```
import pandas as pd

df=pd.read_csv("P3- Churn-Modelling Data.csv")

df.head()
```

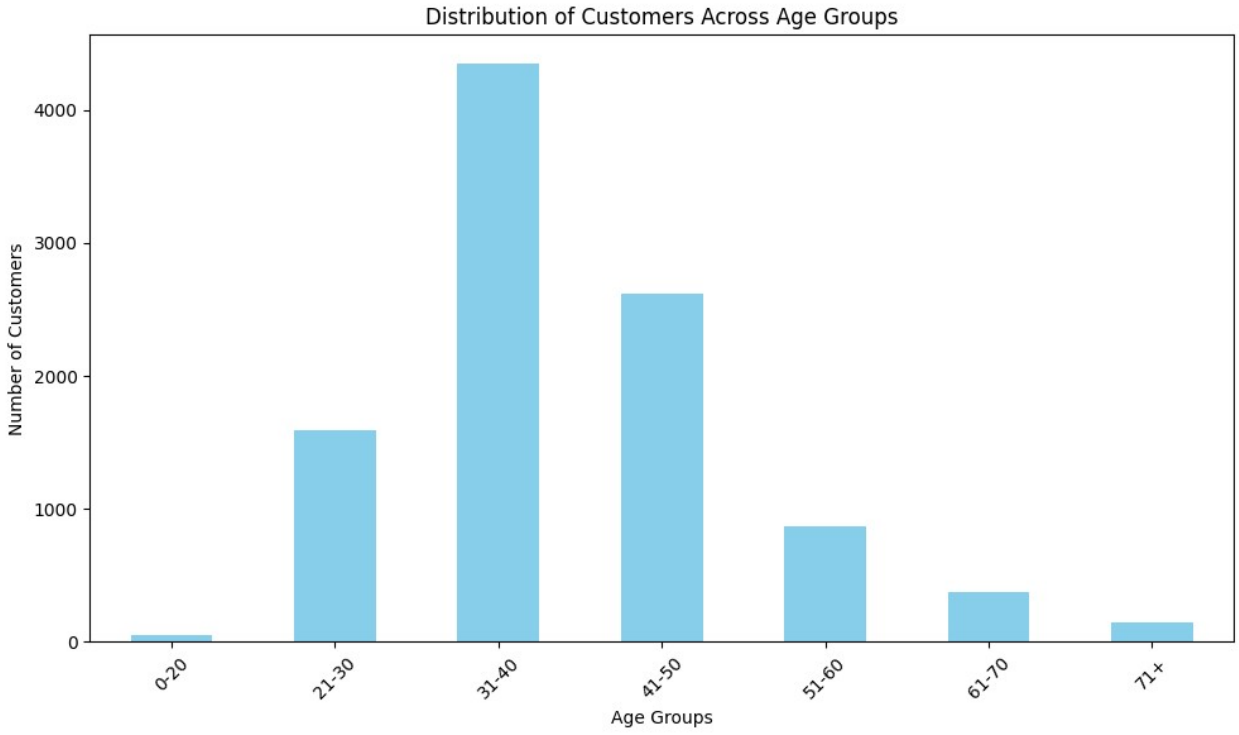
```
   RowNumber  CustomerId   Surname  CreditScore Geography  Gender  Age
\
0          1    15634602  Hargrave          619    France  Female   42

1          2    15647311      Hill          608     Spain  Female   41

2          3    15619304      Onio          502    France  Female   42

3          4    15701354      Boni          699    France  Female   39

4          5    15737888  Mitchell          850     Spain  Female   43


   Tenure    Balance  NumOfProducts  HasCrCard  IsActiveMember  \
0       2       0.00              1          1               1
1       1   83807.86              1          0               1
2       8  159660.80              3          1               0
3       1       0.00              2          0               0
4       2  125510.82              1          1               1

   EstimatedSalary  churned
0        101348.88        1
1        112542.58        0
2        113931.57        1
3         93826.63        0
4         79084.10        0
```

```
df.columns
```

```
Index(['RowNumber', 'CustomerId', 'Surname', 'CreditScore',
'Geography',
       'Gender', 'Age', 'Tenure', 'Balance', 'NumOfProducts',
'HasCrCard',
       'IsActiveMember', 'EstimatedSalary', 'churned'],
      dtype='object')
```

