```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import math
plt.rcParams.update({
    "font.size": 15,
    "font.family": "Arial"
})
bxwidth = 1

df = pd.read_csv("D:/pml/loan_approval_dataset.csv")

df.columns = df.columns.str.strip()

df
```

```
      loan_id  no_of_dependents      education self_employed
income_annum  \
0           1                 2       Graduate            No
9600000
1           2                 0   Not Graduate           Yes
4100000
2           3                 3       Graduate            No
9100000
3           4                 3       Graduate            No
8200000
4           5                 5   Not Graduate           Yes
9800000
...       ...               ...            ...           ...
...
4264     4265                 5       Graduate           Yes
1000000
4265     4266                 0   Not Graduate           Yes
3300000
4266     4267                 2   Not Graduate            No
6500000
4267     4268                 1   Not Graduate            No
4100000
4268     4269                 1       Graduate            No
9200000

      loan_amount  loan_term  cibil_score  residential_assets_value  \
0        29900000         12          778                   2400000
1        12200000          8          417                   2700000
2        29700000         20          506                   7100000
3        30700000          8          467                  18200000
4        24200000         20          382                  12400000
...           ...        ...          ...                       ...
4264      2300000         12          317                   2800000
4265     11300000         20          559                   4200000
```

```
4266     23900000          18           457                  1200000
4267     12800000           8           780                  8200000
4268     29700000          10           607                 17800000

      commercial_assets_value  luxury_assets_value
bank_asset_value  \
0                    17600000             22700000            8000000

1                     2200000              8800000            3300000

2                     4500000             33300000           12800000

