Loan Approval Prediction - Exploratory Data Analysis

Step 1: Import Necessary Libraries

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import LabelEncoder
import category_encoders as ce
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from xgboost import XGBClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import roc_curve, auc
from sklearn.metrics import classification_report, accuracy_score, precision_score, recall_score, f1_sco
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import cross_val_score
```

Step 2: Import Loan Dataset

In [2]:
```
df = pd.read_csv(r'prosperLoanDataCleaned.csv')
df.head()
```

Out[2]:

	Term	MonthsOfEmployementExperience	IsHomeowner	OpenCreditLines	TotalInquiries	AvailableBankcardCredit	DebtTo
0	36	2.000000	1	4.000000	3	1500.000000	
1	36	96.071582	0	9.260164	1	11210.225447	
2	36	19.000000	0	2.000000	5	2580.000000	
3	36	1.000000	0	7.000000	4	3626.000000	
4	36	121.000000	1	9.000000	1	178.000000	

In [3]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 55106 entries, 0 to 55105
Data columns (total 17 columns):
 #   Column                        Non-Null Count  Dtype  
---  ------                        --------------  -----  
 0   Term                          55106 non-null  int64  
 1   MonthsOfEmployementExperience 55106 non-null  float64
 2   IsHomeowner                   55106 non-null  int64  
 3   OpenCreditLines               55106 non-null  float64
 4   TotalInquiries                55106 non-null  int64  
 5   AvailableBankcardCredit       55106 non-null  float64
 6   DebtToIncomeRatio             55106 non-null  float64
 7   IncomeVerifiable              55106 non-null  int64  
 8   StatedMonthlyIncome           55106 non-null  float64
 9   LoanNumber                    55106 non-null  int64  
 10  LoanAmount                    55106 non-null  int64  
 11  MonthlyInstallment            55106 non-null  float64
 12  InterestRate                  55106 non-null  float64
 13  IsEmployed                    55106 non-null  int64  
 14  AverageCreditScore            55106 non-null  int64  
 15  AnyDelinquencies              55106 non-null  int64  
 16  GoodLoan                      55106 non-null  int64  
dtypes: float64(7), int64(10)
memory usage: 7.1 MB
```

Step 3: Data Pre-processing

In [4]:
```
df = df.drop(['LoanNumber'], axis=1)
categorical = ['Term','IsHomeowner','IsEmployed','AnyDelinquencies','IncomeVerifiable']
numerical = ['LoanAmount','InterestRate','MonthlyInstallment','MonthsOfEmployementExperience','AverageCr
             ,'OpenCreditLines','TotalInquiries','AvailableBankcardCredit','DebtToIncomeRatio','StatedMo
```

In [5]:
```
df[numerical].skew()
```

Out[5]:
```
LoanAmount                        1.646822
InterestRate                      0.115913
MonthlyInstallment                1.953124
MonthsOfEmployementExperience     1.834853
AverageCreditScore               -1.351894
OpenCreditLines                   1.131160
TotalInquiries                    6.574083
AvailableBankcardCredit           7.593415
DebtToIncomeRatio                12.416432
StatedMonthlyIncome              44.534218
dtype: float64
```

In [6]:
```
skewed_features = ['TotalInquiries', 'AvailableBankcardCredit', 'DebtToIncomeRatio', 'StatedMonthlyIncom

for feature in skewed_features:
    df[feature] = np.log1p(df[feature])
```

In [7]:
```
Q1 = df[numerical].quantile(0.25)
Q3 = df[numerical].quantile(0.75)
IQR = Q3 - Q1

# Calculate median
median = df[numerical].median()

# Identify outliers
outliers_lower = (df[numerical] < (Q1 - 1.5 * IQR))
outliers_upper = (df[numerical] > (Q3 + 1.5 * IQR))

# Replace outliers with median
df[numerical] = df[numerical].mask(outliers_lower, median, axis=1)
df[numerical] = df[numerical].mask(outliers_upper, median, axis=1)
```

In [8]:
```
df[numerical].skew()
```

Out[8]:
```
LoanAmount                      1.106712
InterestRate                    0.115913
MonthlyInstallment              0.980513
MonthsOfEmployementExperience   0.856838
AverageCreditScore             -0.158725
OpenCreditLines                 0.453486
TotalInquiries                 -0.074052
AvailableBankcardCredit        -0.734401
DebtToIncomeRatio               0.325207
StatedMonthlyIncome            -0.044581
dtype: float64
```

Step 4: Performing Exploratory Data Analysis

In [9]:
```
df.describe()
```

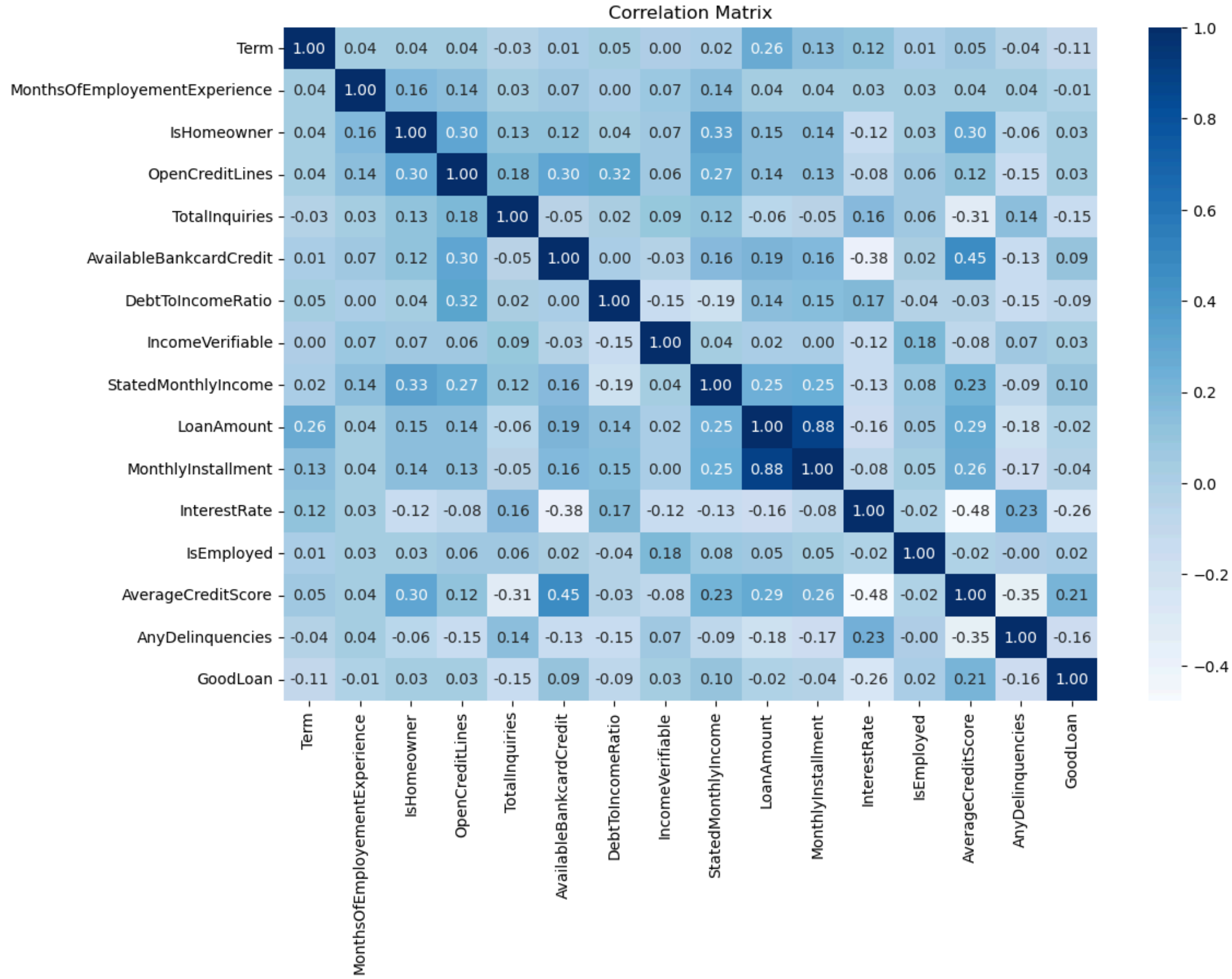
Out[9]:

