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    0.125894
Months
0.101492
dtype: float64
```

[102]:
```python
from sklearn.ensemble import RandomForestRegressor
from sklearn.feature_selection import RFE

model = RandomForestRegressor()

# Initialize RFE with model and no. of features to select
rfe = RFE(model, n_features_to_select=5)
fit = rfe.fit(features, target)

# print selected features
print("Selected features:", fit.support_)
print("Feature ranking:", fit.ranking_)
```

```
Selected features: [ True  True  True  True]
Feature ranking: [1 1 1 1]
```

[104]:
```python
#using Linear Regression
from sklearn.linear_model import LinearRegression
from sklearn.feature_selection import RFE

model = LinearRegression()

# Initialize RFE with model and no. of features to select
rfe = RFE(model, n_features_to_select=5)
fit = rfe.fit(features, target)

# print selected features
print("Selected features:", fit.support_)
print("Feature ranking:", fit.ranking_)
```

```
Selected features: [ True  True  True  True]
Feature ranking: [1 1 1 1]
```

[26]:
```python
from sklearn.feature_selection import SelectKBest, f_classif

selector = SelectKBest(score_func=f_classif, k='all')
fit = selector.fit(features, target)
scores = pd.Series(fit.scores_, index=features.columns)
print(scores.sort_values(ascending=False))
```

```
Months
26.750000
```

```
Year
3.442308
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)       2.371607
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)     1.029126
dtype: float64
```

[106]:

```python
# check if required columns exist
if 'Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million␣
↪rupees)' in df.columns and 'Industry (Micro, Small, Medium and Large) - ␣
↪Total o/s Advances (in million rupees)' in df.columns:
    # Calculate Growth Rate
    df['Growth_Rate'] = (df['Industry (Micro, Small, Medium and Large) -  Total␣
↪Gross NPAs (in million rupees)'] / df['Industry (Micro, Small, Medium and␣
↪Large) -  Total o/s Advances (in million rupees)'] - 1) * 100
    print("Growth Rate calculated successfully.")
else:
    print("Required columns are missing.")

print(df)
print(df[['Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)', 'Industry (Micro, Small, Medium and Large) -  Total o/s␣
↪Advances (in million rupees)', 'Growth_Rate']])
print(df[['Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)', 'Industry (Micro, Small, Medium and Large) -  Total o/s␣
↪Advances (in million rupees)', 'Growth_Rate']].head())
print(df['Growth_Rate'].describe())
df.to_csv("report_with_growth_rate.csv", index=False)
```

```
Growth Rate calculated successfully.
    Year  Months  Industry (Micro, Small, Medium and Large) - Total NPA %  \
0   2018       6                                                 6.10
1   2018       5                                                12.00
2   2018       8                                                17.89
3   2018       2                                                21.10
4   2019       6                                                16.70
5   2019       5                                                16.00
6   2019       7                                                16.10
7   2020       4                                                16.80
8   2020       0                                                17.40
9   2020       7                                                16.10
10  2021       3                                                12.70
11  2021       5                                                12.50
12  2022       1                                                12.80
13  2023       6                                                12.50
14  2023       1                                                 9.00
```

```
15  2024       3                                               2.30

    Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                             1584025
1                                              227976
2                                              249018
3                                              840100
4                                            12199500
5                                            10256000
6                                            10271000
7                                            10920000
8                                            11214300
9                                            10791830
10                                            9048750
11                                            9295000
12                                            2959360
13                                            2862500
14                                            2493000
15                                             648600

    Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  \
0                                            29286725
1                                             1669266
2                                             1638289
3                                            27588000
4                                            73050000
5                                            65520000
6                                            63800000
7                                            65000000
8                                            64450000
9                                            67030000
10                                           71250000
11                                           74360000
12                                           23120000
13                                           22900000
14                                           27700000
15                                           28200000

    Growth_Rate
0    -94.591321
1    -86.342740
2    -84.800118
3    -96.954835
4    -83.299795
5    -84.346764
6    -83.901254
```

```
7    -83.200000
8    -82.600000
9    -83.900000
10   -87.300000
11   -87.500000
12   -87.200000
13   -87.500000
14   -91.000000
15   -97.700000
    Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                             1584025
1                                              227976
2                                              249018
3                                              840100
4                                            12199500
5                                            10256000
6                                            10271000
7                                            10920000
8                                            11214300
9                                            10791830
10                                            9048750
11                                            9295000
12                                            2959360
13                                            2862500
14                                            2493000
15                                             648600

    Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  \
0                                            29286725
1                                             1669266
2                                             1638289
3                                            27588000
4                                            73050000
5                                            65520000
6                                            63800000
7                                            65000000
8                                            64450000
9                                            67030000
10                                           71250000
11                                           74360000
12                                           23120000
13                                           22900000
14                                           27700000
15                                           28200000

    Growth_Rate
```

```
0    -94.591321
1    -86.342740
2    -84.800118
3    -96.954835
4    -83.299795
5    -84.346764
6    -83.901254
7    -83.200000
8    -82.600000
9    -83.900000
10   -87.300000
11   -87.500000
12   -87.200000
13   -87.500000
14   -91.000000
15   -97.700000
   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                            1584025
1                                             227976
2                                             249018
3                                             840100
4                                           12199500

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  \
0                                           29286725
1                                            1669266
2                                            1638289
3                                           27588000
4                                           73050000

   Growth_Rate
0   -94.591321
1   -86.342740
2   -84.800118
3   -96.954835
4   -83.299795
count    16.000000
mean    -87.633552
std       4.901970
min     -97.700000
25%     -88.375000
50%     -86.771370
75%     -83.900940
max     -82.600000
Name: Growth_Rate, dtype: float64
```

```
[31]: df['Ratio'] = df['Industry (Micro, Small, Medium and Large) -  Total o/s␣
↪Advances (in million rupees)'] / df['Industry (Micro, Small, Medium and␣
↪Large) -  Total Gross NPAs (in million rupees)']
print(df)
print(df[['Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)', 'Industry (Micro, Small, Medium and Large) -  Total o/s␣
↪Advances (in million rupees)', 'Ratio']])
print(df[['Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)', 'Industry (Micro, Small, Medium and Large) -  Total o/s␣
↪Advances (in million rupees)', 'Ratio']].head())
print(df['Ratio'].describe())
df.to_csv("report_with_ratio.csv", index=False)
```

```
    Year  Months  Industry (Micro, Small, Medium and Large) - Total NPA %  \
0   2018       6                                               6.10
1   2018       5                                              12.00
2   2018       8                                              17.89
3   2018       2                                              21.10
4   2019       6                                              16.70
5   2019       5                                              16.00
6   2019       7                                              16.10
7   2020       4                                              16.80
8   2020       0                                              17.40
9   2020       7                                              16.10
10  2021       3                                              12.70
11  2021       5                                              12.50
12  2022       1                                              12.80
13  2023       6                                              12.50
14  2023       1                                               9.00
15  2024       3                                               2.30

    Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                             1584025
1                                              227976
2                                              249018
3                                              840100
4                                            12199500
5                                            10256000
6                                            10271000
7                                            10920000
8                                            11214300
9                                            10791830
10                                            9048750
11                                            9295000
12                                            2959360
13                                            2862500
```

```
14                                              2493000
15                                               648600

    Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  \
0                                              29286725
1                                               1669266
2                                               1638289
3                                              27588000
4                                              73050000
5                                              65520000
6                                              63800000
7                                              65000000
8                                              64450000
9                                              67030000
10                                             71250000
11                                             74360000
12                                             23120000
13                                             22900000
14                                             27700000
15                                             28200000

    Growth_Rate      Ratio
0    -94.591321  18.488802
1    -86.342740   7.322113
2    -84.800118   6.578998
3    -96.954835  32.838948
4    -83.299795   5.987950
5    -84.346764   6.388456
6    -83.901254   6.211664
7    -83.200000   5.952381
8    -82.600000   5.747126
9    -83.900000   6.211180
10   -87.300000   7.874016
11   -87.500000   8.000000
12   -87.200000   7.812500
13   -87.500000   8.000000
14   -91.000000  11.111111
15   -97.700000  43.478261
    Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
0                                               1584025
1                                                227976
2                                                249018
3                                                840100
4                                              12199500
5                                              10256000
6                                              10271000
```

```
7                                                   10920000
8                                                   11214300
9                                                   10791830
10                                                   9048750
11                                                   9295000
12                                                   2959360
13                                                   2862500
14                                                   2493000
15                                                    648600

    Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  \
0                                                   29286725
1                                                    1669266
2                                                    1638289
3                                                   27588000
4                                                   73050000
5                                                   65520000
6                                                   63800000
7                                                   65000000
8                                                   64450000
9                                                   67030000
10                                                  71250000
11                                                  74360000
12                                                  23120000
13                                                  22900000
14                                                  27700000
15                                                  28200000

        Ratio
0   18.488802
1    7.322113
2    6.578998
3   32.838948
4    5.987950
5    6.388456
6    6.211664
7    5.952381
8    5.747126
9    6.211180
10   7.874016
11   8.000000
12   7.812500
13   8.000000
14  11.111111
15  43.478261
   Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
```

```
0                                                 1584025
1                                                  227976
2                                                  249018
3                                                  840100
4                                                12199500

   Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)  \
0                                                29286725
1                                                 1669266
2                                                 1638289
3                                                27588000
4                                                73050000

       Ratio
0  18.488802
1   7.322113
2   6.578998
3  32.838948
4   5.987950
count    16.000000
mean     11.750219
std      10.939803
min       5.747126
25%       6.211543
50%       7.567306
75%       8.777778
max      43.478261
Name: Ratio, dtype: float64
```

[108]:

```
from sklearn.decomposition import PCA

pca = PCA(n_components=2)  # Reduce to 2 dimensions
principal_components = pca.fit_transform(features)
pca_df = pd.DataFrame(data=principal_components, columns=['PC1', 'PC2'])
```

[110]:

```
import pandas as pd
import numpy as np
from sklearn.manifold import TSNE
from sklearn.decomposition import PCA
import umap
features = df.drop(columns=['Industry (Micro, Small, Medium and Large) - Total␣
 ↪NPA %']) #our target column

# check no. of samples
num_samples = features.shape[0]
print("Number of samples:", num_samples)
```

```
# adjust perplexity or use PCA for dimensionality reduction before t-SNE
if num_samples > 30:
    tsne = TSNE(n_components=2, perplexity=min(30, num_samples - 1))
    tsne_results = tsne.fit_transform(features)
    tsne_df = pd.DataFrame(data=tsne_results, columns=['TSNE1', 'TSNE2'])
else:
    # Use UMAP if t-SNE is not feasible
    umap_model = umap.UMAP(n_components=2)
    umap_results = umap_model.fit_transform(features)
    tsne_df = pd.DataFrame(data=umap_results, columns=['UMAP1', 'UMAP2'])

print(tsne_df.head())
```

```
Number of samples: 16
      UMAP1      UMAP2
0 -4.040857  20.748528
1 -4.255658  19.427542
2 -3.741169  19.501846
3 -4.377507  20.393936
4 -8.165012  13.626151
```

[112]:
```
import pandas as pd
from sklearn.model_selection import train_test_split
features = df.drop(columns=['Industry (Micro, Small, Medium and Large) - Total␣
 ↪NPA %'])
target = df['Industry (Micro, Small, Medium and Large) - Total NPA %']

# split data into training and test sets (85% training, 15% test)
X_train, X_temp, y_train, y_temp = train_test_split(features, target,␣
 ↪test_size=0.15, random_state=42)

# split temporary set into validation and test sets (50% validation, 50% test␣
 ↪of the 15%)
X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size=0.5,␣
 ↪random_state=42)

print("Training set size:", X_train.shape)
print("Validation set size:", X_val.shape)
print("Test set size:", X_test.shape)
```