3                     3300000             23300000            7900000

4                     8200000             29400000            5000000

...                       ...                  ...                ...

4264                   500000              3300000             800000

4265                  2900000             11000000            1900000

4266                 12400000             18100000            7300000

4267                   700000             14100000            5800000

4268                 11800000             35700000           12000000


     loan_status
0       Approved
1       Rejected
2       Rejected
3       Rejected
4       Rejected
...          ...
4264    Rejected
4265    Approved
4266    Rejected
4267    Approved
4268    Approved

[4269 rows x 13 columns]

print(df.describe())
print(df.info())

           loan_id  no_of_dependents  income_annum   loan_amount
loan_term  \
count  4269.000000       4269.000000  4.269000e+03  4.269000e+03
4269.000000
```

```
mean   2135.000000          2.498712  5.059124e+06  1.513345e+07
10.900445
std    1232.498479          1.695910  2.806840e+06  9.043363e+06
5.709187
min       1.000000          0.000000  2.000000e+05  3.000000e+05
2.000000
25%    1068.000000          1.000000  2.700000e+06  7.700000e+06
6.000000
50%    2135.000000          3.000000  5.100000e+06  1.450000e+07
10.000000
75%    3202.000000          4.000000  7.500000e+06  2.150000e+07
16.000000
max    4269.000000          5.000000  9.900000e+06  3.950000e+07
20.000000

       cibil_score  residential_assets_value  commercial_assets_value
\
count  4269.000000              4.269000e+03             4.269000e+03

mean    599.936051              7.472617e+06             4.973155e+06

std     172.430401              6.503637e+06             4.388966e+06

min     300.000000             -1.000000e+05             0.000000e+00

25%     453.000000              2.200000e+06             1.300000e+06

50%     600.000000              5.600000e+06             3.700000e+06

75%     748.000000              1.130000e+07             7.600000e+06

max     900.000000              2.910000e+07             1.940000e+07


       luxury_assets_value  bank_asset_value
count         4.269000e+03      4.269000e+03