	Term	MonthsOfEmployementExperience	IsHomeowner	OpenCreditLines	TotalInquiries	AvailableBankcardCre
count	55106.000000	55106.000000	55106.000000	55106.000000	55106.000000	55106.000(
mean	37.248213	66.350954	0.479240	8.093467	1.729962	8.1995
std	7.800320	50.984545	0.499573	4.059213	0.824806	1.788(
min	12.000000	0.000000	0.000000	0.000000	0.000000	2.3025
25%	36.000000	24.000000	0.000000	5.000000	1.098612	7.180(
50%	36.000000	63.000000	0.000000	8.000000	1.791759	8.3824
75%	36.000000	96.071582	1.000000	10.000000	2.302585	9.324(
max	60.000000	224.000000	1.000000	20.000000	4.094345	13.3789

In [10]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 55106 entries, 0 to 55105
Data columns (total 16 columns):
 #   Column                         Non-Null Count  Dtype  
---  ------                         --------------  -----  
 0   Term                           55106 non-null  int64  
 1   MonthsOfEmployementExperience  55106 non-null  float64
 2   IsHomeowner                    55106 non-null  int64  
 3   OpenCreditLines                55106 non-null  float64
 4   TotalInquiries                 55106 non-null  float64
 5   AvailableBankcardCredit        55106 non-null  float64
 6   DebtToIncomeRatio              55106 non-null  float64
 7   IncomeVerifiable               55106 non-null  int64  
 8   StatedMonthlyIncome            55106 non-null  float64
 9   LoanAmount                     55106 non-null  int64  
 10  MonthlyInstallment             55106 non-null  float64
 11  InterestRate                   55106 non-null  float64
 12  IsEmployed                     55106 non-null  int64  
 13  AverageCreditScore             55106 non-null  int64  
 14  AnyDelinquencies               55106 non-null  int64  
 15  GoodLoan                       55106 non-null  int64  
dtypes: float64(8), int64(8)
memory usage: 6.7 MB
```

In [11]:
```
corr_matrix = df.corr()
plt.figure(figsize=(12, 8))
sns.heatmap(corr_matrix, annot=True, cmap='Blues', fmt=".2f")
plt.title('Correlation Matrix')
plt.show()
```




```
The target variable is GoodLoan, which is a binary classification of whether a loan is
good or not. Based on the correlation matrix in the image, here are some of the
variables that are related to GoodLoan:
```

- Interest rate: This has a negative correlation of -0.25 with GoodLoan. Low-interest rates are associated with an increased likelihood of a good loan.
- AverageCreditScore: This has a positive correlation of 0.22 with GoodLoan. This means a higher credit score is associated with an increased likelihood of a good loan.
- AnyDelinquencies: This has a weak negative correlation of -0.13 with GoodLoan. Fewer delinquencies are associated with an increased likelihood of a good loan.
- Term: This has a weak negative correlation of -0.11 with GoodLoan. This means a lower, shorter term is associated with an increased likelihood of a good loan.
- DebtToIncomeRatio: This has a weak negative correlation of -0.10 with GoodLoan. This means a lower debt-to-income ratio is associated with an increased likelihood of a good loan.
- StatedMonthlyIncome: This has a weak positive correlation of 0.10 with GoodLoan. This means that a higher stated monthly income is associated with an increased likelihood of a good loan.
- AvailableBankcardCredit: This has a weak positive correlation of 0.10 with GoodLoan. This means a higher available bankcard credit limit is associated with an increased likelihood of a good loan.

Other variables related to GoodLoan include LoanAmount, InterestRate, MonthlyInstallment, IsEmployed, MonthsOfEmployementExperience, and IsHomeowner. However, the strength of their correlations is lower than those mentioned above.

In [12]:
```
df = df.sample(frac=1, random_state=42)
df
```

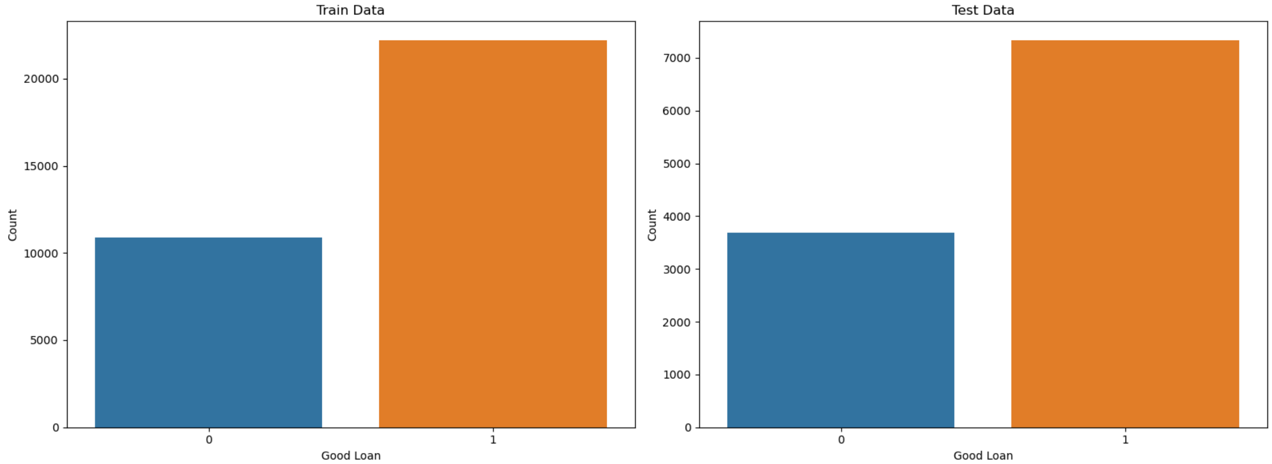
Out[12]:

	Term	MonthsOfEmployementExperience	IsHomeowner	OpenCreditLines	TotalInquiries	AvailableBankcardCredit	De
2098	36	60.000000	1	8.000000	1.791759	5.894403	
43905	36	9.000000	0	5.000000	2.302585	8.382404	
46310	36	96.071582	0	9.260164	0.693147	9.324671	
53388	36	63.000000	1	6.000000	1.791759	7.556951	
32128	36	11.000000	1	9.000000	2.197225	4.934474	
...	...	...	...	...	...	...	
44732	36	49.000000	1	4.000000	1.791759	8.860357	
54343	36	22.000000	0	2.000000	1.945910	8.382404	
38158	36	87.000000	0	6.000000	2.639057	6.198479	
860	36	18.000000	1	8.000000	2.708050	8.889170	
15795	36	16.000000	0	6.000000	1.098612	10.297420	

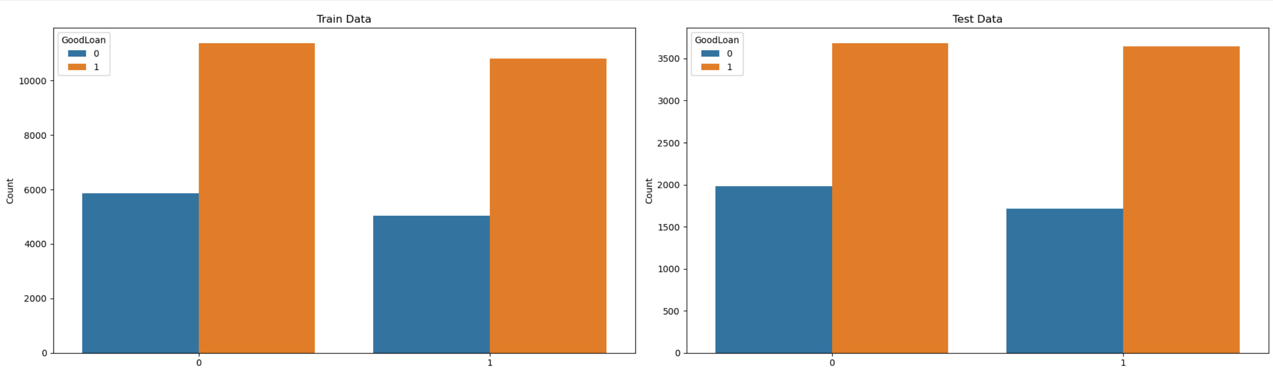
55106 rows × 16 columns

In [13]:
```
train,test = train_test_split(df, test_size=0.2, random_state=42)
train,val = train_test_split(train, test_size=0.25, random_state=42)
```

In [14]:
```
fig, axes = plt.subplots(1, 2, figsize=(16, 6))  # 1 row, 2 columns