```
Training set size: (13, 5)
Validation set size: (1, 5)
Test set size: (2, 5)
```

[114]:
```
from sklearn.preprocessing import StandardScaler
```

```
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_val_scaled = scaler.transform(X_val)
X_test_scaled = scaler.transform(X_test)
```

[116]:
```
from sklearn.ensemble import RandomForestRegressor

# Initialize the model
model = RandomForestRegressor(random_state=42)

# Train the model
model.fit(X_train_scaled, y_train)
```

[116]: RandomForestRegressor(random_state=42)

[118]:
```
from sklearn.model_selection import GridSearchCV

param_grid = {
    'n_estimators': [100, 200],
    'max_depth': [10, 20]
}
grid_search = GridSearchCV(model, param_grid, cv=5)
grid_search.fit(X_train_scaled, y_train)
best_model = grid_search.best_estimator_
```

[120]:
```
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score

# Predictions
y_val_pred = best_model.predict(X_val_scaled)
y_test_pred = best_model.predict(X_test_scaled)

# Evaluation metrics
print("Validation MAE:", mean_absolute_error(y_val, y_val_pred))
print("Validation MSE:", mean_squared_error(y_val, y_val_pred))
print("Validation R^2:", r2_score(y_val, y_val_pred))

print("Test MAE:", mean_absolute_error(y_test, y_test_pred))
print("Test MSE:", mean_squared_error(y_test, y_test_pred))
print("Test R^2:", r2_score(y_test, y_test_pred))
```

```
Validation MAE: 0.4256999999999813
Validation MSE: 0.18122048999998408
Validation R^2: nan
Test MAE: 8.911399999999999
Test MSE: 91.68475956999978
Test R^2: -9.535450683137004
```

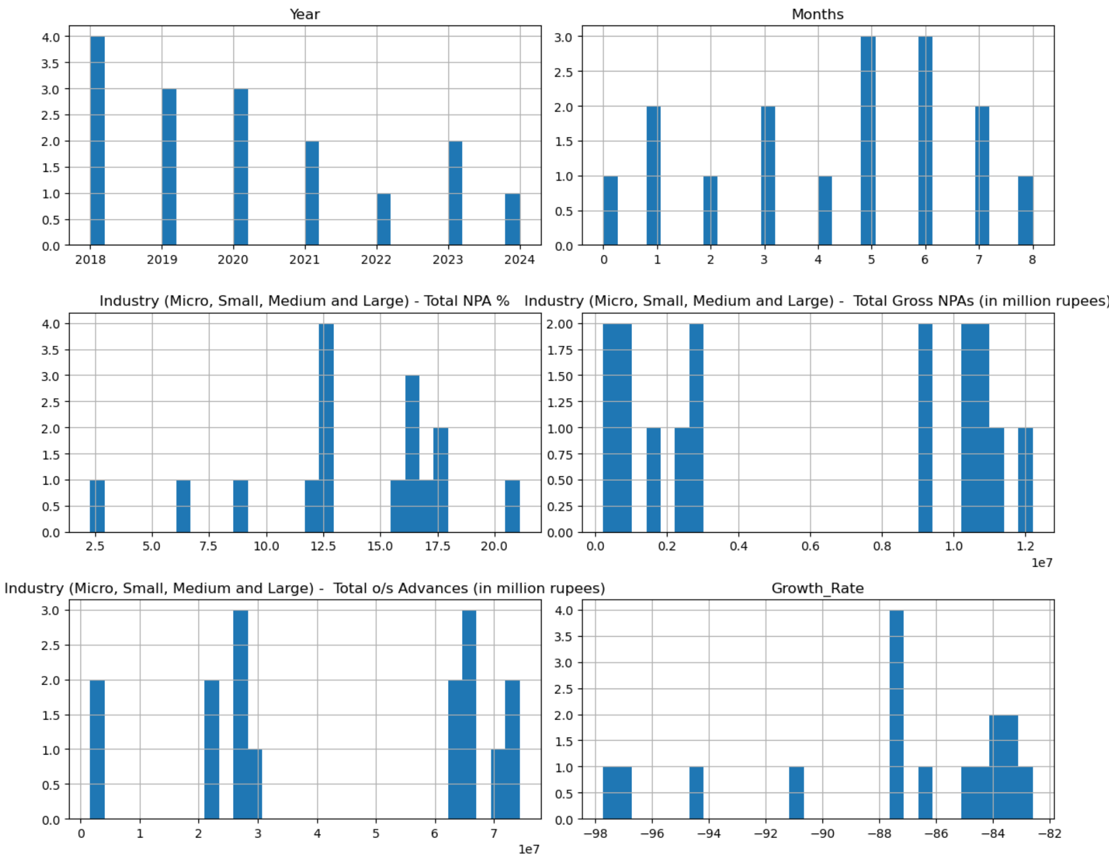
```
C:\Users\91807\anaconda3\Lib\site-packages\sklearn\metrics\_regression.py:1187:
```

```
UndefinedMetricWarning: R^2 score is not well-defined with less than two
samples.
  warnings.warn(msg, UndefinedMetricWarning)
```

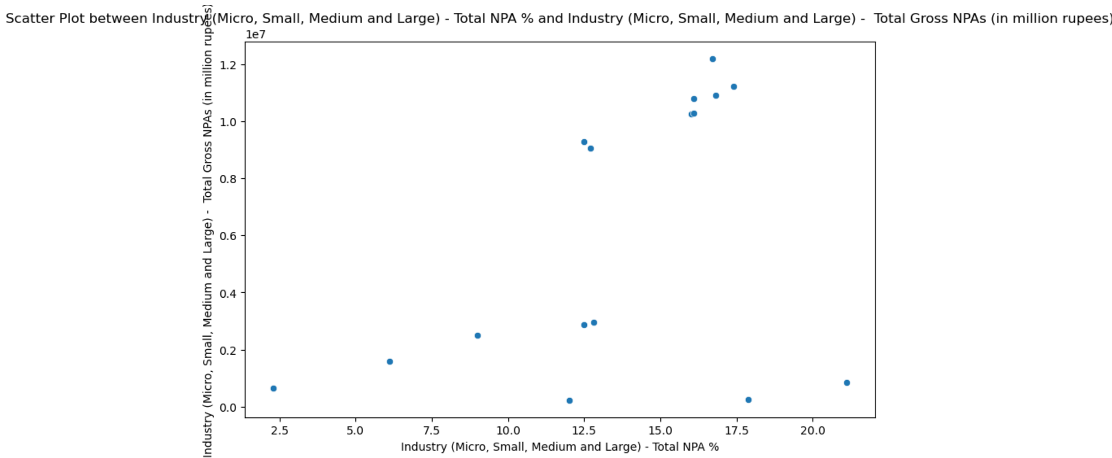
[122]:
```
importances = model.feature_importances_
feature_names = X_train.columns
importance_df = pd.DataFrame({'Feature': feature_names, 'Importance':
↪importances})
print(importance_df.sort_values(by='Importance', ascending=False))
```

```
                                             Feature  Importance
0                                               Year    0.720526
4                                        Growth_Rate    0.177961
2   Industry (Micro, Small, Medium and Large) -  T…    0.055089
3   Industry (Micro, Small, Medium and Large) -  T…    0.024458
1                                             Months    0.021966
```

[124]:
```
import matplotlib.pyplot as plt
import seaborn as sns