mean          1.512631e+07      4.976692e+06
std           9.103754e+06      3.250185e+06
min           3.000000e+05      0.000000e+00
25%           7.500000e+06      2.300000e+06
50%           1.460000e+07      4.600000e+06
75%           2.170000e+07      7.100000e+06
max           3.920000e+07      1.470000e+07
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4269 entries, 0 to 4268
Data columns (total 13 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   loan_id                   4269 non-null   int64
 1   no_of_dependents          4269 non-null   int64
```

```
 2   education                 4269 non-null   object
 3   self_employed             4269 non-null   object
 4   income_annum              4269 non-null   int64
 5   loan_amount               4269 non-null   int64
 6   loan_term                 4269 non-null   int64
 7   cibil_score               4269 non-null   int64
 8   residential_assets_value  4269 non-null   int64
 9   commercial_assets_value   4269 non-null   int64
 10  luxury_assets_value       4269 non-null   int64
 11  bank_asset_value          4269 non-null   int64
 12  loan_status               4269 non-null   object
dtypes: int64(10), object(3)
memory usage: 433.7+ KB
None
```

```
print(df.isnull().sum())
```

```
loan_id                     0
no_of_dependents            0
education                   0
self_employed               0
income_annum                0
loan_amount                 0
loan_term                   0
cibil_score                 0
residential_assets_value    0
commercial_assets_value     0
luxury_assets_value         0
bank_asset_value            0
loan_status                 0
dtype: int64
```

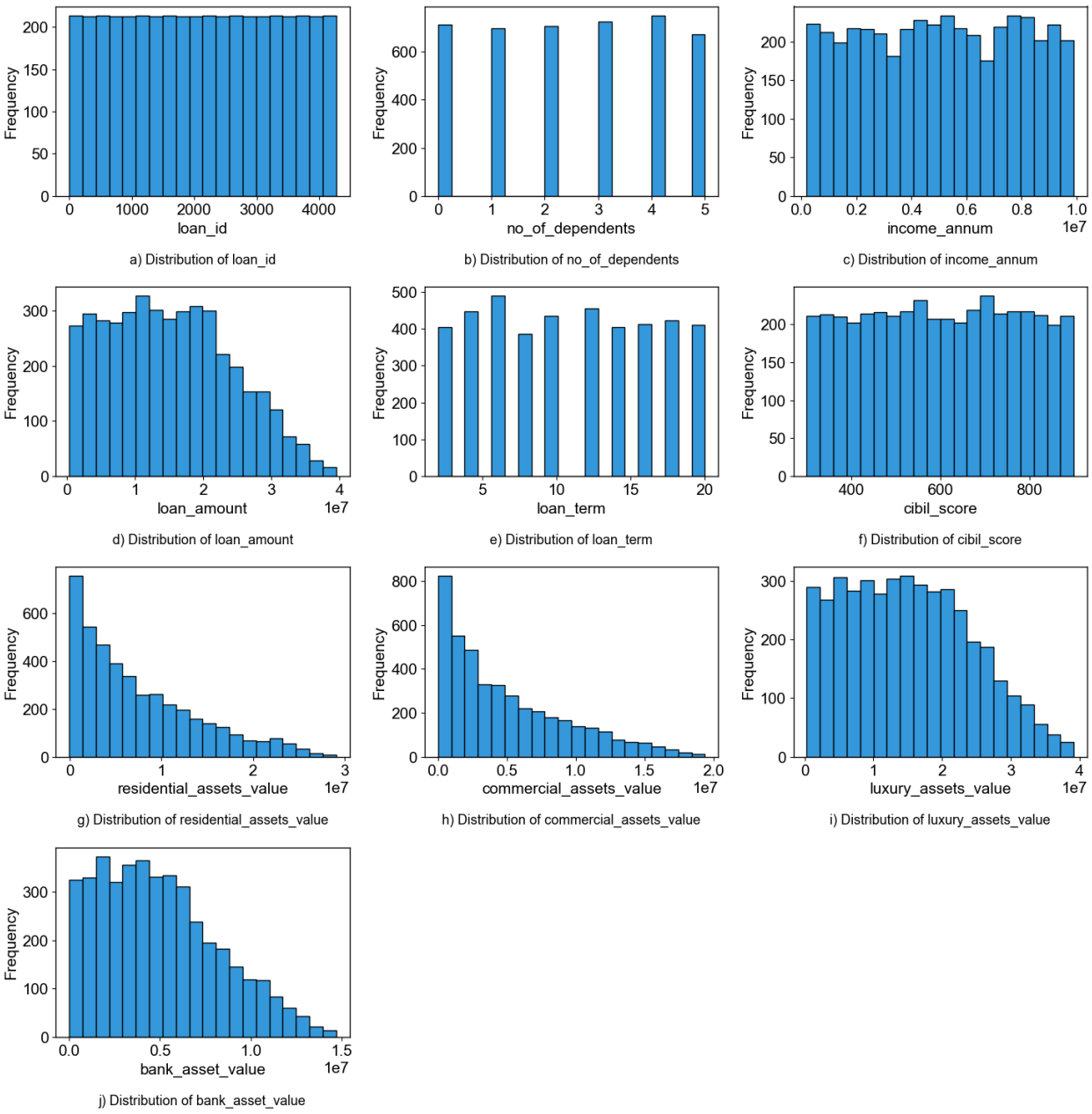
```
cols = df.columns
print(cols)
```

```
Index(['loan_id', 'no_of_dependents', 'education', 'self_employed',
       'income_annum', 'loan_amount', 'loan_term', 'cibil_score',
       'residential_assets_value', 'commercial_assets_value',
       'luxury_assets_value', 'bank_asset_value', 'loan_status'],
      dtype='object')
```

```
numeric_cols = df.select_dtypes(include=["int64", "float64"]).columns
print(numeric_cols)
```

```
Index(['loan_id', 'no_of_dependents', 'income_annum', 'loan_amount',