# Plot the first count plot on the left subplot
sns.countplot(x='GoodLoan', data=train, ax=axes[0])
axes[0].set_title('Train Data')
axes[0].set_xlabel('Good Loan')
axes[0].set_ylabel('Count')

# Plot the second count plot on the right subplot
sns.countplot(x='GoodLoan', data=test, ax=axes[1])
axes[1].set_title('Test Data')
axes[1].set_xlabel('Good Loan')
axes[1].set_ylabel('Count')

# Adjust layout to prevent overlap
plt.tight_layout()

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

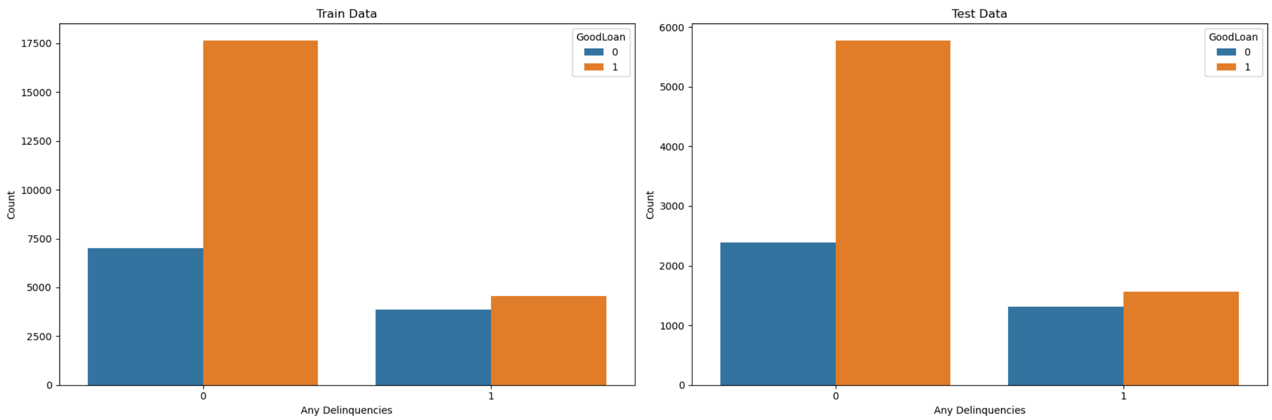


In [15]:
```
fig, axes = plt.subplots(1, 2, figsize=(20, 6))  # 1 row, 2 columns

# Plot on the first subplot
sns.countplot(x='IsHomeowner', hue='GoodLoan', data=train, ax=axes[0])
axes[0].set_title('Train Data')
axes[0].set_xlabel('Is Homeowner')
axes[0].set_ylabel('Count')

# Plot on the second subplot
sns.countplot(x='IsHomeowner', hue='GoodLoan', data=test, ax=axes[1])
axes[1].set_title('Test Data')
axes[1].set_xlabel('Is Homeowner')
axes[1].set_ylabel('Count')

# Adjust layout to prevent overlap
plt.tight_layout()

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

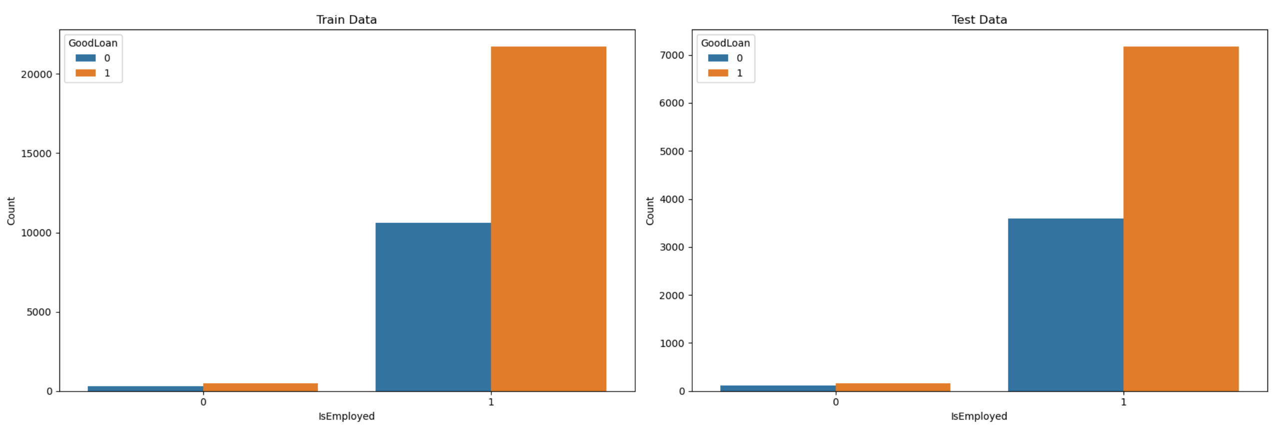


In [16]:
```
fig, axes = plt.subplots(1, 2, figsize=(18, 6))

# Plot the first count plot on the first subplot
sns.countplot(x='AnyDelinquencies', hue='GoodLoan', data=train, ax=axes[0])
axes[0].set_title('Train Data')
axes[0].set_xlabel('Any Delinquencies')
axes[0].set_ylabel('Count')

# Plot the second count plot on the second subplot
sns.countplot(x='AnyDelinquencies', hue='GoodLoan', data=test, ax=axes[1])
axes[1].set_title('Test Data')
axes[1].set_xlabel('Any Delinquencies')
axes[1].set_ylabel('Count')