# Plot histogram for each feature
df.hist(figsize=(12, 10), bins=30)
plt.tight_layout()
plt.show()
```

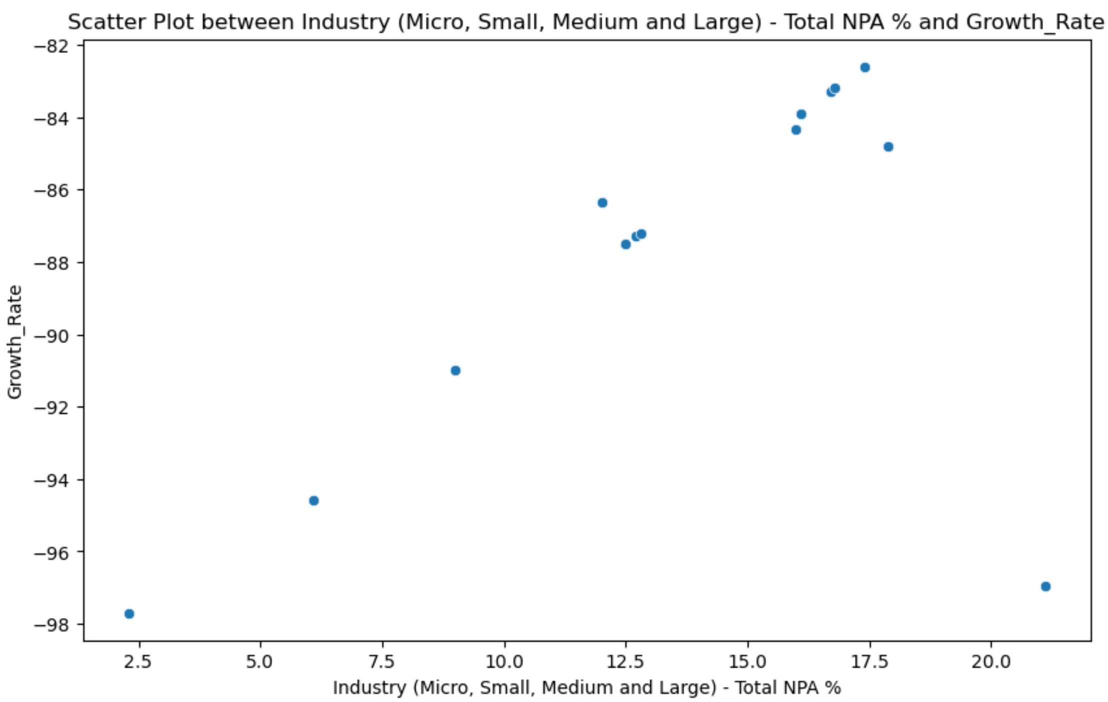


[126]:
```
# Scatter plot between two features
plt.figure(figsize=(10, 6))
sns.scatterplot(x='Industry (Micro, Small, Medium and Large) - Total NPA %',
 ↪y='Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
 ↪rupees)', data=df)
plt.title('Scatter Plot between Industry (Micro, Small, Medium and Large) -
 ↪Total NPA % and Industry (Micro, Small, Medium and Large) -  Total Gross
 ↪NPAs (in million rupees)')
plt.show()
```

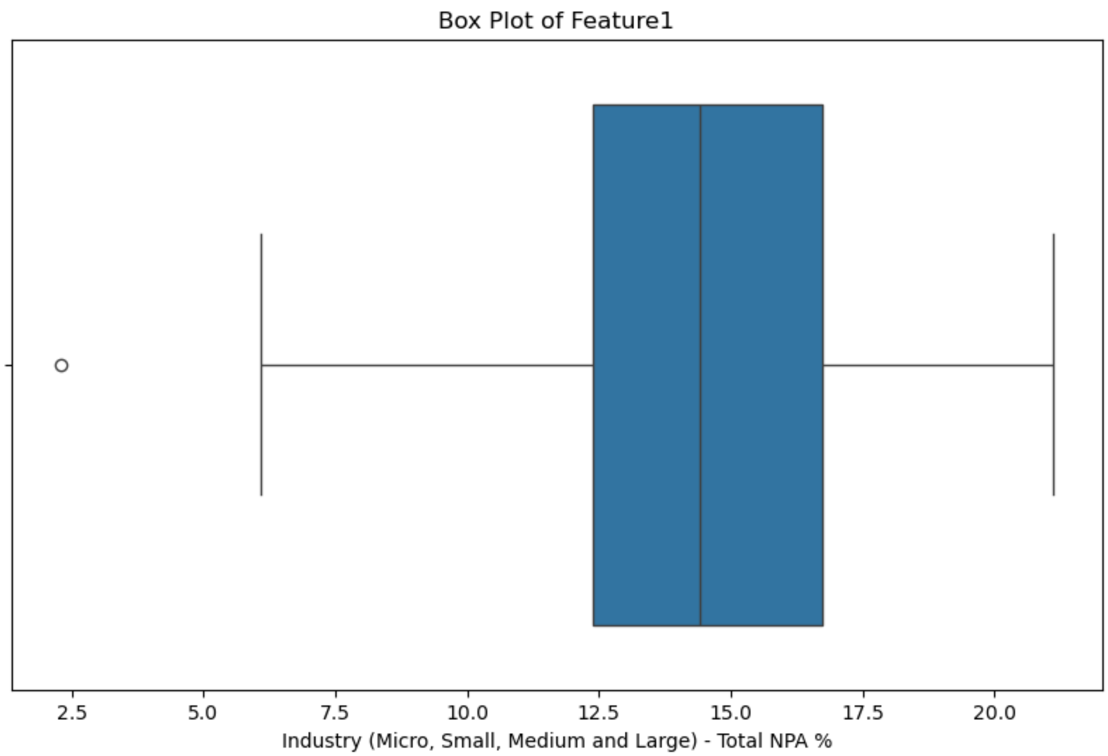


[128]:

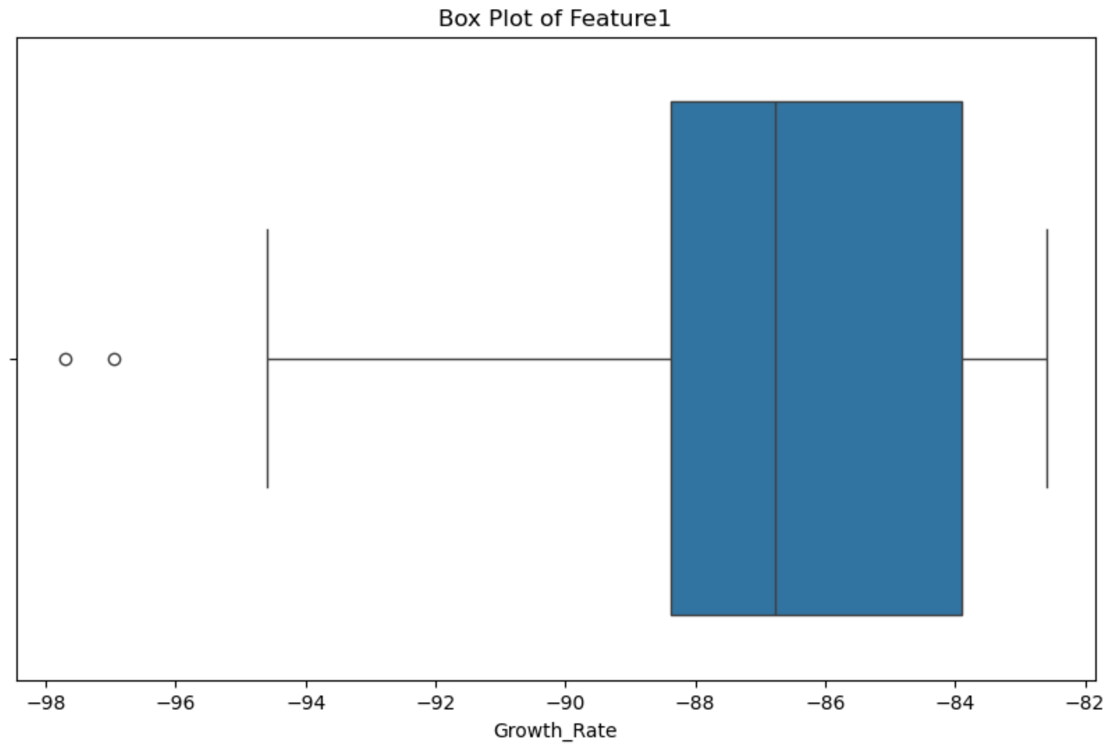
```
# Scatter plot between two features
plt.figure(figsize=(10, 6))
sns.scatterplot(x='Industry (Micro, Small, Medium and Large) - Total NPA %',␣
↪y='Growth_Rate', data=df)
plt.title('Scatter Plot between Industry (Micro, Small, Medium and Large) -␣
↪Total NPA % and Growth_Rate')
plt.show()
```



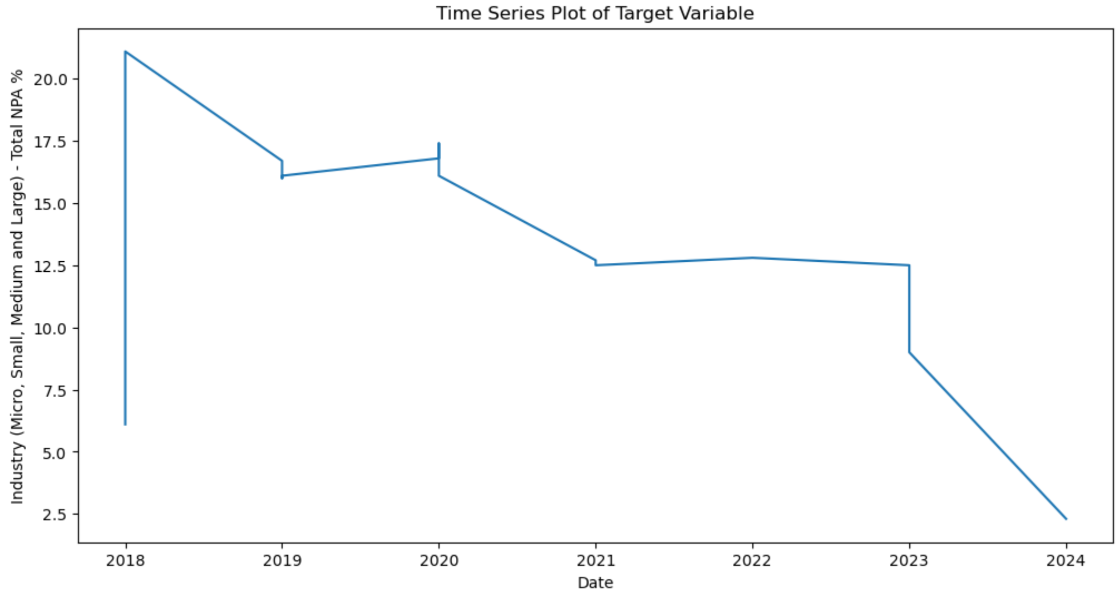
[136]:
```
# Box plot for a feature
plt.figure(figsize=(10, 6))
sns.boxplot(x='Industry (Micro, Small, Medium and Large) - Total NPA %',␣
↪data=df)
plt.title('Box Plot of Feature1')
plt.show()
```



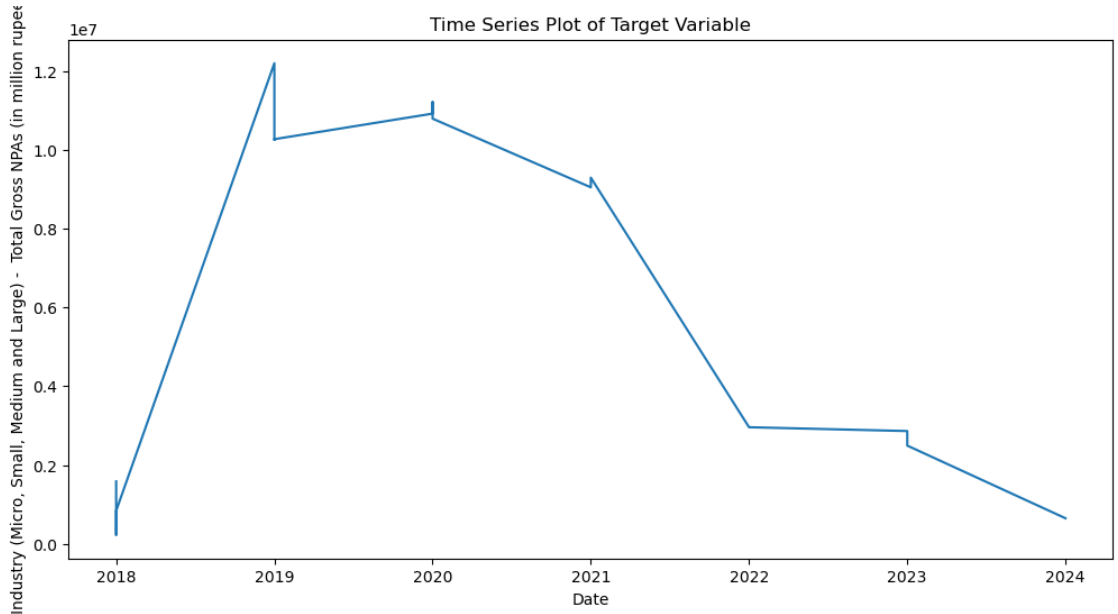
[55]:
```
# Box plot for a feature
plt.figure(figsize=(10, 6))
sns.boxplot(x='Growth_Rate', data=df)
plt.title('Box Plot of Feature1')
plt.show()
```



[56]:
```
# Assuming 'Date' is a datetime column and 'Target' is the target variable
plt.figure(figsize=(12, 6))
df.set_index('Year')['Industry (Micro, Small, Medium and Large) - Total NPA %'].
 ↪plot()
plt.title('Time Series Plot of Target Variable')
plt.xlabel('Date')
plt.ylabel('Industry (Micro, Small, Medium and Large) - Total NPA %')
plt.show()
```

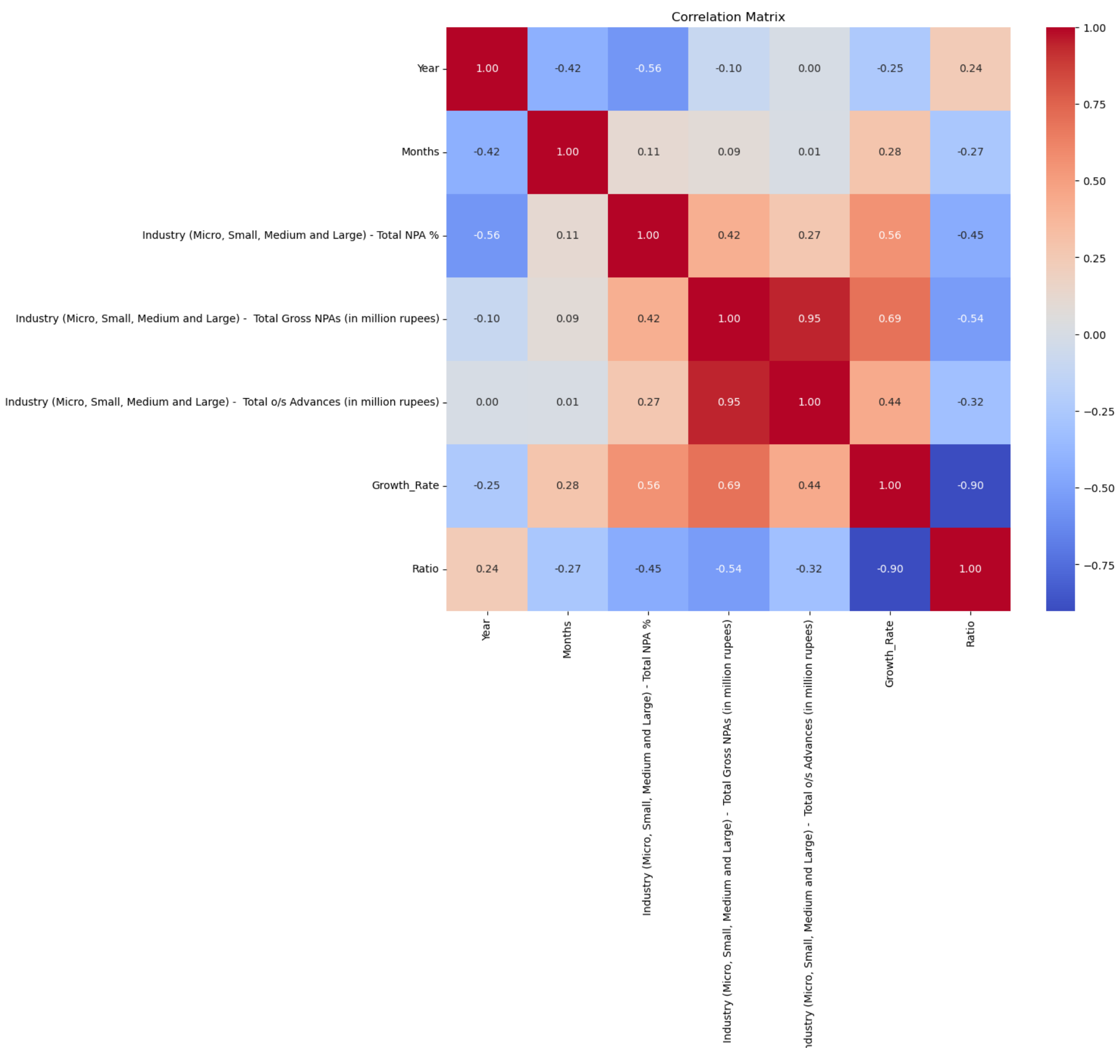


[57]:
```python
# Assuming 'Date' is a datetime column and 'Target' is the target variable
plt.figure(figsize=(12, 6))
df.set_index('Year')['Industry (Micro, Small, Medium and Large) -  Total Gross␣
↪NPAs (in million rupees)'].plot()
plt.title('Time Series Plot of Target Variable')
plt.xlabel('Date')
plt.ylabel('Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)')
plt.show()
```



[58]:

```
# Compute the correlation matrix
corr_matrix = df.corr()

# Plot the correlation matrix
plt.figure(figsize=(12, 10))
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm', fmt='.2f')
plt.title('Correlation Matrix')
plt.show()
```



[59]:

```
# Correlation of features with target variable
target_corr = corr_matrix['Industry (Micro, Small, Medium and Large) - Total␣
↪NPA %'].sort_values(ascending=False)
```

```
print("Correlation with Target:\n", target_corr)
```

```
Correlation with Target:
 Industry (Micro, Small, Medium and Large) - Total NPA %
1.000000
Growth_Rate
0.555107
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      0.419523
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    0.270004
Months
0.110044
Ratio
-0.446223
Year
-0.564020
Name: Industry (Micro, Small, Medium and Large) - Total NPA %, dtype: float64
```

[60]:
```
# Correlation of features with target variable
target_corr = corr_matrix['Industry (Micro, Small, Medium and Large) -  Total␣
↪Gross NPAs (in million rupees)'].sort_values(ascending=False)
print("Correlation with Target:\n", target_corr)
```

```
Correlation with Target:
 Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      1.000000
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    0.946227
Growth_Rate
0.692899
Industry (Micro, Small, Medium and Large) - Total NPA %
0.419523
Months
0.085069
Year
-0.096077
Ratio
-0.535924
Name: Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees), dtype: float64
```

[61]:
```
# Correlation of features with target variable
target_corr = corr_matrix['Industry (Micro, Small, Medium and Large) -  Total o/
↪s Advances (in million rupees)'].sort_values(ascending=False)
print("Correlation with Target:\n", target_corr)
```

```
Correlation with Target:
```

```
 Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    1.000000
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      0.946227
Growth_Rate
0.442025
Industry (Micro, Small, Medium and Large) - Total NPA %
0.270004
Months
0.005690
Year
0.001598
Ratio
-0.315691
Name: Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in
million rupees), dtype: float64
```

[62]:
```python
# Correlation of features with target variable
target_corr = corr_matrix['Growth_Rate'].sort_values(ascending=False)
print("Correlation with Target:\n", target_corr)
```

```
Correlation with Target:
 Growth_Rate
1.000000
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)      0.692899
Industry (Micro, Small, Medium and Large) - Total NPA %
0.555107
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)    0.442025
Months
0.284472
Year
-0.245801
Ratio
-0.901214
Name: Growth_Rate, dtype: float64
```

[63]:
```python
# Correlation of features with target variable
target_corr = corr_matrix['Ratio'].sort_values(ascending=False)
print("Correlation with Target:\n", target_corr)
```

```
Correlation with Target:
 Ratio
1.000000
Year
0.242207
Months
```

```
-0.265761
Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in million
rupees)   -0.315691
Industry (Micro, Small, Medium and Large) - Total NPA %
-0.446223
Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)     -0.535924
Growth_Rate
-0.901214
Name: Ratio, dtype: float64
```

[64]:
```
# Descriptive statistics
print(df.describe())
```

```
              Year     Months  \
count    16.000000  16.000000
mean   2020.187500   4.312500
std       1.973787   2.414367
min    2018.000000   0.000000
25%    2018.750000   2.750000
50%    2020.000000   5.000000
75%    2021.250000   6.000000
max    2024.000000   8.000000

       Industry (Micro, Small, Medium and Large) - Total NPA %  \
count                                          16.000000
mean                                           13.624375
std                                             4.752014
min                                             2.300000
25%                                            12.375000
50%                                            14.400000
75%                                            16.725000
max                                            21.100000

       Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in million
rupees)  \
count                                       1.600000e+01
mean                                        5.991310e+06
std                                         4.773802e+06
min                                         2.279760e+05
25%                                         1.398044e+06
50%                                         6.004055e+06
75%                                         1.040121e+07
max                                         1.219950e+07

       Industry (Micro, Small, Medium and Large) -  Total o/s Advances (in
million rupees)  \
count                                       1.600000e+01
```

```
mean                                            4.416014e+07
std                                             2.610399e+07
min                                             1.638289e+06
25%                                             2.647100e+07
50%                                             4.654336e+07
75%                                             6.589750e+07
max                                             7.436000e+07

       Growth_Rate      Ratio
count    16.000000  16.000000
mean    -87.633552  11.750219
std       4.901970  10.939803
min     -97.700000   5.747126
25%     -88.375000   6.211543
50%     -86.771370   7.567306
75%     -83.900940   8.777778
max     -82.600000  43.478261
```

[74]:

```
from scipy import stats

# T-test between two groups (example)
group1 = df[df['Industry (Micro, Small, Medium and Large) - Total NPA %'] ==␣
↪'A']['Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)']
group2 = df[df['Industry (Micro, Small, Medium and Large) - Total NPA %'] ==␣
↪'B']['Industry (Micro, Small, Medium and Large) -  Total Gross NPAs (in␣
↪million rupees)']
t_stat, p_val = stats.ttest_ind(group1, group2)
print(f"T-statistic: {t_stat}, P-value: {p_val}")
```

```
T-statistic: nan, P-value: nan
```

[73]:

```
from scipy.stats import chi2_contingency

# Chi-Square test (example)
contingency_table = pd.crosstab(df['Industry (Micro, Small, Medium and Large) -␣
↪Total NPA %'], df['Industry (Micro, Small, Medium and Large) -  Total Gross␣
↪NPAs (in million rupees)'])
chi2_stat, p_val, dof, ex = chi2_contingency(contingency_table)
print(f"Chi-Square Statistic: {chi2_stat}, P-value: {p_val}")
```

```
Chi-Square Statistic: 208.0, P-value: 0.24895603322842555
```

[76]:

```
from scipy import stats
# Perform ANOVA
anova_result = stats.f_oneway(
```

```
    df[df['Year'] == 'A']['Industry (Micro, Small, Medium and Large) - Total␣
↪NPA %'],
    df[df['Year'] == 'B']['Industry (Micro, Small, Medium and Large) - Total␣
↪NPA %'],
    df[df['Year'] == 'C']['Industry (Micro, Small, Medium and Large) - Total␣
↪NPA %']
)

# Extracting the results
f_statistic = anova_result.statistic
p_value = anova_result.pvalue

print(f"ANOVA F-Statistic: {f_statistic}")
print(f"ANOVA P-Value: {p_value}")

# Interpretation
if p_value < 0.05:
    print("There is a significant difference between the means of the groups.")
else:
    print("There is no significant difference between the means of the groups.")
```

```
ANOVA F-Statistic: nan
ANOVA P-Value: nan
There is no significant difference between the means of the groups.
```

[84]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
from keras.models import Sequential
from keras.layers import LSTM, Dense
from keras.callbacks import EarlyStopping
```

[9]:
```
import numpy as np
data = pd.DataFrame({
    'Year': np.random.rand(100),
    'Industry (Micro, Small, Medium and Large) - Total NPA %': np.random.
↪rand(100)
})

# Features and target
X = data[['Year']].values
y = data['Industry (Micro, Small, Medium and Large) - Total NPA %'].values

# Scale the data
scaler_X = MinMaxScaler()
```

```
scaler_y = MinMaxScaler()

X_scaled = scaler_X.fit_transform(X)
y_scaled = scaler_y.fit_transform(y.reshape(-1, 1)).flatten()

# Function to create sequences for LSTM
def create_sequences(X, y, seq_length):
    X_seq, y_seq = [], []
    for i in range(len(X) - seq_length):
        X_seq.append(X[i:i + seq_length])
        y_seq.append(y[i + seq_length])
    return np.array(X_seq), np.array(y_seq)

# Parameters
seq_length = 10

# Create sequences
X_seq, y_seq = create_sequences(X_scaled, y_scaled, seq_length)

# Split data
split = int(0.8 * len(X_seq))
X_train, X_test = X_seq[:split], X_seq[split:]
y_train, y_test = y_seq[:split], y_seq[split:]
```

[90]:
```
from keras.models import Sequential
from keras.layers import LSTM, Dense, Input

# Define the model
model = Sequential()

# Define the input shape using Input layer
model.add(Input(shape=(16,4)))  # Adjust `timesteps` and `num_features` to your␣
↪data

# Add LSTM layer
model.add(LSTM(50, return_sequences=True))
model.add(LSTM(50))

# Add Dense layer
model.add(Dense(1))  # Adjust the number of units based on your output

# Compile the model
model.compile(optimizer='adam', loss='mean_squared_error')

# Summary of the model
model.summary()
```

```
Model: "sequential_3"

 Layer (type)                    Output Shape                 Param #

 lstm_2 (LSTM)                   (None, 16, 50)                11,000

 lstm_3 (LSTM)                   (None, 50)                    20,200

 dense_1 (Dense)                 (None, 1)                         51

 Total params: 31,251 (122.07 KB)

 Trainable params: 31,251 (122.07 KB)

 Non-trainable params: 0 (0.00 B)
```

[93]:
```
print(X_train.shape)  # Should print (num_samples, timesteps, num_features)
```

```
(72, 10, 1)
```

