In [1]:

```
import warnings
warnings.filterwarnings('ignore')
```

In [2]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

from sklearn.datasets import fetch_openml

from sklearn.model_selection import train_test_split,cross_val_score,GridSearchCV,KFold
from sklearn.preprocessing import OneHotEncoder,StandardScaler
from sklearn.compose import make_column_transformer,ColumnTransformer
from sklearn.pipeline import make_pipeline, Pipeline

from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import LinearSVC
```

In [3]:

```
data = fetch_openml("credit-g")
```

In [4]:

```
X = data["data"]
y = data["target"]
features = data["feature_names"]
```

In [5]:

```
categorical_columns = list(data["categories"].keys())
continuous_columns = list(set(features) - set(categorical_columns))
category_values = list(data["categories"].values())
```

In [6]:

```
categorical_columns_index = [i for i,v in enumerate(features) if(v in categorical_colum
ns)]
continuous_columns_index = [i for i,v in enumerate(features) if(v in continuous_columns
)]
```

In [7]:

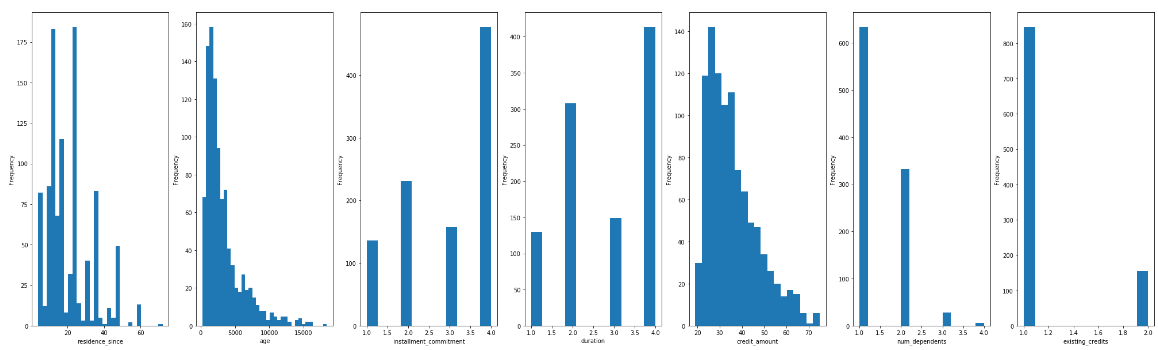
```
print("- Following is the list of continuous features:")
print(continuous_columns)
print()
print("- Following is the list of categorical features:")
print(categorical_columns)
```

```
- Following is the list of continuous features:
['residence_since', 'age', 'installment_commitment', 'duration', 'credit_a
mount', 'num_dependents', 'existing_credits']

- Following is the list of categorical features:
['checking_status', 'credit_history', 'purpose', 'savings_status', 'employ
ment', 'personal_status', 'other_parties', 'property_magnitude', 'other_pa
yment_plans', 'housing', 'job', 'own_telephone', 'foreign_worker']
```

In [8]:

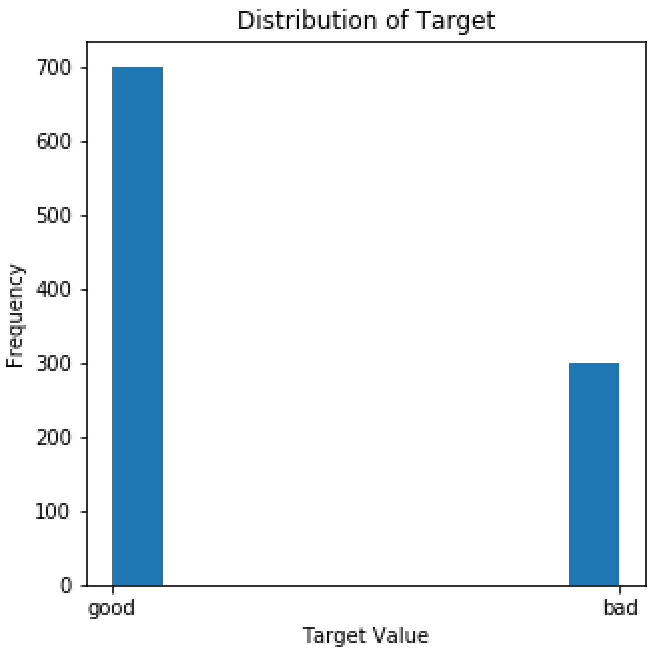
```
fig, axes = plt.subplots(1, len(continuous_columns_index) , figsize=(35, 10))