       'loan_term', 'cibil_score', 'residential_assets_value',
       'commercial_assets_value', 'luxury_assets_value',
'bank_asset_value'],
      dtype='object')
```

```
numeric_df = df.select_dtypes(include=["int64", "float64"])
cols = numeric_df.columns
rows = math.ceil(len(cols) / 3)

fig, axes = plt.subplots(rows, 3, figsize=(15, 4 * rows))
axes = axes.flatten()
subplot_labels = [f"{chr(97+i)})" for i in range(len(cols))]

for i, col in enumerate(cols):
    ax = axes[i]
    ax.hist(numeric_df[col].dropna(), bins=20, edgecolor="black",
color="#3498db")

    ax.set_title("")
    ax.set_xlabel(col)
    ax.set_ylabel("Frequency")

    ax.text(0.5, -0.30, f"{subplot_labels[i]} Distribution of {col}",
            ha="center", va="top", transform=ax.transAxes,
fontsize=13)

    for spine in ax.spines.values():
        spine.set_linewidth(bxwidth)

for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

fig.text(0.5, 0.01, "Histograms showing the distribution of numeric
features in the dataset.",
         ha="center", fontsize=15)

plt.tight_layout(rect=[0, 0.05, 1, 1])
plt.savefig("histogram_numeric_features.eps", format="eps", dpi=600,
bbox_inches="tight")
plt.show()
```



Histograms showing the distribution of numeric features in the dataset.

```
rows = math.ceil(len(cols) / 3)
fig, axes = plt.subplots(rows, 3, figsize=(15, 4 * rows))
axes = axes.flatten()

for i, col in enumerate(cols):
    ax = axes[i]
    sns.boxplot(x=numeric_df[col], ax=ax, color="#9b59b6", width=0.6)

    ax.set_title("")
```

```
    ax.set_xlabel(col)

    ax.text(0.5, -0.30, f"{subplot_labels[i]} Boxplot of {col}",
            ha="center", va="top", transform=ax.transAxes,
fontsize=13)

    for spine in ax.spines.values():
        spine.set_linewidth(bxwidth)

for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

fig.text(0.5, 0.01, "Figure: Boxplots identifying outliers and
quartiles for numeric features.",
         ha="center", fontsize=15)

plt.tight_layout(rect=[0, 0.05, 1, 1])
plt.savefig("boxplot_numeric_features.eps", format="eps", dpi=600,
bbox_inches="tight")
plt.show()
```

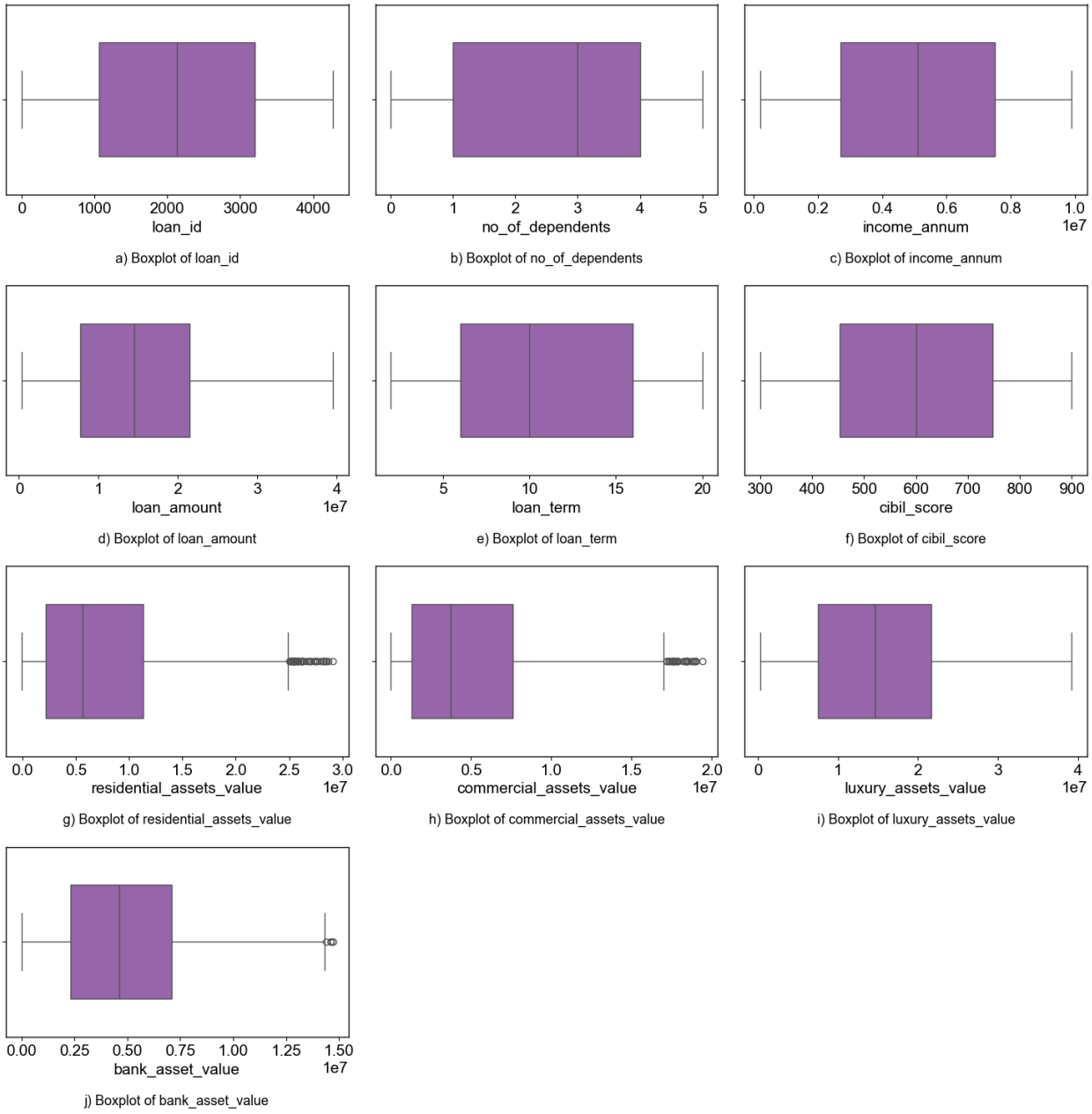


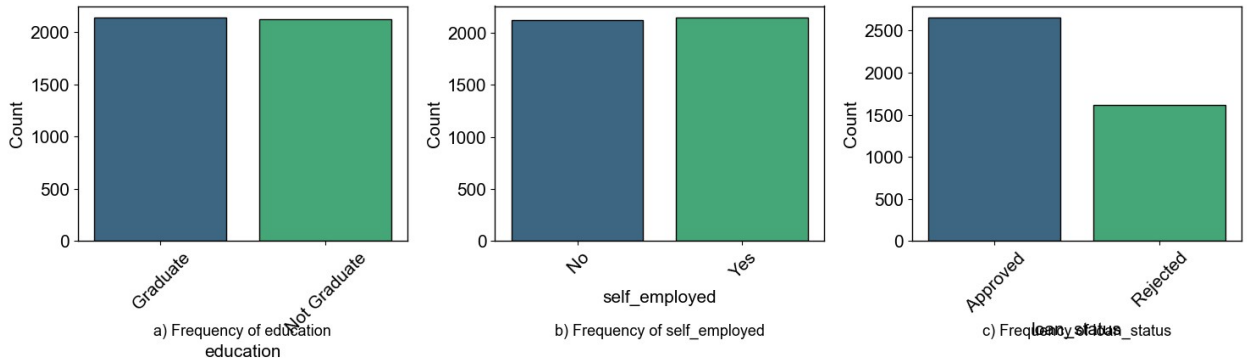
Figure: Boxplots identifying outliers and quartiles for numeric features.