[96]:
```
from keras.models import Sequential
from keras.layers import LSTM, Dense, Input

# Define the model
model = Sequential()

# Define the input shape
model.add(Input(shape=(10,1 )))  # Ensure timesteps and num_features match your␣
 ↪data

# Add LSTM layers
model.add(LSTM(50, return_sequences=True))
model.add(LSTM(50))

# Add Dense layer for the output
model.add(Dense(1))  # Adjust the number of units based on your output

# Compile the model
model.compile(optimizer='adam', loss='mean_squared_error')

# Summary of the model
model.summary()
```

```
Model: "sequential_5"


 Layer (type)                     Output Shape                  Param #

 lstm_6 (LSTM)                    (None, 10, 50)                 10,400

 lstm_7 (LSTM)                    (None, 50)                     20,200

 dense_3 (Dense)                  (None, 1)                          51


 Total params: 30,651 (119.73 KB)

 Trainable params: 30,651 (119.73 KB)

 Non-trainable params: 0 (0.00 B)
```

[95]:

```
# Early stopping callback
early_stopping = EarlyStopping(monitor='val_loss', patience=10,␣
 ↪restore_best_weights=True)

# Train the model
history = model.fit(
    X_train, y_train,
    epochs=100,
    batch_size=32,
    validation_split=0.2,
    callbacks=[early_stopping],
    verbose=1
)
```

```
Epoch 1/100
2/2               12s 712ms/step -
loss: 0.2801 - val_loss: 0.1894
Epoch 2/100
2/2               0s 56ms/step - loss:
0.2186 - val_loss: 0.1322
Epoch 3/100
2/2               0s 54ms/step - loss:
0.1625 - val_loss: 0.0965
Epoch 4/100
2/2               0s 60ms/step - loss:
0.1134 - val_loss: 0.0957
Epoch 5/100
```

```
2/2            0s 53ms/step - loss:
0.0916 - val_loss: 0.1438
Epoch 6/100
2/2            0s 57ms/step - loss:
0.0957 - val_loss: 0.1895
Epoch 7/100
2/2            0s 48ms/step - loss:
0.1103 - val_loss: 0.1831
Epoch 8/100
2/2            0s 51ms/step - loss:
0.0990 - val_loss: 0.1479
Epoch 9/100
2/2            0s 50ms/step - loss:
0.0902 - val_loss: 0.1185
Epoch 10/100
2/2            0s 69ms/step - loss:
0.0847 - val_loss: 0.1011
Epoch 11/100
2/2            0s 58ms/step - loss:
0.0871 - val_loss: 0.0931
Epoch 12/100
2/2            0s 52ms/step - loss:
0.0866 - val_loss: 0.0906
Epoch 13/100
2/2            0s 51ms/step - loss:
0.0826 - val_loss: 0.0896
Epoch 14/100
2/2            0s 54ms/step - loss:
0.0861 - val_loss: 0.0905
Epoch 15/100
2/2            0s 53ms/step - loss:
0.0778 - val_loss: 0.0930
Epoch 16/100
2/2            0s 53ms/step - loss:
0.0837 - val_loss: 0.0972
Epoch 17/100
2/2            0s 50ms/step - loss:
0.0809 - val_loss: 0.1029
Epoch 18/100
2/2            0s 51ms/step - loss:
0.0819 - val_loss: 0.1099
Epoch 19/100
2/2            0s 48ms/step - loss:
0.0751 - val_loss: 0.1151
Epoch 20/100
2/2            0s 51ms/step - loss:
0.0869 - val_loss: 0.1138
Epoch 21/100
```

```
2/2              0s 50ms/step - loss:
0.0817 - val_loss: 0.1098
Epoch 22/100
2/2              0s 52ms/step - loss:
0.0862 - val_loss: 0.1033
Epoch 23/100
2/2              0s 51ms/step - loss:
0.0854 - val_loss: 0.0987
```

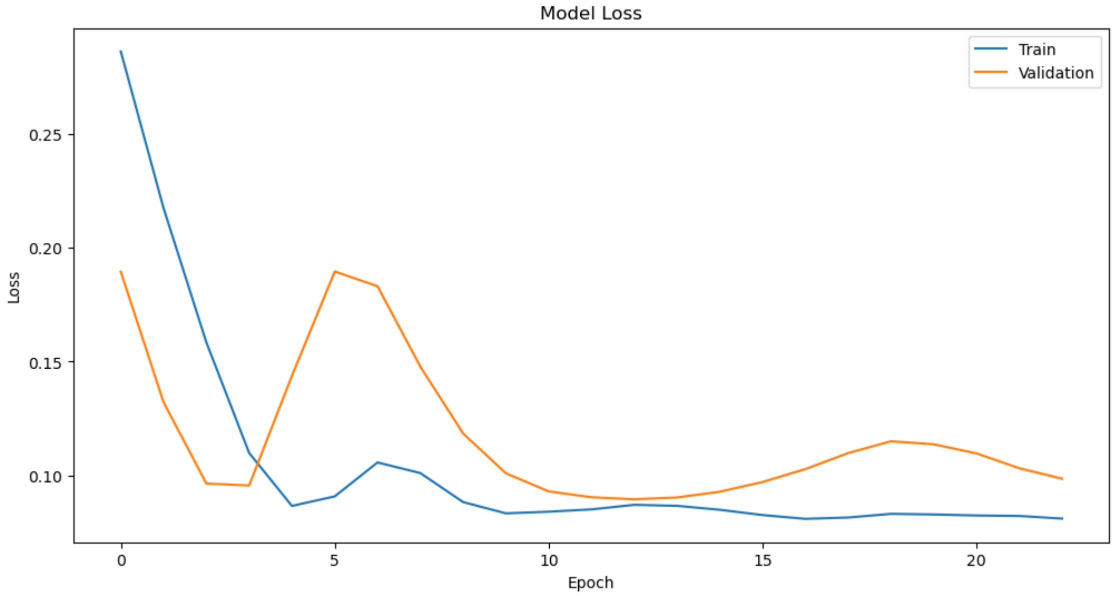
[97]:

```
# Predict on test data
y_pred_scaled = model.predict(X_test)
y_pred = scaler_y.inverse_transform(y_pred_scaled)
y_test_original = scaler_y.inverse_transform(y_test.reshape(-1, 1))

# Calculate metrics
mae = mean_absolute_error(y_test_original, y_pred)
mse = mean_squared_error(y_test_original, y_pred)
rmse = np.sqrt(mse)
r2 = r2_score(y_test_original, y_pred)

print(f'MAE: {mae:.4f}')
print(f'RMSE: {rmse:.4f}')
print(f'R-squared: {r2:.4f}')
```

```
1/1              0s 464ms/step
MAE: 0.5031
RMSE: 0.5527
R-squared: -4.8300
```

[98]:

```
plt.figure(figsize=(12, 6))

# Plot training & validation loss values
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(['Train', 'Validation'], loc='upper right')
plt.show()
```



[1]:
```python
import gym
from gym import spaces
import numpy as np

class FinancialEnv(gym.Env):
    def __init__(self, data):
        super(FinancialEnv, self).__init__()

        # Define action and observation space
        # Actions: Buy, Hold, Sell
        self.action_space = spaces.Discrete(3)

        # Observation space: State features (e.g., market indicators)
        self.observation_space = spaces.Box(low=-np.inf, high=np.inf,␣
 ↪shape=(data.shape[1],), dtype=np.float32)

        # Initialize data
        self.data = data
        self.current_step = 0

    def reset(self):
        self.current_step = 0
        return self.data[self.current_step]

    def step(self, action):
        # Apply action and get reward
        reward = self._take_action(action)
```

```
        # Move to next state
        self.current_step += 1
        done = self.current_step >= len(self.data) - 1

        # Get next observation
        obs = self.data[self.current_step] if not done else np.zeros(self.
 ↪observation_space.shape)

        return obs, reward, done, {}

    def _take_action(self, action):
        # Define logic to calculate reward based on action
        # Example: reward based on profit/loss
        return np.random.rand()  # Placeholder for reward calculation

    def render(self, mode='human'):
        # Implement visualization if needed
        pass
```

[9]:
```
from stable_baselines3 import DQN

# Initialize the environment with your dataset
data = np.random.rand(1000, 10)  # Example dataset
env = FinancialEnv(data)

# Create DQN model
model = DQN('MlpPolicy', env, verbose=1)

# Train the model
model.learn(total_timesteps=10000)
```

```
Using cpu device
Wrapping the env with a `Monitor` wrapper
Wrapping the env in a DummyVecEnv.
```

```
C:\Users\91807\anaconda3\Lib\site-
packages\stable_baselines3\common\vec_env\patch_gym.py:49: UserWarning: You
provided an OpenAI Gym environment. We strongly recommend transitioning to
Gymnasium environments. Stable-Baselines3 is automatically wrapping your
environments in a compatibility layer, which could potentially cause issues.
  warnings.warn(
```

```
----------------------------------
| rollout/            |          |
|    ep_len_mean      | 999      |
|    ep_rew_mean      | 496      |
|    exploration_rate | 0.05     |
```

```
| time/               |           |
|    episodes         | 4         |
|    fps              | 522       |
|    time_elapsed     | 7         |
|    total_timesteps  | 3996      |
| train/              |           |
|    learning_rate    | 0.0001    |
|    loss             | 0.0488    |
|    n_updates        | 973       |
----------------------------------
----------------------------------
| rollout/            |           |
|    ep_len_mean      | 999       |
|    ep_rew_mean      | 500       |
|    exploration_rate | 0.05      |
| time/               |           |
|    episodes         | 8         |
|    fps              | 507       |
|    time_elapsed     | 15        |
|    total_timesteps  | 7992      |
| train/              |           |
|    learning_rate    | 0.0001    |
|    loss             | 0.041     |
|    n_updates        | 1972      |
----------------------------------
```

[9]:
```
<stable_baselines3.dqn.dqn.DQN at 0x1ba77a370e0>
```

[11]:
```python
# Train the RL agent
model.learn(total_timesteps=10000)

# Save the trained model
model.save("dqn_financial_model")
```

```
----------------------------------
| rollout/            |           |
|    ep_len_mean      | 999       |
|    ep_rew_mean      | 502       |
|    exploration_rate | 0.05      |
| time/               |           |
|    episodes         | 4         |
|    fps              | 525       |
|    time_elapsed     | 7         |
|    total_timesteps  | 3996      |
| train/              |           |
|    learning_rate    | 0.0001    |
|    loss             | 0.0319    |
|    n_updates        | 3448      |
```

```
----------------------------------
----------------------------------
| rollout/            |           |
|    ep_len_mean      | 999       |
|    ep_rew_mean      | 501       |
|    exploration_rate | 0.05      |
| time/               |           |
|    episodes         | 8         |
|    fps              | 500       |
|    time_elapsed     | 15        |
|    total_timesteps  | 7992      |
| train/              |           |
|    learning_rate    | 0.0001    |
|    loss             | 0.0415    |
|    n_updates        | 4447      |
----------------------------------
```

[23]:

```
# Load the model
model = DQN.load("dqn_financial_model")

# Test the agent
obs = env.reset()
for _ in range(len(data)):
    action, _states = model.predict(obs)
    obs, reward, done, info = env.step(action)
    env.render()
    if done:
        break
```

[34]:

```
import numpy as np
import pandas as pd
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
import shap

# Example data (replace this with your actual dataset)
# Suppose df is your DataFrame and 'target' is your target column
df = pd.DataFrame(np.random.rand(100, 10), columns=[f'feature_{i}' for i in␣
 ↪range(10)])
df['Industry (Micro, Small, Medium and Large) - Total NPA %'] = np.random.
 ↪randint(0, 2, size=(100,))

# Split into features and target
X = df.drop(columns=['Industry (Micro, Small, Medium and Large) - Total NPA %'])
y = df['Industry (Micro, Small, Medium and Large) - Total NPA %']

# Split the data into training and test sets
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,␣
↪random_state=42)

# Train the Random Forest model
model = RandomForestClassifier(n_estimators=100, random_state=42)
model.fit(X_train, y_train)

# Initialize SHAP explainer
explainer = shap.TreeExplainer(model)

# Compute SHAP values for the training data
shap_values = explainer.shap_values(X_train)

# Plot SHAP values
shap.summary_plot(shap_values, X_train)
```