for i in range(len(continuous_columns_index)):
    axes[i].hist(X[:,continuous_columns_index[i]],bins = "auto")
    axes[i].set_xlabel(continuous_columns[i])
    axes[i].set_ylabel("Frequency")

fig.suptitle("Distribution of Continuous Features", fontsize=32)
plt.show()
```

Distribution of Continuous Features



In [9]:

```
fig, axes = plt.subplots(figsize=(5, 5))
axes.hist(y)
axes.set_xlabel("Target Value")
axes.set_ylabel("Frequency")
axes.set_title("Distribution of Target")

plt.show()
```



In [10]:

```
X_df = pd.DataFrame(X, columns = features)
y_df = pd.DataFrame(y, columns = ["target"])
```

In [11]:

```
X_train_val, X_test, y_train_val, y_test = train_test_split(X_df, y_df, test_size=0.20,
random_state=42)
```

In [12]:

```
X_train, X_val, y_train, y_val = train_test_split(X_train_val, y_train_val, test_size=
0.20, random_state=42)
```

In [13]:

```
# categorical_features has been removed from sklear>= 0.20
# Older documentation (0.20) for OneHotEncoder shows that 'categorical_features' will b
e removed in 0.22
# ohe = OneHotEncoder(categorical_features=categorical_columns_index, handle_unknown="i
gnore")
# ohe = ohe.fit(X_train)
# X_train_preprocessed = ohe.transform(X_train)
# X_val_preprocessed = ohe.transform(X_val)

# For higher versions run the next cell
```

In [14]:

```
ohe = OneHotEncoder(handle_unknown="ignore")
ct = ColumnTransformer([('my_ohe', OneHotEncoder(), categorical_columns_index)], remain
der='passthrough')
ct = ct.fit(X_train)
X_train_preprocessed = ct.transform(X_train)
X_val_preprocessed = ct.transform(X_val)
```

In [15]:

```
log_reg = LogisticRegression(random_state = 42)
```

In [16]:

```
log_reg.fit(X_train_preprocessed,y_train)
```

Out[16]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=Tru
e,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=42, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [17]:

```
score = log_reg.score(X_val_preprocessed,y_val)
print("The validation score for Logistic Regression is: " + str(score))
```

```
The validation score for Logistic Regression is: 0.7375
```

In [18]:

```
model_names = ["LogisticRegression", "LinearSVC", "KNeighboursClassifier"]
model_list = [ LogisticRegression(), LinearSVC(), KNeighborsClassifier()]
```

In [19]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),remainder="passthrough")

scores = []
for i in range(len(model_list)):
    score = cross_val_score(make_pipeline(preprocess, model_list[i]), X_train_val, y_tr
ain_val, cv=5)
    scores.append(np.mean(score))

for i in range(len(model_names)):
    print("The validation score for " + model_names[i] +" is " + str(scores[i]))
```

```
The validation score for LogisticRegression is 0.7387499999999999
The validation score for LinearSVC is 0.59
The validation score for KNeighboursClassifier is 0.6537499999999999
```

In [20]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

scores = []
for i in range(len(model_list)):
    score = cross_val_score(make_pipeline(preprocess, model_list[i]), X_train_val, y_tr
ain_val, cv=5)
    scores.append(np.mean(score))

for i in range(len(model_names)):
    print("The validation score for " + model_names[i] +" is " + str(scores[i]))
```