```
categorical_cols = df.select_dtypes(include=["object",
"category"]).columns
rows = math.ceil(len(categorical_cols) / 3)

fig, axes = plt.subplots(rows, 3, figsize=(15, 5 * rows))
axes = axes.flatten()

for i, col in enumerate(categorical_cols):
    ax = axes[i]
```

```
    sns.countplot(x=df[col], ax=ax, edgecolor="black",
palette="viridis")

    ax.set_title("")
    ax.set_xlabel(col)
    ax.set_ylabel("Count")
    plt.setp(ax.get_xticklabels(), rotation=45)

    ax.text(0.5, -0.35, f"{chr(97+i)}) Frequency of {col}",
            ha="center", va="top", transform=ax.transAxes,
fontsize=13)

    for spine in ax.spines.values():
        spine.set_linewidth(bxwidth)

for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

fig.text(0.5, 0.01, "Frequency distribution of categorical features.",
ha="center", fontsize=15)
plt.tight_layout(rect=[0, 0.05, 1, 1])
plt.savefig("countplot_categorical.eps", format="eps", dpi=600,
bbox_inches="tight")
plt.show()
```

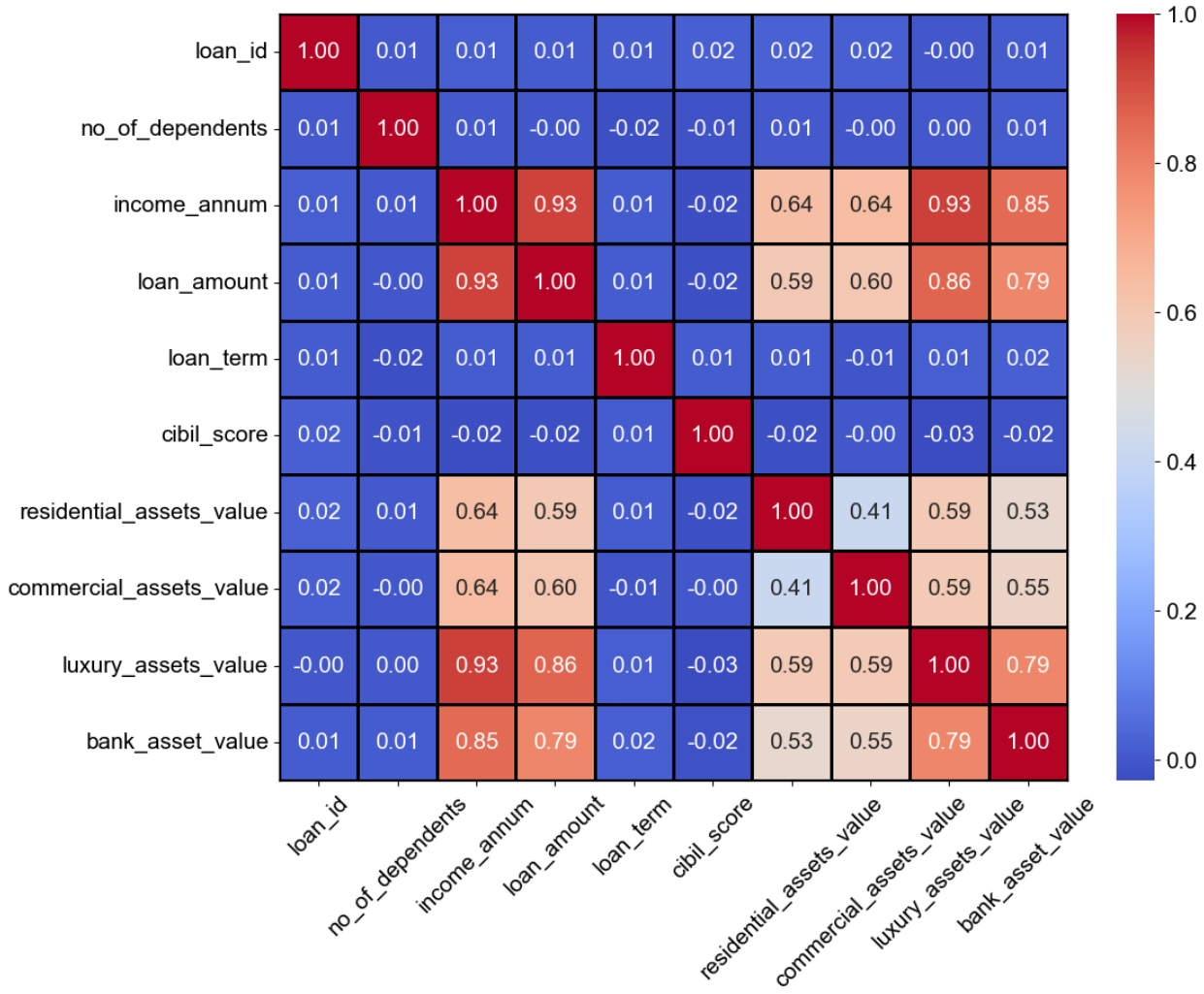
```
C:\Users\KESHA\AppData\Local\Temp\ipykernel_15916\3130164084.py:9:
FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be
removed in v0.14.0. Assign the `x` variable to `hue` and set
`legend=False` for the same effect.

  sns.countplot(x=df[col], ax=ax, edgecolor="black",
palette="viridis")
C:\Users\KESHA\AppData\Local\Temp\ipykernel_15916\3130164084.py:9:
FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be
removed in v0.14.0. Assign the `x` variable to `hue` and set
`legend=False` for the same effect.

  sns.countplot(x=df[col], ax=ax, edgecolor="black",