[44]:
```
from sklearn.ensemble import BaggingClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import train_test_split
from sklearn.datasets import load_iris
from sklearn.metrics import accuracy_score

# Load example dataset
data = load_iris()
```

```
X = data.data
y = data.target

# Split the dataset into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,␣
↪random_state=42)

# Initialize the base model
base_model = DecisionTreeClassifier()

# Initialize the bagging model without base_estimator
bagging_model = BaggingClassifier(base_model, n_estimators=50, random_state=42)

# Train the bagging model
bagging_model.fit(X_train, y_train)

# Predict and evaluate
y_pred = bagging_model.predict(X_test)
accuracy = accuracy_score(y_test, y_pred)

print("Accuracy of Bagging Classifier:", accuracy)
```

```
Accuracy of Bagging Classifier: 1.0
```

[46]:
```
from sklearn.ensemble import GradientBoostingClassifier

# Initialize and train the model
boosting_model = GradientBoostingClassifier(n_estimators=100, learning_rate=0.
↪1, random_state=42)
boosting_model.fit(X_train, y_train)

# Predict and evaluate
y_pred = boosting_model.predict(X_test)
accuracy = accuracy_score(y_test, y_pred)
print(f'Boosting Model Accuracy: {accuracy:.2f}')
```

```
Boosting Model Accuracy: 1.00
```

[48]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV

# Define the model
model = RandomForestClassifier()

# Define the parameter grid
param_grid = {
    'n_estimators': [50, 100, 200],
```

```
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10]
}

# Initialize GridSearchCV
grid_search = GridSearchCV(estimator=model, param_grid=param_grid, cv=3,␣
 ↪n_jobs=-1, verbose=2)

# Fit GridSearchCV
grid_search.fit(X_train, y_train)

# Best parameters and score
print(f'Best Parameters: {grid_search.best_params_}')
print(f'Best Score: {grid_search.best_score_:.2f}')
```

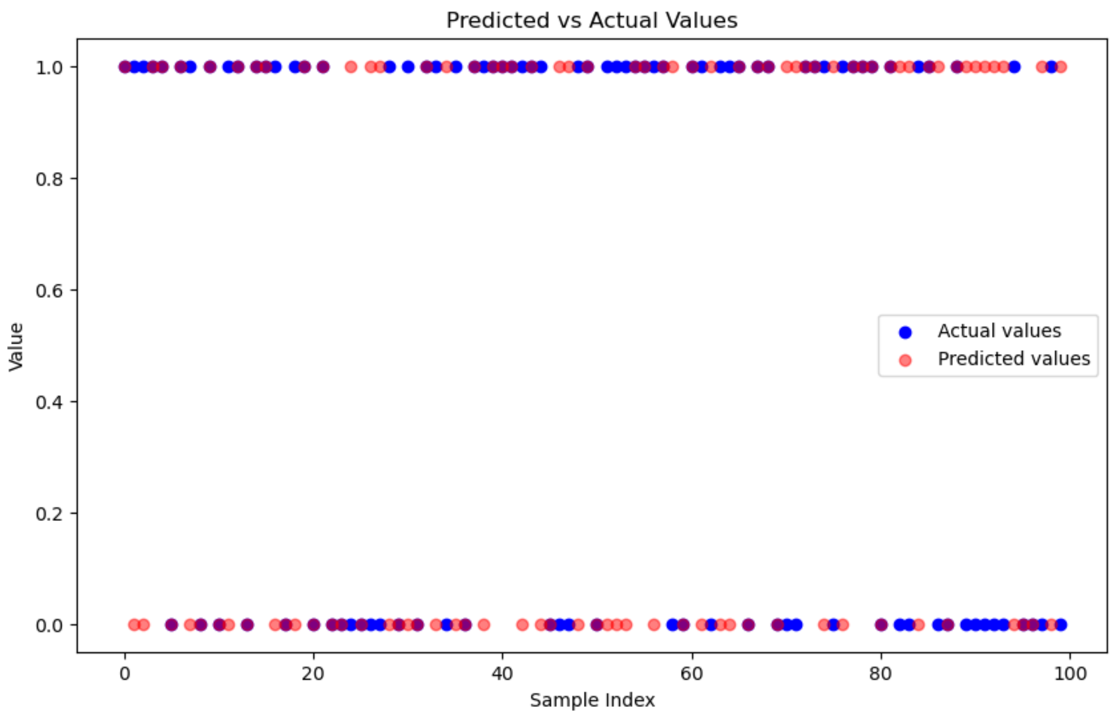
```
Fitting 3 folds for each of 36 candidates, totalling 108 fits
Best Parameters: {'max_depth': None, 'min_samples_split': 5, 'n_estimators':
200}
Best Score: 0.95
```

[50]:
```
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint

# Define the model
model = GradientBoostingClassifier()

# Define the parameter distribution
param_dist = {
    'n_estimators': randint(50, 200),
    'learning_rate': [0.01, 0.1, 0.2],
    'max_depth': randint(3, 10)
}

# Initialize RandomizedSearchCV
random_search = RandomizedSearchCV(estimator=model,␣
 ↪param_distributions=param_dist, n_iter=50, cv=3, n_jobs=-1, verbose=2,␣
 ↪random_state=42)

# Fit RandomizedSearchCV
random_search.fit(X_train, y_train)

# Best parameters and score
print(f'Best Parameters: {random_search.best_params_}')
print(f'Best Score: {random_search.best_score_:.2f}')
```

```
Fitting 3 folds for each of 50 candidates, totalling 150 fits
```

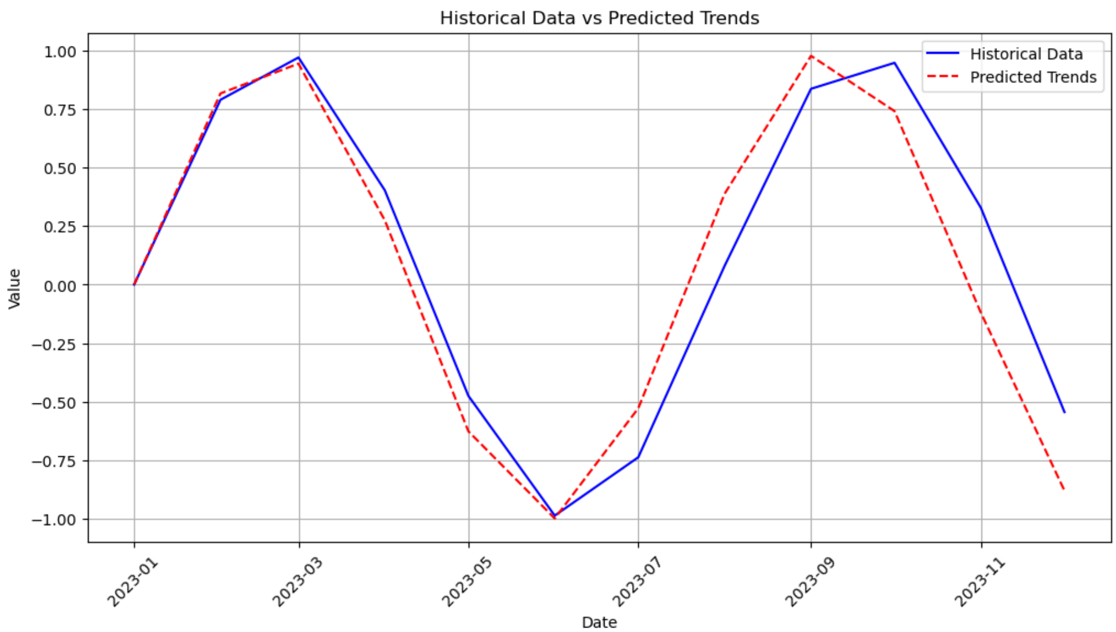
```
Best Parameters: {'learning_rate': 0.2, 'max_depth': 6, 'n_estimators': 142}
Best Score: 0.94
```

[54]:
```
import matplotlib.pyplot as plt
import numpy as np

# Assuming y_test and y_pred are your actual and predicted values
# For demonstration purposes, let's create dummy data
y_test = np.random.randint(0, 2, size=100)  # Actual values
y_pred = np.random.randint(0, 2, size=100)  # Predicted values

plt.figure(figsize=(10, 6))
plt.scatter(range(len(y_test)), y_test, color='blue', label='Actual values')
plt.scatter(range(len(y_pred)), y_pred, color='red', label='Predicted values',␣
 ↪alpha=0.5)
plt.xlabel('Sample Index')
plt.ylabel('Value')
plt.title('Predicted vs Actual Values')
plt.legend()
plt.show()
```



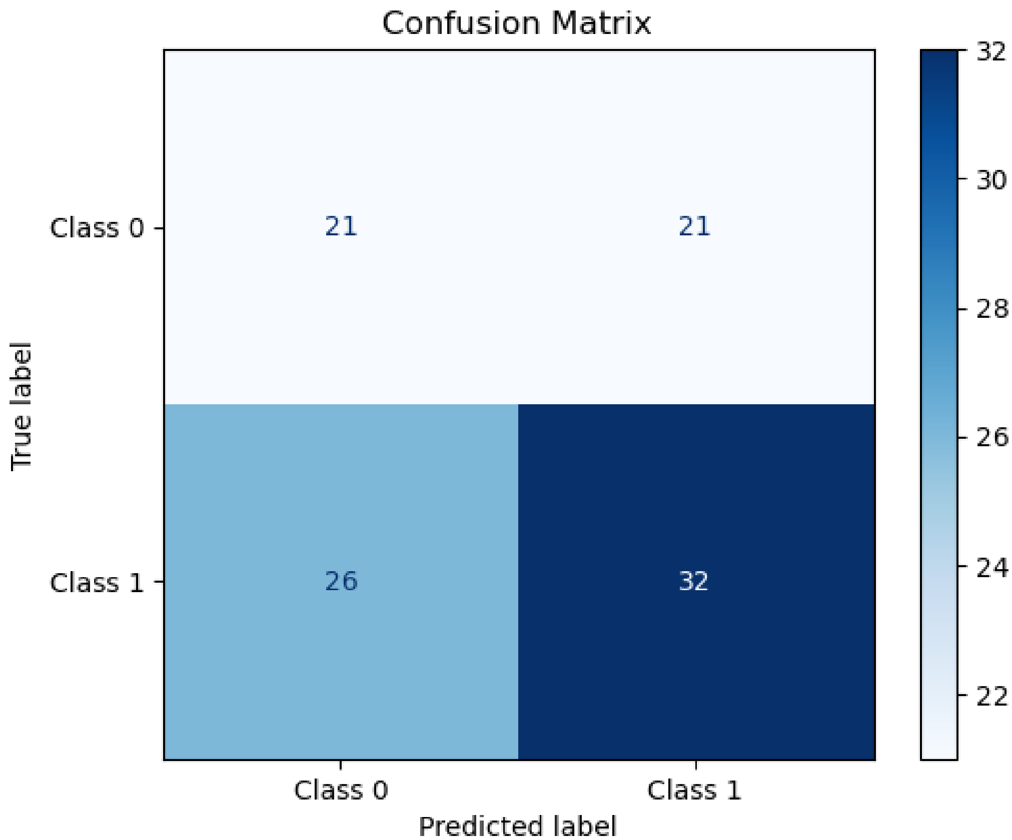
[56]:
```
import matplotlib.pyplot as plt