# Adjust layout to prevent overlap
plt.tight_layout()
```

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

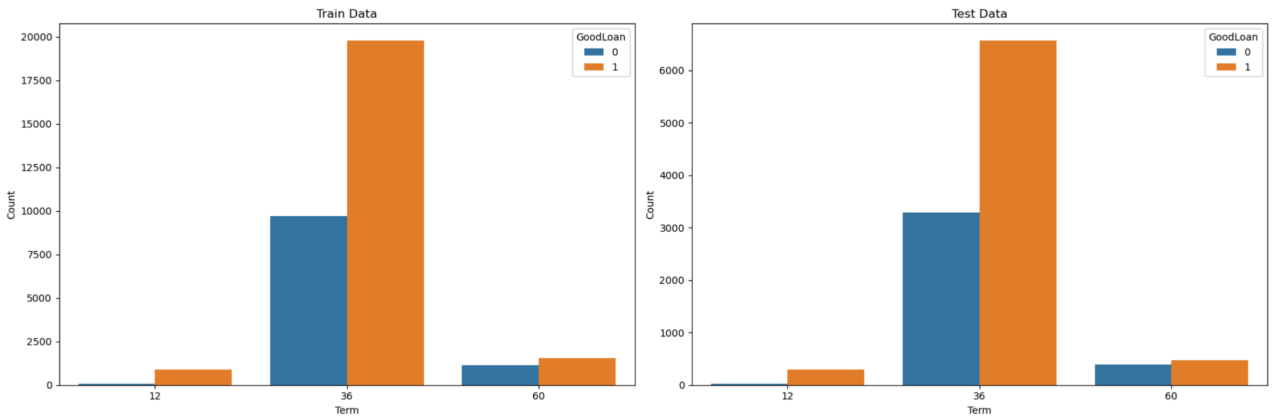


In [17]:
```
fig, axes = plt.subplots(1, 2, figsize=(18, 6))

# Plot the first count plot on the first subplot
sns.countplot(x='IsEmployed', hue='GoodLoan', data=train, ax=axes[0])
axes[0].set_title('Train Data')
axes[0].set_xlabel('IsEmployed')
axes[0].set_ylabel('Count')

# Plot the second count plot on the second subplot
sns.countplot(x='IsEmployed', hue='GoodLoan', data=test, ax=axes[1])
axes[1].set_title('Test Data')
axes[1].set_xlabel('IsEmployed')
axes[1].set_ylabel('Count')