```
The validation score for LogisticRegression is 0.745
The validation score for LinearSVC is 0.745
The validation score for KNeighboursClassifier is 0.7324999999999999
```

We can see that the scaling helps a lot in the case of KNearestNeighbours classifier which is quite intutive from the fact that it relies upon the distances and use them intensively for the prediction of the class.

The results for Linear SVM and Logistic Regression also are improved.

In [21]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

pipe = Pipeline([('preprocess', preprocess),
                 ('classfier', LogisticRegression())])

param_grid = [{'classfier': [LogisticRegression(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [LinearSVC(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [KNeighborsClassifier()],
               'classfier__n_neighbors': range(1,15,2)}
             ]
grid = GridSearchCV(pipe, param_grid)
grid.fit(X_train_val, y_train_val)
best_score = grid.score(X_test, y_test)

print("The best score:" + str(best_score))
print("The best method along with its parameter values is: " + str(grid.best_params_))
```

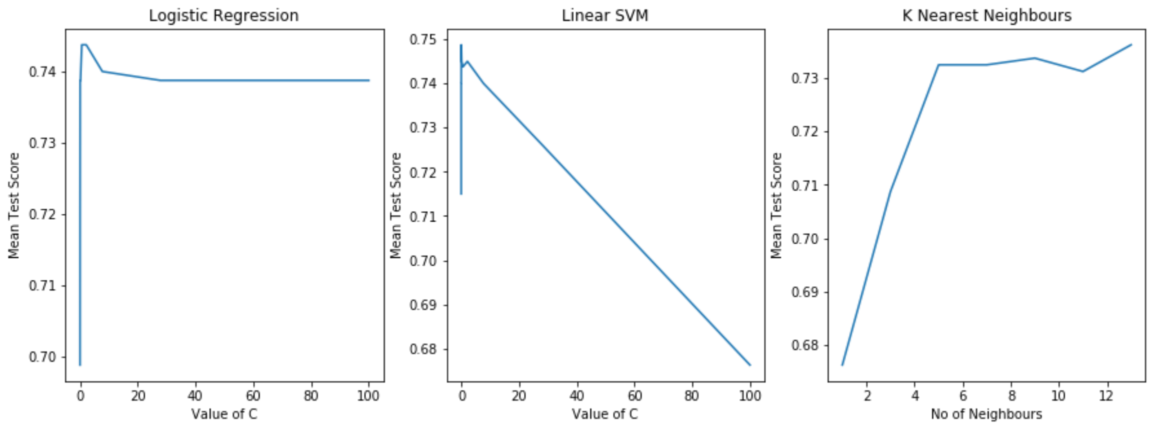
```
The best score:0.8
The best method along with its parameter values is: {'classfier': LinearSV
C(C=0.046415888336127795, class_weight=None, dual=True,
          fit_intercept=True, intercept_scaling=1, loss='squared_hinge',
          max_iter=1000, multi_class='ovr', penalty='l2', random_state=42,
          tol=0.0001, verbose=0), 'classfier__C': 0.046415888336127795}
```

In [22]:

```
plots = pd.DataFrame(grid.cv_results_)
plots["LR"]= [isinstance(plots["param_classfier"][i],LogisticRegression) for i in range
(plots.shape[0])]
plots["SVM"] = [isinstance(plots["param_classfier"][i],LinearSVC) for i in range(plots.
shape[0])]
plots["KNN"] = [isinstance(plots["param_classfier"][i],KNeighborsClassifier) for i in r
ange(plots.shape[0])]
```

In [23]:

```
fig, axes = plt.subplots(1, 3, figsize=(15, 5))

axes[0].plot(plots[plots["LR"]]["param_classfier__C"],plots[plots["LR"]]["mean_test_sco
re"])
axes[1].plot(plots[plots["SVM"]]["param_classfier__C"],plots[plots["SVM"]]["mean_test_s
core"])
axes[2].plot(plots[plots["KNN"]]["param_classfier__n_neighbors"],plots[plots["KNN"]]["m
ean_test_score"])
axes[0].set_xlabel("Value of C")
axes[0].set_ylabel("Mean Test Score")
axes[0].set_title("Logistic Regression")

axes[1].set_xlabel("Value of C")
axes[1].set_ylabel("Mean Test Score")
axes[1].set_title("Linear SVM")

axes[2].set_xlabel("No of Neighbours")
axes[2].set_ylabel("Mean Test Score")
axes[2].set_title("K Nearest Neighbours")

plt.show()
```



The results as can be seen has improved from all of the three case having scores (0.74, 0.74, 0.73) respectively. While after the gridsearch it can be seen that the best model is found to have a score of 0.79.