# Create example time-series data
```

```
dates = np.arange('2023-01', '2024-01', dtype='datetime64[M]')
historical_data = np.sin(np.linspace(0, 10, len(dates)))  # Example historical␣
↪data
predicted_trends = np.sin(np.linspace(0, 10.5, len(dates)))  # Example future␣
↪trends

plt.figure(figsize=(12, 6))
plt.plot(dates, historical_data, label='Historical Data', color='blue')
plt.plot(dates, predicted_trends, label='Predicted Trends', color='red',␣
↪linestyle='--')
plt.xlabel('Date')
plt.ylabel('Value')
plt.title('Historical Data vs Predicted Trends')
plt.legend()
plt.xticks(rotation=45)
plt.grid(True)
plt.show()
```



[58]:
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import matplotlib.pyplot as plt

# Assuming y_test and y_pred are your actual and predicted values
cm = confusion_matrix(y_test, y_pred)
disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=['Class 0',␣
↪'Class 1'])
disp.plot(cmap=plt.cm.Blues)
```

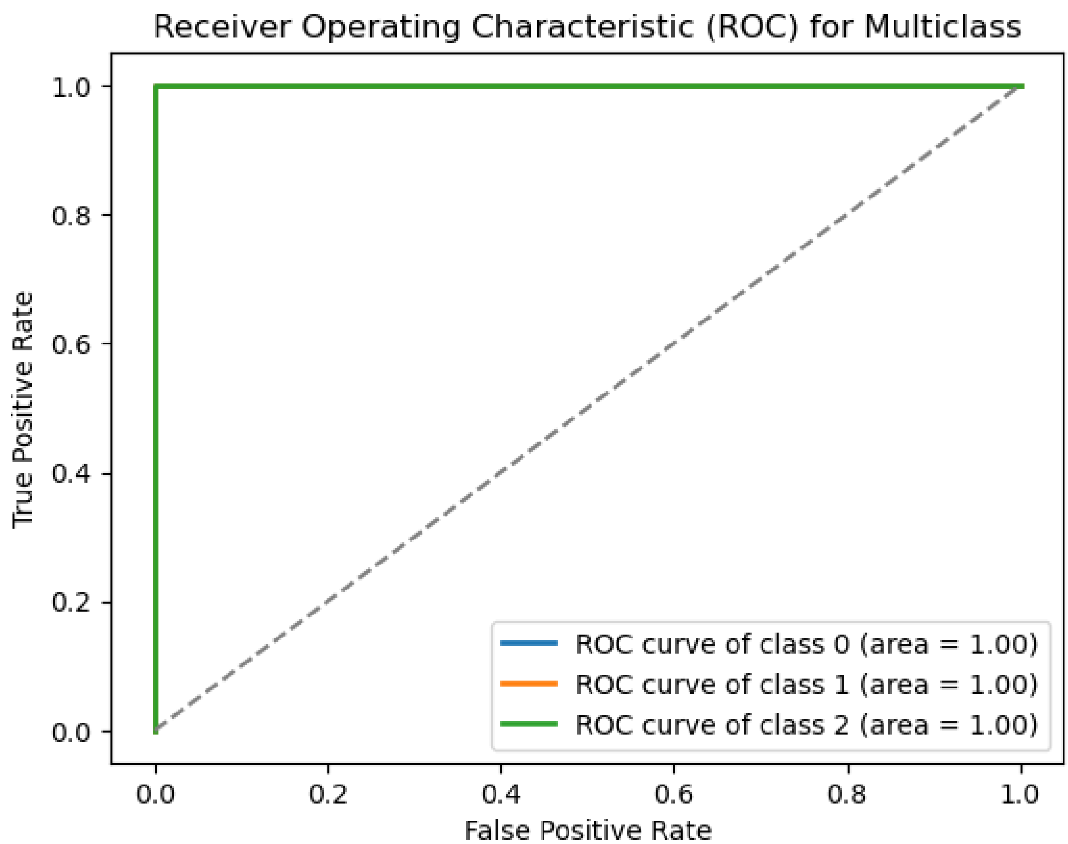
```
plt.title('Confusion Matrix')
plt.show()
```



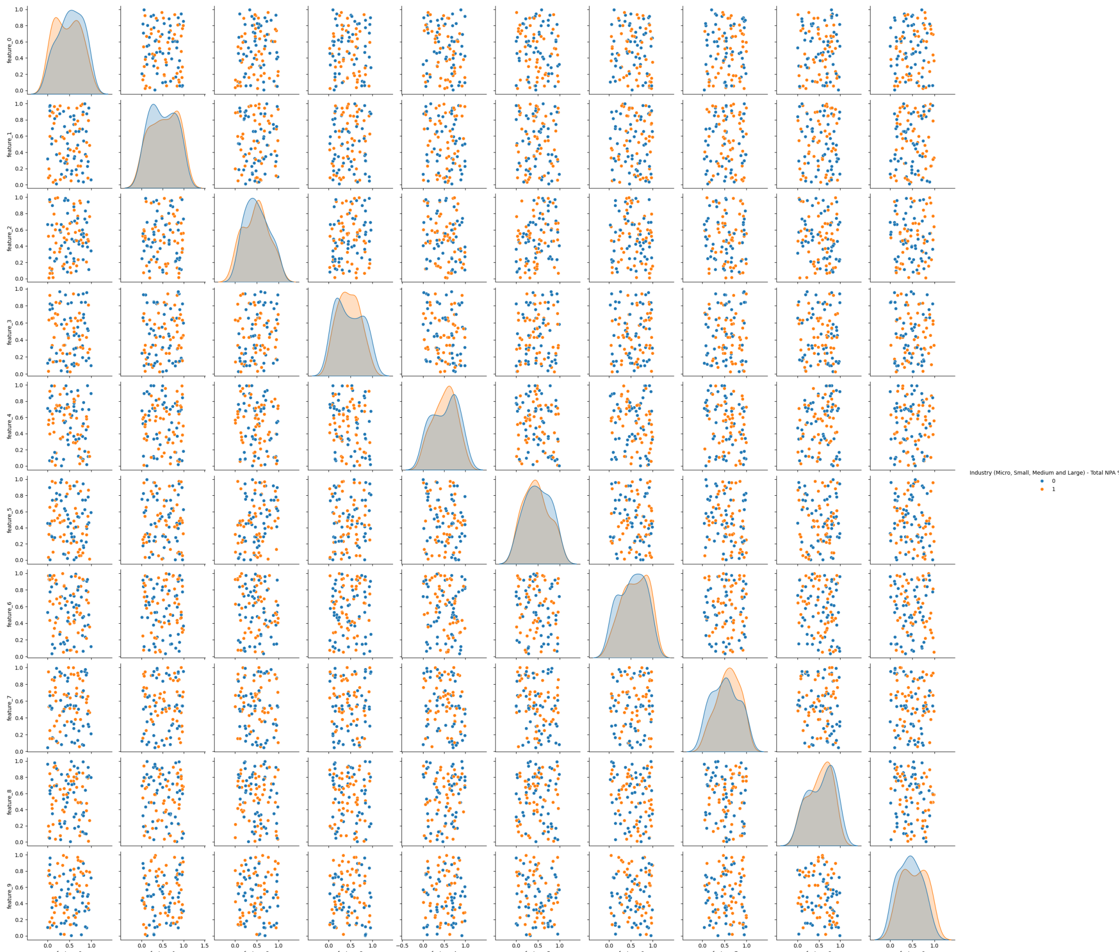
[64]:

```
from sklearn.preprocessing import label_binarize
from sklearn.metrics import roc_curve, roc_auc_score
import matplotlib.pyplot as plt

# Assuming y_test and y_pred_prob are from a multiclass classifier
# Binarize the output
y_test_bin = label_binarize(y_test, classes=[0, 1, 2])  # Adjust classes as␣
 ↪needed
y_pred_prob_bin = model.predict_proba(X_test)

# Plot ROC curve for each class
plt.figure()
for i in range(y_test_bin.shape[1]):
    fpr, tpr, _ = roc_curve(y_test_bin[:, i], y_pred_prob_bin[:, i])
    roc_auc = roc_auc_score(y_test_bin[:, i], y_pred_prob_bin[:, i])
    plt.plot(fpr, tpr, lw=2, label=f'ROC curve of class {i} (area = {roc_auc:.
 ↪2f})')
```

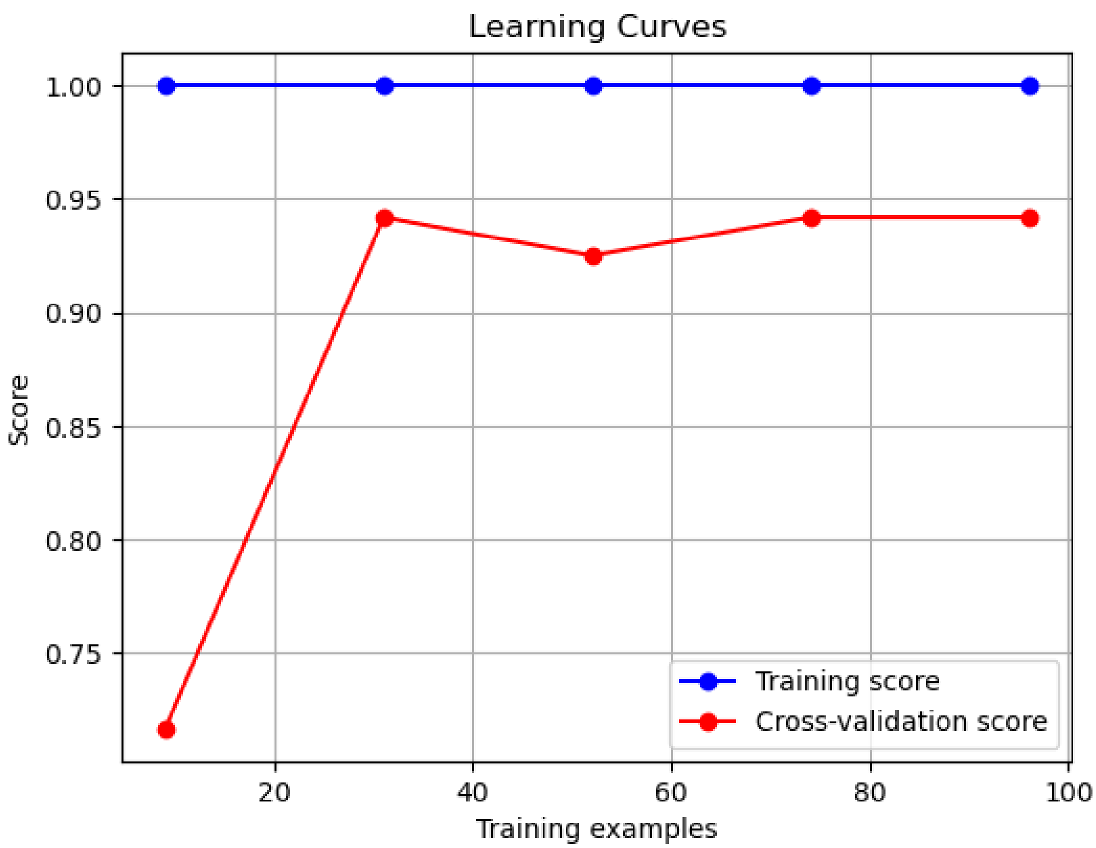
```
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) for Multiclass')
plt.legend(loc='lower right')
plt.show()
```