# Adjust layout to prevent overlap
plt.tight_layout()

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

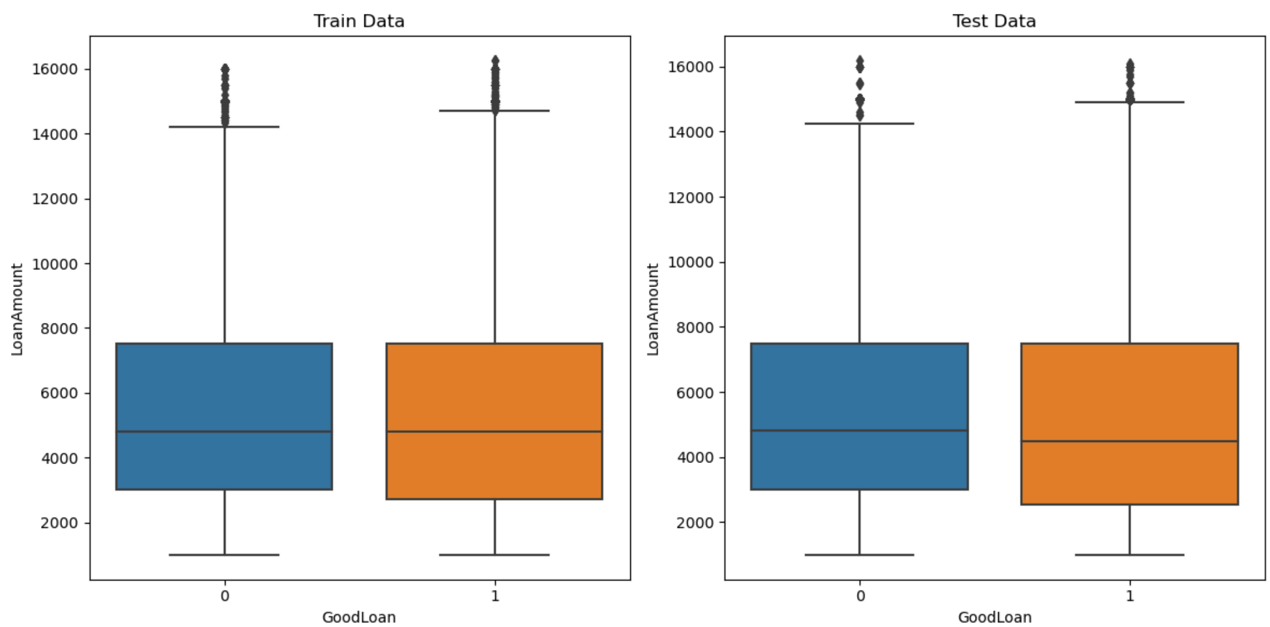


In [18]:
```
fig, axes = plt.subplots(1, 2, figsize=(18, 6))

# Plot the first count plot on the first subplot
sns.countplot(x='Term', hue='GoodLoan', data=train, ax=axes[0])
axes[0].set_title('Train Data')
axes[0].set_xlabel('Term')
axes[0].set_ylabel('Count')

# Plot the second count plot on the second subplot
sns.countplot(x='Term', hue='GoodLoan', data=test, ax=axes[1])
axes[1].set_title('Test Data')
axes[1].set_xlabel('Term')
axes[1].set_ylabel('Count')

# Adjust layout to prevent overlap
```

```
plt.tight_layout()

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

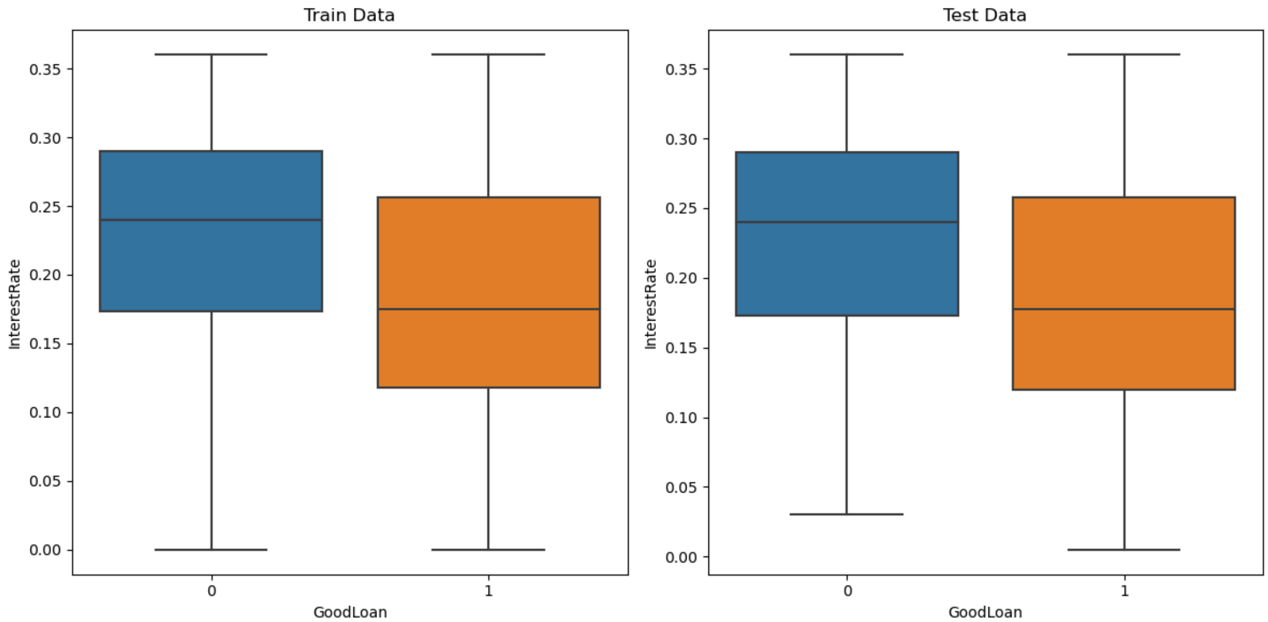


In [19]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='LoanAmount', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='LoanAmount', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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



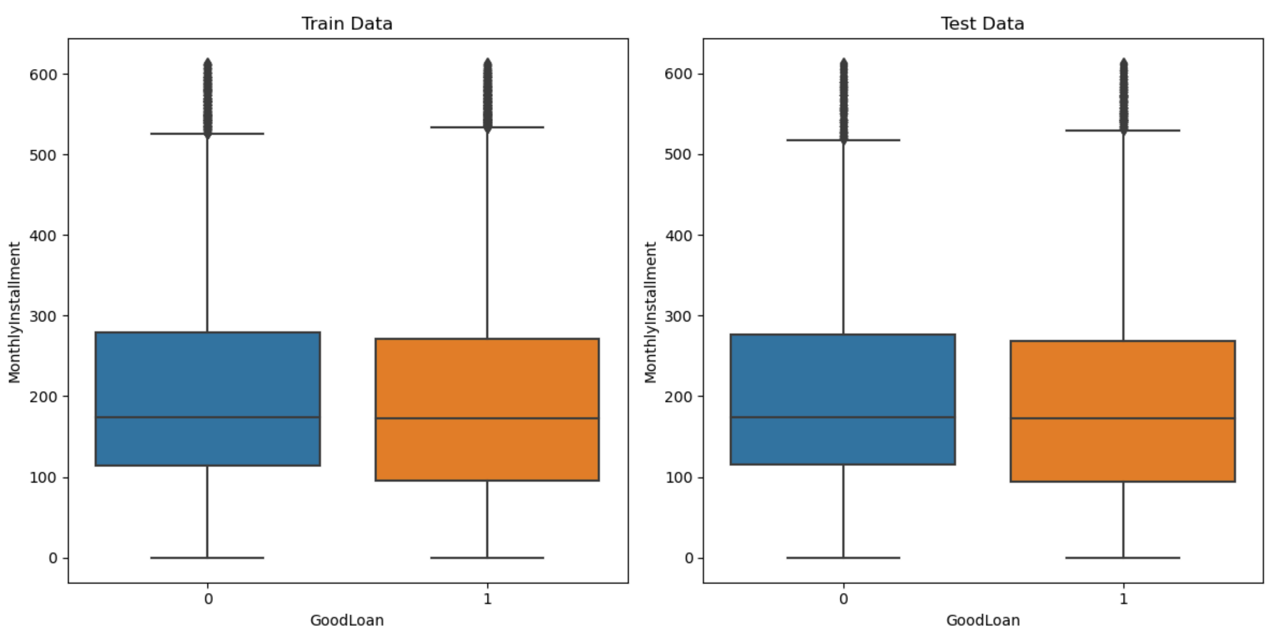
In [20]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='InterestRate', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='InterestRate', data=test, ax=axes[1])
axes[1].set_title('Test Data')
```

```
# Adjust layout to prevent overlap
plt.tight_layout()

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



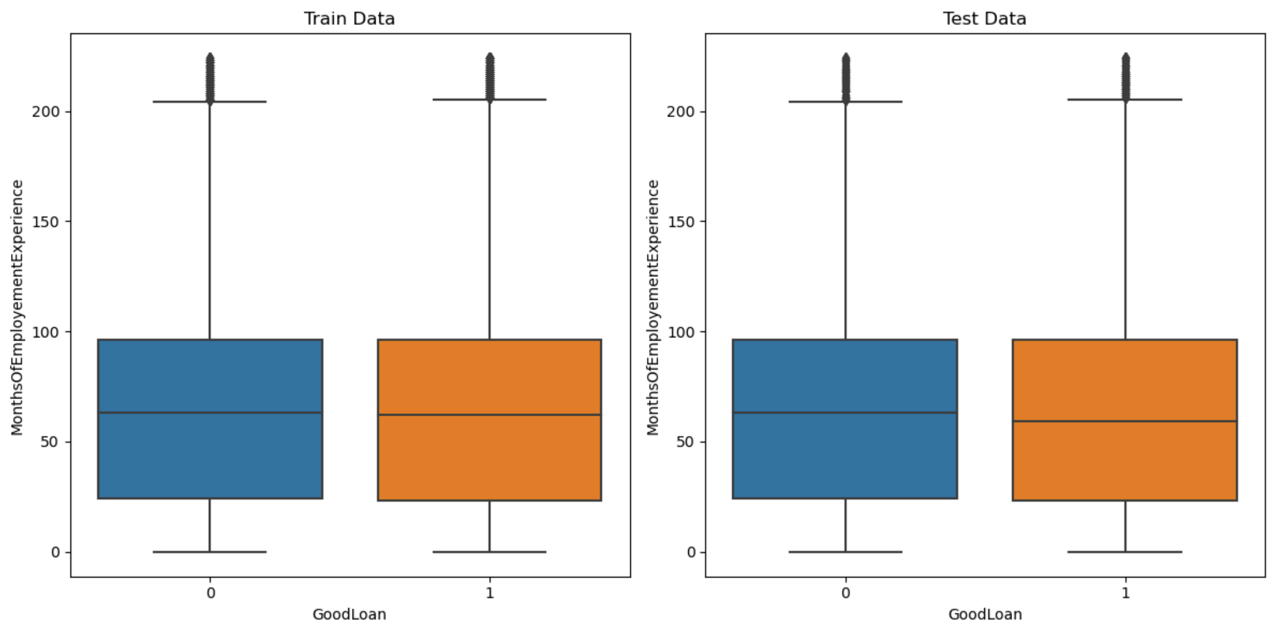
In [21]:

```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='MonthlyInstallment', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='MonthlyInstallment', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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