In [24]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

pipe = Pipeline([('preprocess', preprocess),
                 ('classfier', LogisticRegression())])

param_grid = [{'classfier': [LogisticRegression(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [LinearSVC(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [KNeighborsClassifier()],
               'classfier__n_neighbors': range(1,15,2)}
             ]
grid = GridSearchCV(pipe, param_grid,cv = KFold(shuffle=True , random_state=100))
grid.fit(X_train_val, y_train_val)
best_score = grid.score(X_test, y_test)

print("The best score (on the test):" + str(best_score))
print("The best method along with its parameter values is: " + str(grid.best_params_))
```

```
The best score (on the test):0.795
The best method along with its parameter values is: {'classfier': Logistic
Regression(C=0.1668100537200059, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, l1_ratio=None,
                   max_iter=100, multi_class='auto', n_jobs=None, penalty
='l2',
                   random_state=42, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False), 'classfier__C': 0.1668100537200059}
```

In [25]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

pipe = Pipeline([('preprocess', preprocess),
                 ('classfier', LogisticRegression())])

param_grid = [{'classfier': [LogisticRegression(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [LinearSVC(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [KNeighborsClassifier()],
               'classfier__n_neighbors': range(1,15,2)}
             ]
grid = GridSearchCV(pipe, param_grid,cv = KFold(shuffle=True , random_state=42))
grid.fit(X_train_val, y_train_val)
best_score = grid.score(X_test, y_test)

print("The best score (on the test):" + str(best_score))
print("The best method along with its parameter values is: " + str(grid.best_params_))
```

```
The best score (on the test):0.795
The best method along with its parameter values is: {'classfier': Logistic
Regression(C=0.1668100537200059, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, l1_ratio=None,
                   max_iter=100, multi_class='auto', n_jobs=None, penalty
='l2',
                   random_state=42, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False), 'classfier__C': 0.1668100537200059}
```

In [26]:

```
X_train_val, X_test, y_train_val, y_test = train_test_split(X_df, y_df, test_size=0.20,
random_state=83)

preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

pipe = Pipeline([('preprocess', preprocess),
                 ('classfier', LogisticRegression())])

param_grid = [{'classfier': [LogisticRegression(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [LinearSVC(random_state=42)],
               'classfier__C': np.logspace(-3, 2, 10)},
              {'classfier': [KNeighborsClassifier()],
               'classfier__n_neighbors': range(1,15,2)}
             ]
grid = GridSearchCV(pipe, param_grid,cv = KFold(shuffle=True , random_state=42))
grid.fit(X_train_val, y_train_val)
best_score = grid.score(X_test, y_test)

print("The best score (on the test):" + str(best_score))
print("The best method along with its parameter values is: " + str(grid.best_params_))
```

```
The best score (on the test):0.72
The best method along with its parameter values is: {'classfier': Logistic
Regression(C=0.5994842503189409, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, l1_ratio=None,
                   max_iter=100, multi_class='auto', n_jobs=None, penalty
='l2',
                   random_state=42, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False), 'classfier__C': 0.5994842503189409}
```

- The above 3 blocks of code show that the results change with change in value of random seed. These changes are evident from change in random seed's value at both the positions (i.e.) while performing the train_test split as well as one used in the KFold method to indicate random shuffling.

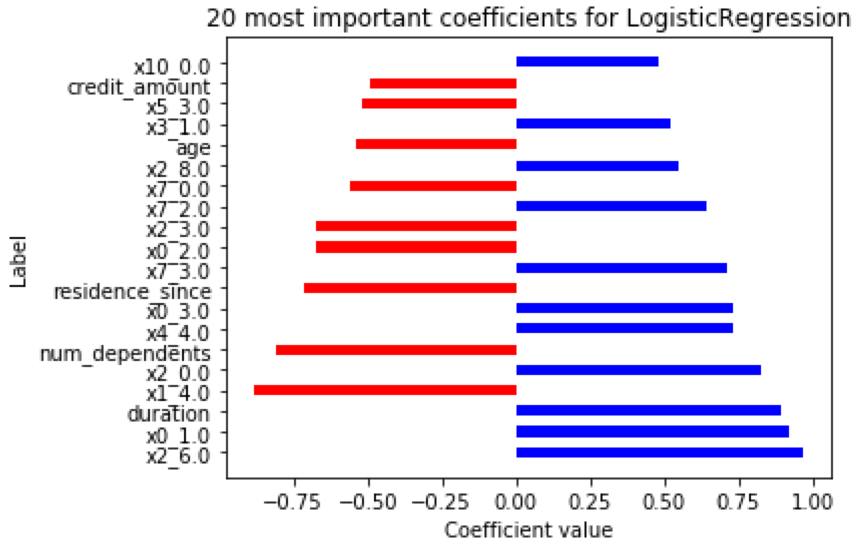
In [27]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