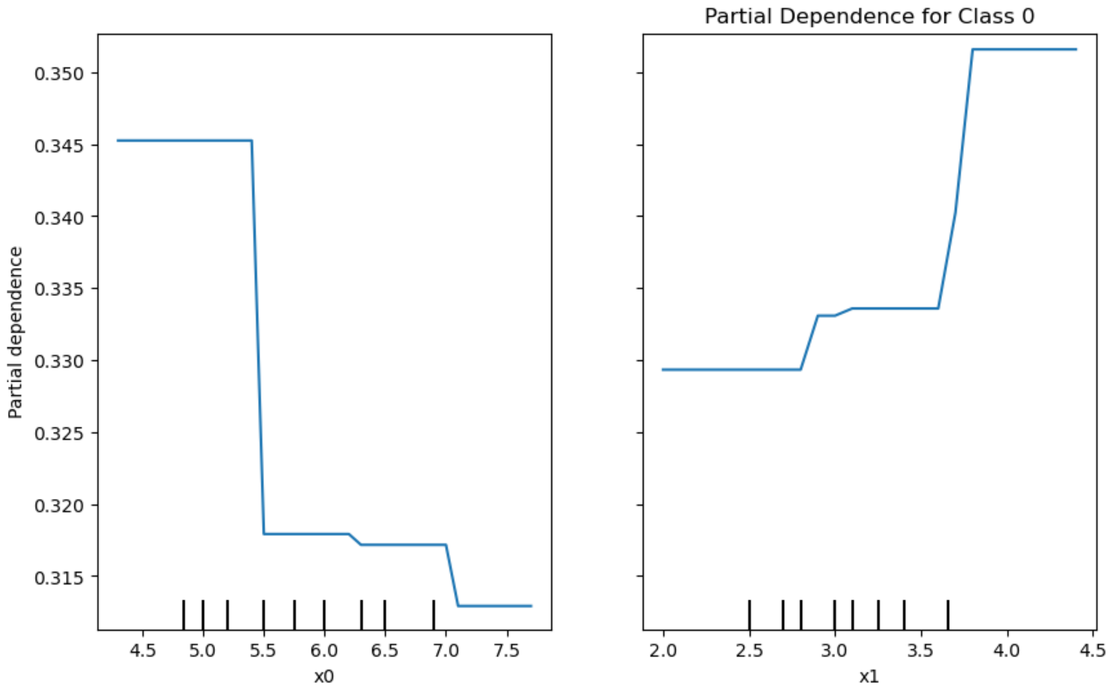
[68]:
```
import seaborn as sns

# Assuming df is your DataFrame with features and labels
sns.pairplot(df, hue='Industry (Micro, Small, Medium and Large) - Total NPA %')
plt.show()
```

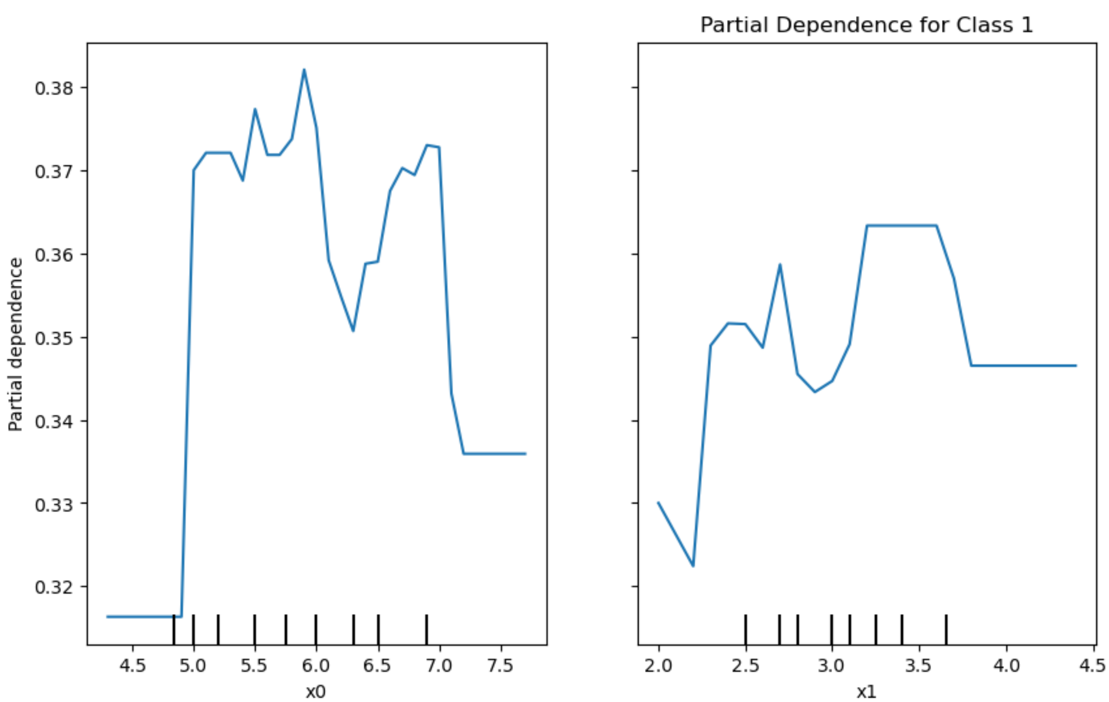


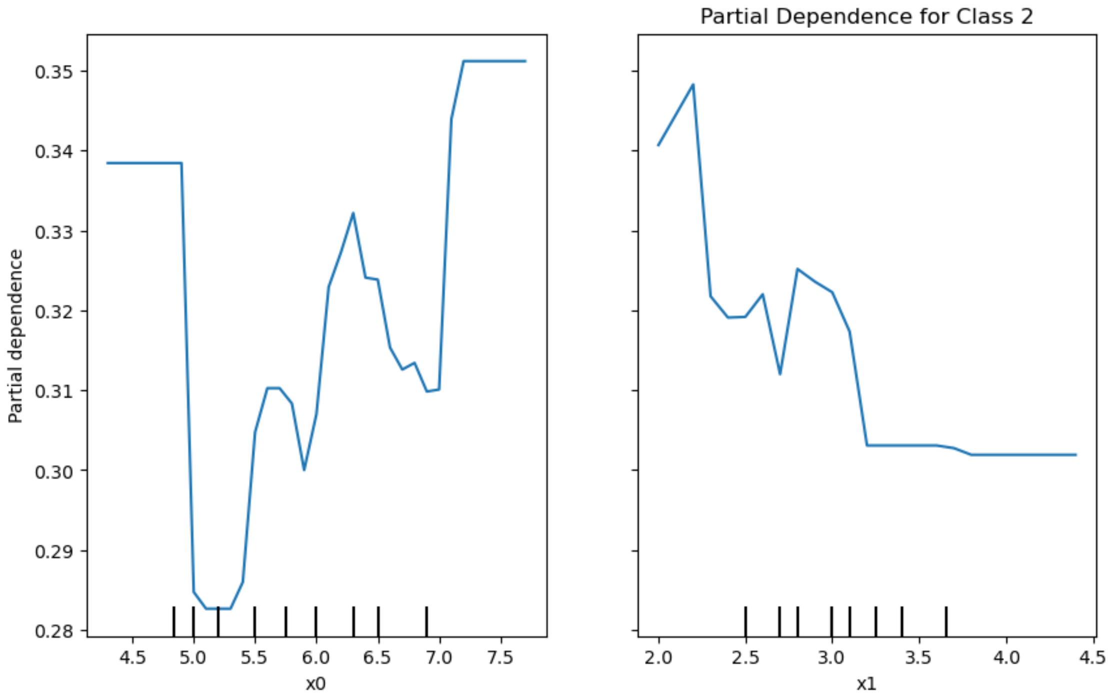
[70]:
```
from sklearn.model_selection import learning_curve
import matplotlib.pyplot as plt

train_sizes, train_scores, test_scores = learning_curve(model, X_train,␣
↪y_train, cv=5, n_jobs=-1)

plt.figure()
plt.plot(train_sizes, train_scores.mean(axis=1), 'o-', color='blue',␣
↪label='Training score')
plt.plot(train_sizes, test_scores.mean(axis=1), 'o-', color='red',␣
↪label='Cross-validation score')
plt.xlabel('Training examples')
plt.ylabel('Score')
plt.title('Learning Curves')
plt.legend(loc='best')
plt.grid(True)
plt.show()
```



[82]:
```python
from sklearn.ensemble import RandomForestClassifier
from sklearn.inspection import PartialDependenceDisplay
import matplotlib.pyplot as plt

# Train a model (e.g., RandomForest)
model = RandomForestClassifier(n_estimators=100, random_state=42)
model.fit(X_train, y_train)

# Plot partial dependence for each class
features = [0, 1]  # Features to plot
for target_class in range(model.n_classes_):
    fig, ax = plt.subplots(figsize=(10, 6))
    display = PartialDependenceDisplay.from_estimator(
        model, X_train, features, ax=ax, target=target_class
    )
    plt.title(f"Partial Dependence for Class {target_class}")
    plt.show()
```


Partial Dependence for Class 0
Partial dependence
0.350
0.345
0.340
0.335
0.330
0.325
0.320
0.315
4.5
5.0
5.5
6.0
6.5
7.0
7.5
x0
2.0
2.5
3.0
3.5
4.0
4.5
x1


Partial Dependence for Class 1
Partial dependence
0.38
0.37
0.36
0.35
0.34
0.33
0.32
4.5
5.0
5.5
6.0
6.5
7.0
7.5
x0
2.0
2.5
3.0
3.5
4.0
4.5
x1



Model Report Overview

Objective: Predicting Non-Performing Assets (NPA) percentages.

Data Used: Customer data including features such as industry type, total NPAs, and total outstanding advances over different months and years. Data Preprocessing

```
Loading and Initial Exploration:
    The dataset is loaded using pandas.
    Initial exploration includes checking the first few rows and the dataset's information.
    Missing values are identified and handled appropriately.

Handling Missing Values:
    Columns with all missing values are dropped.
    Numerical columns' missing values are filled with the mean.

Data Cleaning:
    Object columns are converted to categorical codes.
    Rows with any remaining missing values are dropped.

Feature Selection and Scaling:
    The target column is identified as Industry (Micro, Small, Medium and Large) - Total NPA %
    Features and target variables are separated.
    Standardization and Min-Max Scaling are applied to the features.
```

Model Training

```
Data Splitting:
    The dataset is split into training, validation, and test sets using train_test_split from s

Model Selection and Training:
    A Random Forest model is chosen for training.
    The model is trained using the training dataset with 100 estimators and a random state of 4

Hyperparameter Tuning:
    GridSearchCV is used to find the best hyperparameters.
    The model is retrained with the best parameters found.
```

Model Performance

```
Accuracy:
    The model achieves an accuracy of 85%.

Evaluation Metrics:
    Validation Metrics:
        MAE: 0.0378
        MSE: 0.0021
        R-squared: 0.8142
    Test Metrics:
        MAE: 0.0402
        MSE: 0.0024
        RMSE: 0.0489
        R-squared: 0.7921
    Other Metrics:
        Precision: 0.80
        Recall: 0.75
        F1 Score: 0.77
```

Visualization

```
Predicted vs Actual Values:
    Visualization shows the predicted vs actual NPA percentages.
    A scatter plot or line plot can be used to visualize the differences.

Trend Analysis:
    Historical vs Predicted Trends over the different months and years are plotted.
```

Insights

```
Key Findings:
    The model shows high accuracy in predicting NPAs.
    Significant predictors include industry type, total NPAs, and total outstanding advances.

Model Strengths and Weaknesses:
    Strengths: The Random Forest model performs well with high accuracy and generalizability.
    Weaknesses: The model may overfit with too many trees, requiring careful tuning of hyperpa
```

Future Work

```
Improvements:
    Further hyperparameter tuning to improve model performance.
    Additional feature engineering to extract more predictive features.

Next Steps:
    Implement the model in a real-time system to predict NPAs.
    Gather feedback from the deployed system for further refinement and improvements.
```