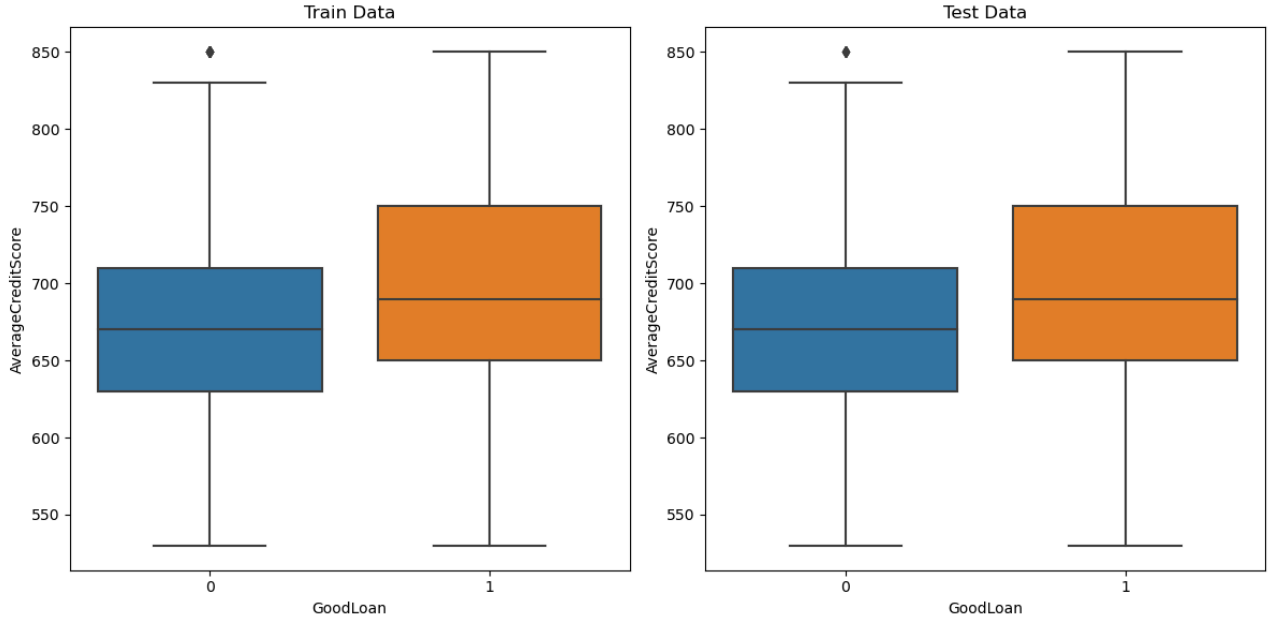
In [22]:

```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='MonthsOfEmployementExperience', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='MonthsOfEmployementExperience', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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

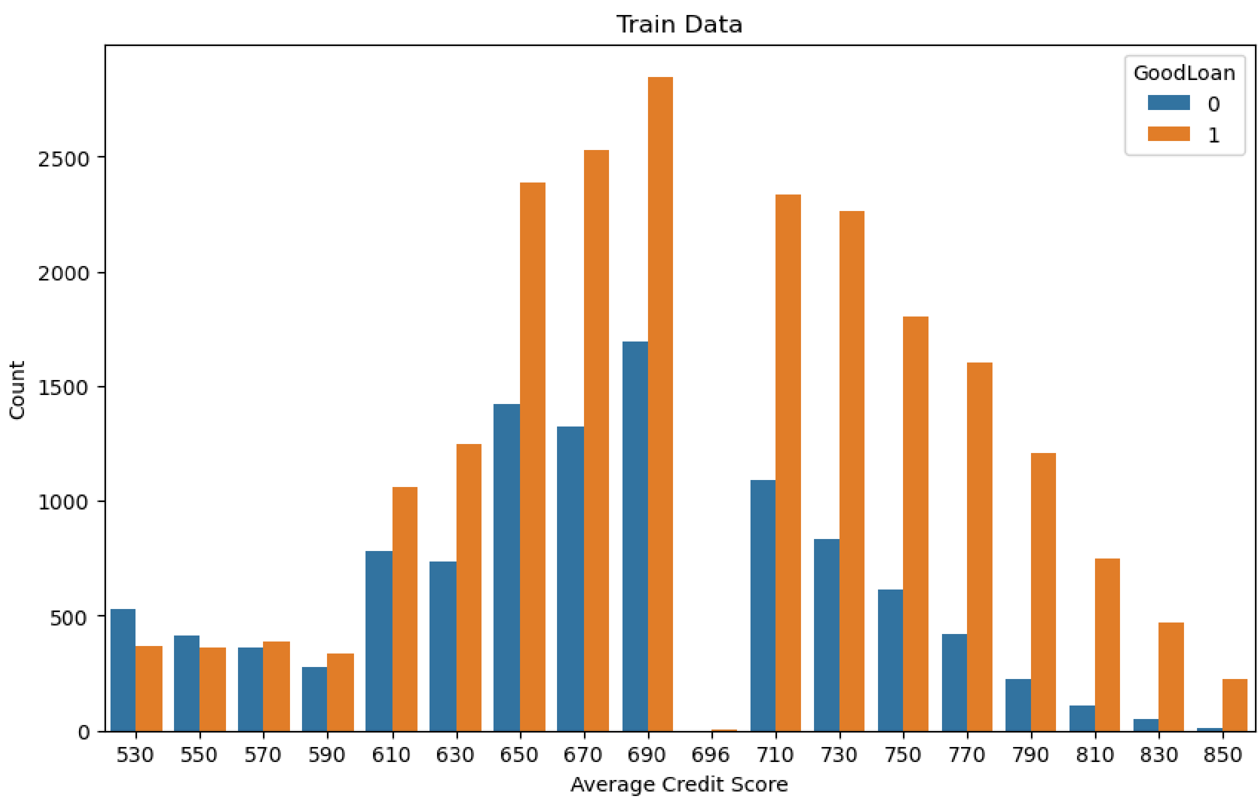


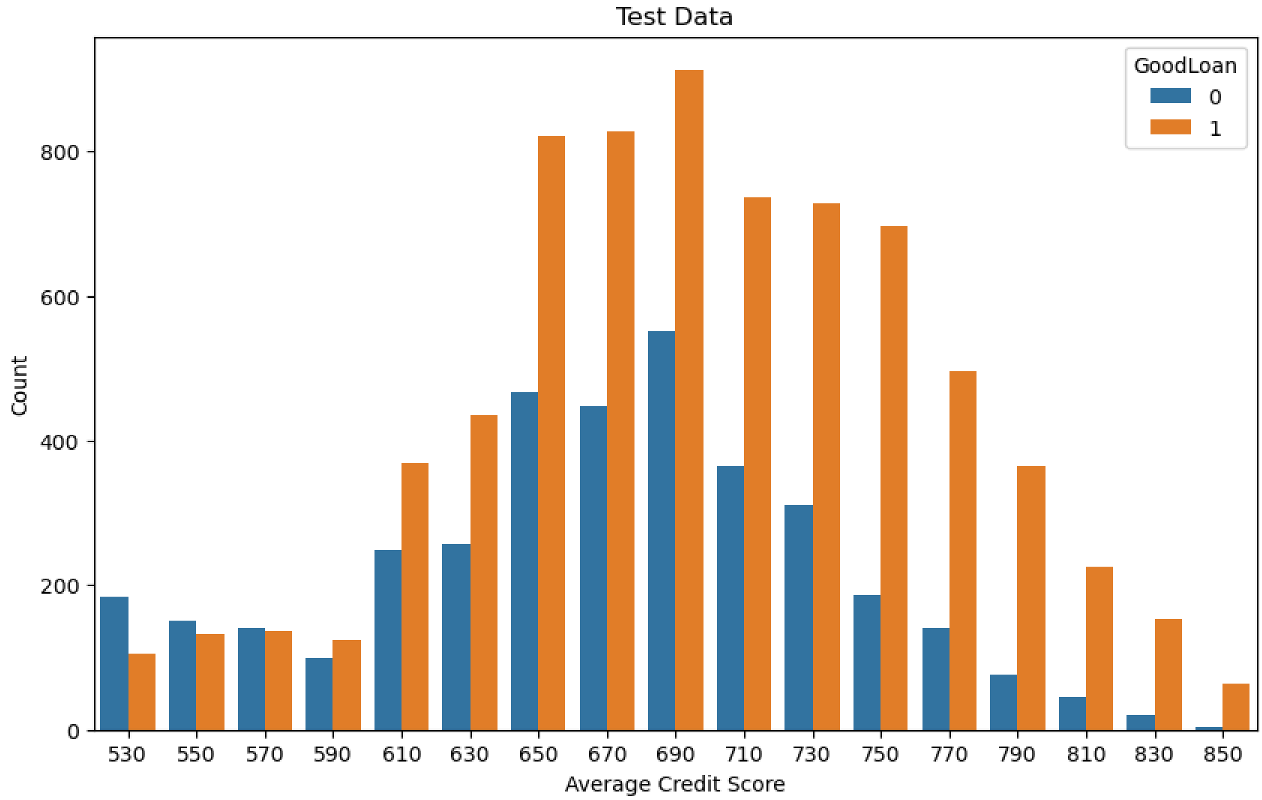
In [23]:

```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='AverageCreditScore', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='AverageCreditScore', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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

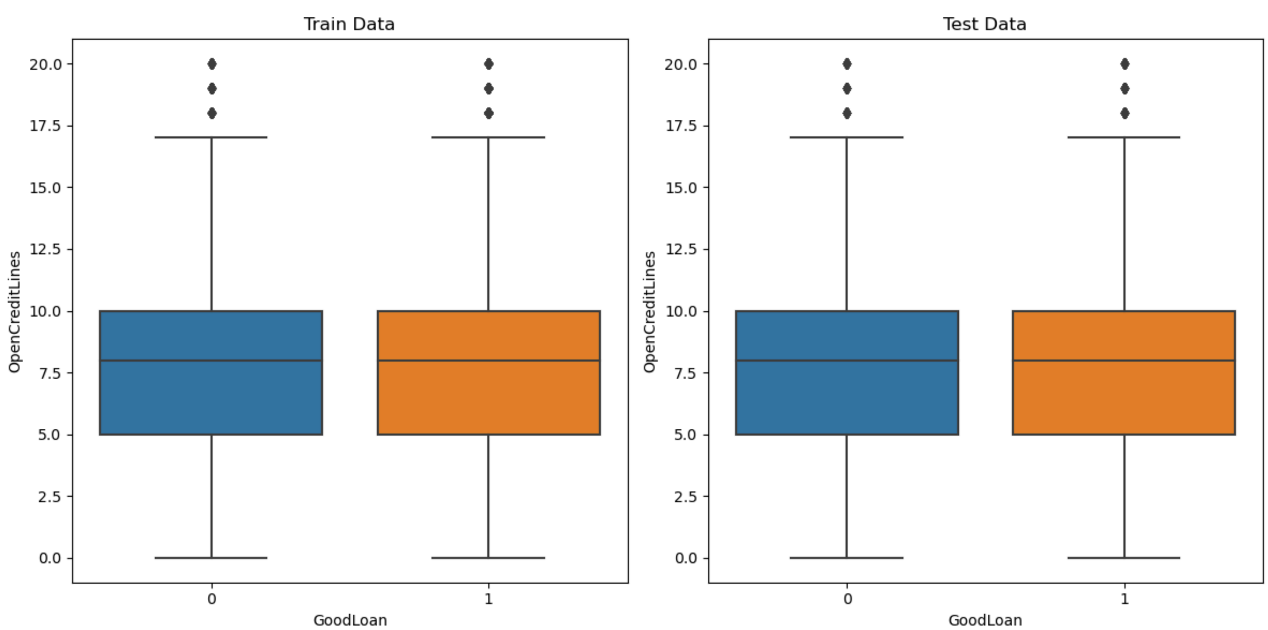


In [24]:
```
plt.figure(figsize=(10, 6))
sns.countplot(x='AverageCreditScore', hue='GoodLoan', data=train)
plt.title('Train Data')
plt.xlabel('Average Credit Score')
plt.ylabel('Count')
plt.show()

plt.figure(figsize=(10, 6))
sns.countplot(x='AverageCreditScore', hue='GoodLoan', data=test)
plt.title('Test Data')
plt.xlabel('Average Credit Score')
plt.ylabel('Count')
plt.show()
```