palette="viridis")
C:\Users\KESHA\AppData\Local\Temp\ipykernel_15916\3130164084.py:9:
FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be
removed in v0.14.0. Assign the `x` variable to `hue` and set
`legend=False` for the same effect.
```

```
  sns.countplot(x=df[col], ax=ax, edgecolor="black",
palette="viridis")
```



Frequency distribution of categorical features.

```
plt.figure(figsize=(12, 10))
ax = sns.heatmap(df[cols].corr(), annot=True, cmap="coolwarm",
fmt=".2f", linewidths=1, linecolor='black')

for _, spine in ax.spines.items():
    spine.set_visible(True)
    spine.set_linewidth(bxwidth)

# plt.title("Correlation Matrix")
plt.xticks(rotation=45)

plt.figtext(0.5, 0.01, "Correlation Heatmap of numeric features.",
ha="center", fontsize=15)

plt.tight_layout(rect=[0, 0.05, 1, 1])
plt.savefig("correlation_matrix.eps", format="eps", dpi=600,
bbox_inches="tight")
plt.show()
```

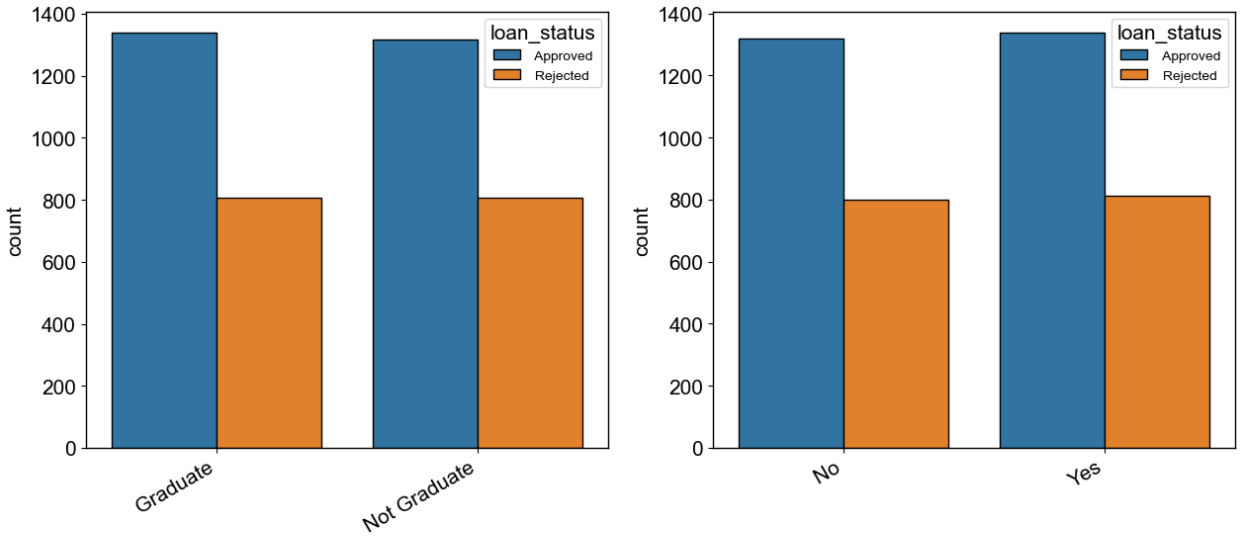


Correlation Heatmap of numeric features.

```
import matplotlib.pyplot as plt
import seaborn as sns
import math


rows = math.ceil(len(cat_features) / 2)
fig, axes = plt.subplots(rows, 2, figsize=(15, 7 * rows))
axes = axes.flatten()

for i, col in enumerate(cat_features):
    ax = axes[i]
    sns.countplot(data=df, x=col, hue=target, ax=ax,
edgecolor="black")

    ax.set_title("")
    ax.set_xlabel("")
```

```
    plt.setp(ax.get_xticklabels(), rotation=30, ha="right")
    ax.legend(title=target, fontsize=10)

    for spine in ax.spines.values():
        spine.set_linewidth(bxwidth)