pipe1 = Pipeline([('preprocess', preprocess),
                 ('classifier', LogisticRegression(random_state=42))])

param_grid = [{'classifier__C': np.logspace(-3, 2, 10)}]
grid = GridSearchCV(pipe1, param_grid)
grid.fit(X_train_val, y_train_val)
best_score = grid.score(X_test, y_test)

print("The best parameter values for Logistic Regression: " + str(grid.best_params_))
```

```
The best parameter values for Logistic Regression: {'classifier__C': 7.742
636826811277}
```

In [28]:

```
pipe = Pipeline([('scaler', preprocess),('classifier', LogisticRegression(C=grid.best_p
arams_["classifier__C"]))])
pipe.fit(X_train_val,y_train_val)

coefficients=pipe.get_params()['classifier'].coef_
cat_names= list(preprocess.named_transformers_['onehotencoder'].get_feature_names())
features = continuous_columns.copy()
features.extend(cat_names)


coefficient_list = list(coefficients[0])

# combined_list = [(i,j) for i,j in zip(coefficient_list,features)]
# sorted_combination =sorted(combined_list, key = lambda x: abs(x[0]),reverse=True)
# top_20 = sorted_combination[:20]

fig, axes = plt.subplots()
for coef in sorted(coefficient_list,key = lambda x: abs(x),reverse=True)[:20]:
    plt.barh(features[coefficient_list.index(coef)], coef, height=.5, color=plt.cm.bwr_
r(np.sign(coef)))

plt.xlabel("Coefficient value")
plt.ylabel("Label")
plt.title("20 most important coefficients for LogisticRegression")
plt.tight_layout()
```



In [29]:

```
preprocess = make_column_transformer((OneHotEncoder(handle_unknown="ignore"), categoric
al_columns_index),(StandardScaler(), continuous_columns_index))

pipe1 = Pipeline([('preprocess', preprocess),
                  ('classifier', LinearSVC(random_state=42))])

param_grid = [{'classifier__C': np.logspace(-3, 2, 10)}]
grid = GridSearchCV(pipe1, param_grid)

grid.fit(X_train_val, y_train_val)
best_score = grid.score(X_test, y_test)

print("The best parameter values for Linear SVM: " + str(grid.best_params_))
```

```
The best parameter values for Linear SVM: {'classifier__C': 0.599484250318
9409}
```

In [30]:

```
pipe = Pipeline([('scaler', preprocess),('classifier', LinearSVC(C=grid.best_params_["c
lassifier__C"]))])
pipe.fit(X_train_val,y_train_val)

coefficients=pipe.get_params()['classifier'].coef_
cat_names= list(preprocess.named_transformers_['onehotencoder'].get_feature_names())
features = continuous_columns.copy()
features.extend(cat_names)

coefficient_list = list(coefficients[0])

# combined_list = [(i,j) for i,j in zip(coefficient_list,features)]
# sorted_combination =sorted(combined_list, key = lambda x: abs(x[0]),reverse=True)
# top_20 = sorted_combination[:20]

fig, axes = plt.subplots()
for coef in sorted(coefficient_list,key = lambda x: abs(x),reverse=True)[:20]:
    plt.barh(features[coefficient_list.index(coef)], coef, height=.5, color=plt.cm.bwr_
r(np.sign(coef)))

plt.xlabel("Coefficient value")
plt.ylabel("Label")
plt.title("20 most important coefficients for LogisticRegression")
plt.tight_layout()
```