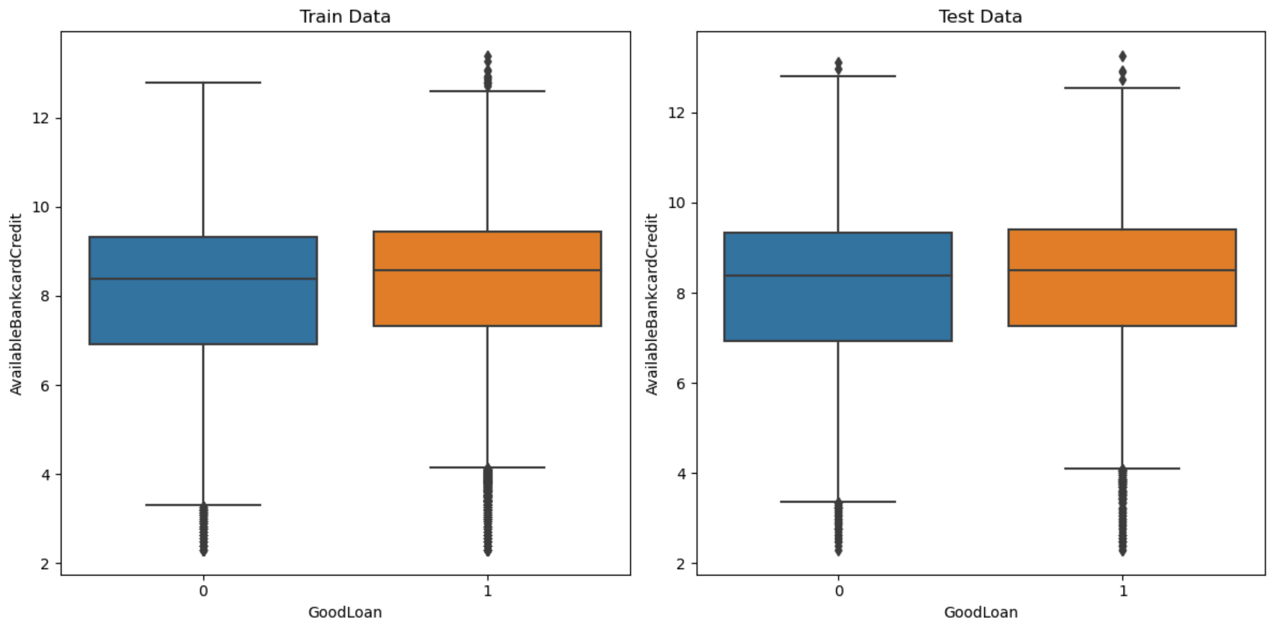




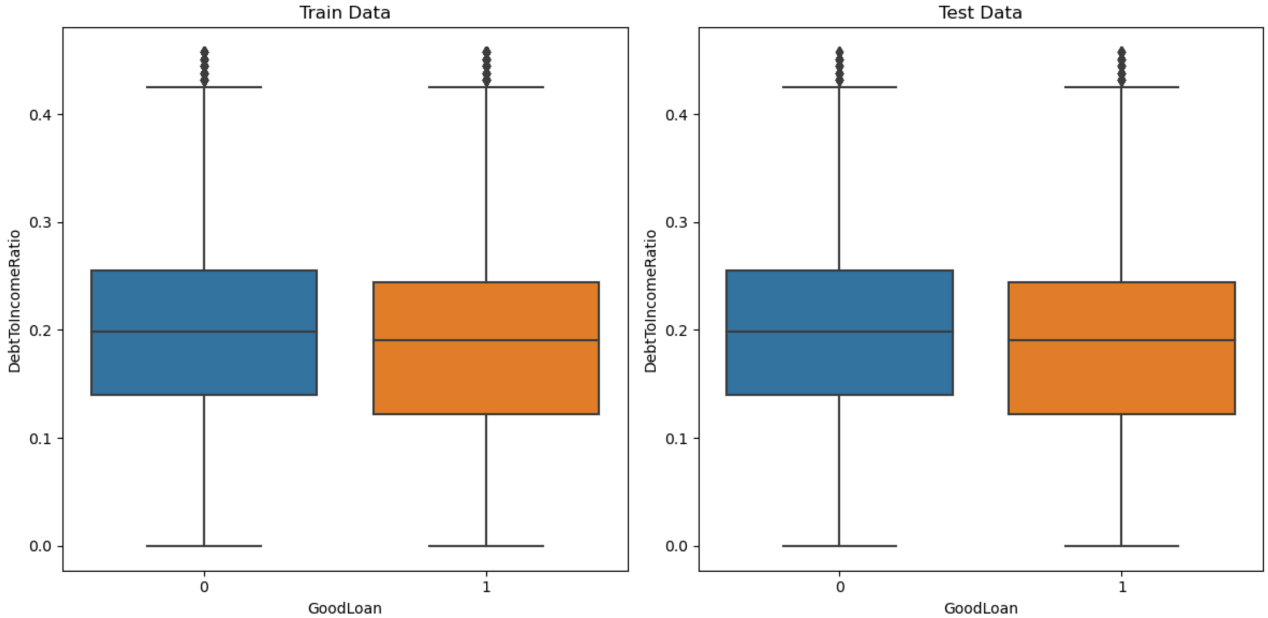
In [25]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='OpenCreditLines', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='OpenCreditLines', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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



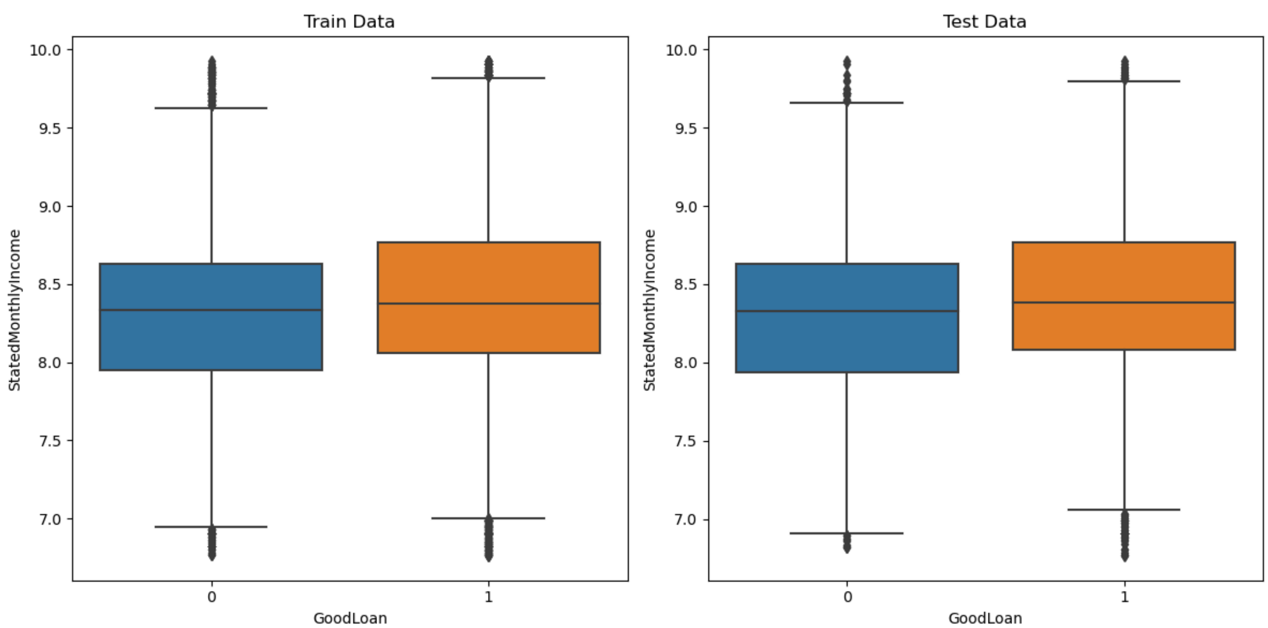
In [26]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='AvailableBankcardCredit', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='AvailableBankcardCredit', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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



In [27]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='DebtToIncomeRatio', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='DebtToIncomeRatio', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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

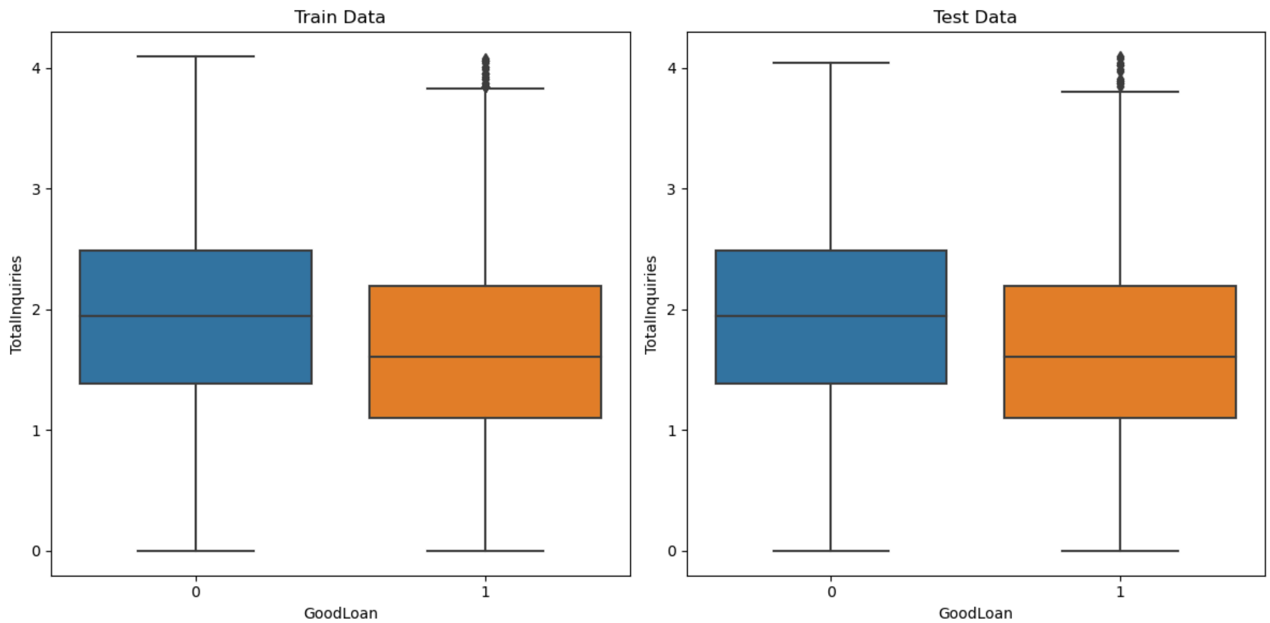


In [28]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='StatedMonthlyIncome', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
sns.boxplot(x='GoodLoan', y='StatedMonthlyIncome', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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



In [29]:
```
fig, axes = plt.subplots(1, 2, figsize=(12, 6))  # 1 row, 2 columns

# Plot the first seaborn boxplot on the first subplot
sns.boxplot(x='GoodLoan', y='TotalInquiries', data=train, ax=axes[0])
axes[0].set_title('Train Data')

# Plot the second seaborn boxplot on the second subplot
```

```
sns.boxplot(x='GoodLoan', y='TotalInquiries', data=test, ax=axes[1])
axes[1].set_title('Test Data')

# Adjust layout to prevent overlap
plt.tight_layout()

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



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