for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

plt.subplots_adjust(bottom=0.25, hspace=0.6)

features_list = ", ".join(cat_features)
main_heading = f"Bivariate analysis of {features_list} against
{target}."

fig.text(0.5, 0.03, main_heading, ha="center", fontsize=16,
fontweight='bold')

plt.savefig("bivariate_analysis.eps", format="eps", dpi=600,
bbox_inches="tight")
plt.show()
```

```
The PostScript backend does not support transparency; partially
transparent artists will be rendered opaque.
```



Bivariate analysis of education, self_employed against loan_status.

```
numerical_cols = df.select_dtypes(include=['int64','float64'])
categorical_cols = df.select_dtypes(include=['object','category'])
y = df['loan_status']
```

```
from sklearn.preprocessing import MinMaxScaler
scaled = MinMaxScaler().fit_transform(numerical_cols)
scaled
```

```
array([[0.00000000e+00, 4.00000000e-01, 9.69072165e-01, ...,
        9.07216495e-01, 5.75835476e-01, 5.44217687e-01],
       [2.34301781e-04, 0.00000000e+00, 4.02061856e-01, ...,
        1.13402062e-01, 2.18508997e-01, 2.24489796e-01],
       [4.68603561e-04, 6.00000000e-01, 9.17525773e-01, ...,
        2.31958763e-01, 8.48329049e-01, 8.70748299e-01],
       ...,
       [9.99531396e-01, 4.00000000e-01, 6.49484536e-01, ...,
        6.39175258e-01, 4.57583548e-01, 4.96598639e-01],
       [9.99765698e-01, 2.00000000e-01, 4.02061856e-01, ...,
        3.60824742e-02, 3.54755784e-01, 3.94557823e-01],
       [1.00000000e+00, 2.00000000e-01, 9.27835052e-01, ...,
        6.08247423e-01, 9.10025707e-01, 8.16326531e-01]])
```