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

# Assuming 'df' is your DataFrame containing the churned dataset
# Ensure 'Age' column is numerical and valid

# Define age groups
bins = [0, 20, 30, 40, 50, 60, 70, float('inf')]
labels = ['0-20', '21-30', '31-40', '41-50', '51-60', '61-70', '71+']
```

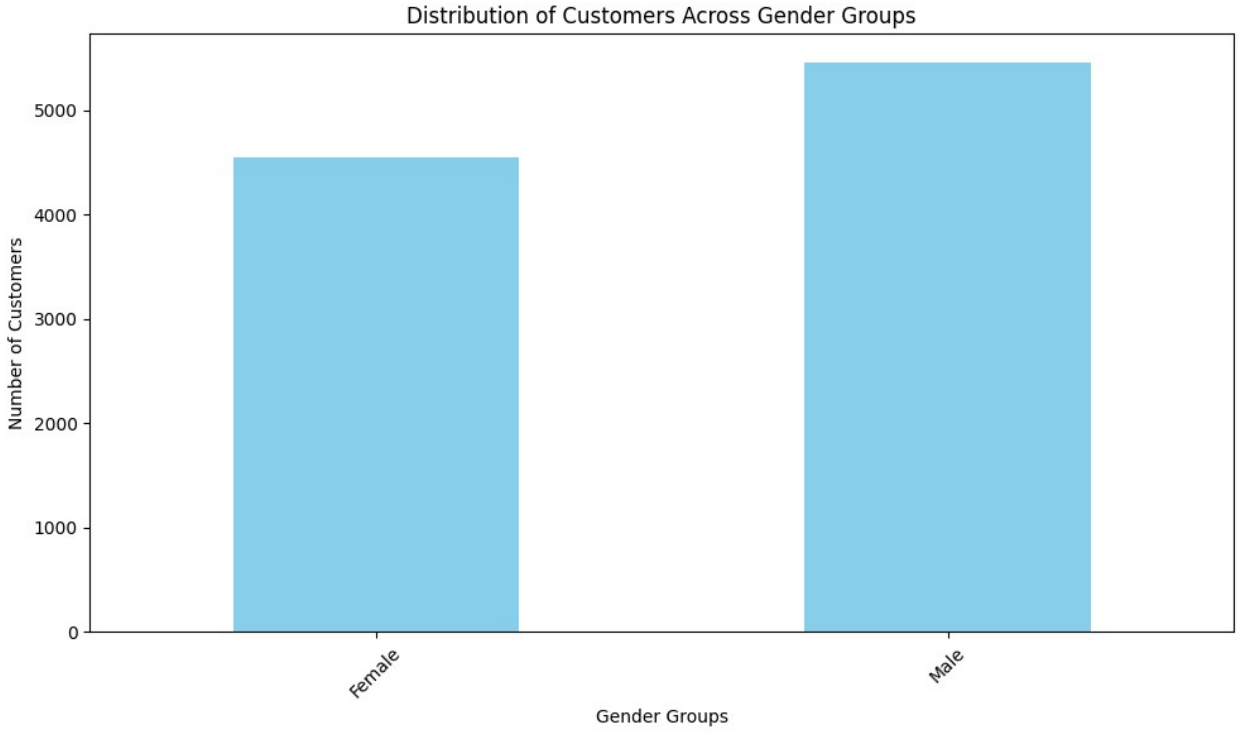
```
# Group customers by age groups
df['AgeGroup'] = pd.cut(df['Age'], bins=bins, labels=labels,
right=False)

# Count customers in each age group
age_group_counts = df['AgeGroup'].value_counts().sort_index()

# Plotting the distribution
plt.figure(figsize=(10, 6))
age_group_counts.plot(kind='bar', color='skyblue')
plt.title('Distribution of Customers Across Age Groups')
plt.xlabel('Age Groups')
plt.ylabel('Number of Customers')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()

# Optionally, you can also display the counts directly
print("Distribution of customers across different age groups:")
print(age_group_counts)
```




```
Distribution of customers across different age groups:
AgeGroup
0-20       49
21-30    1592
31-40    4346
```

```
41-50    2618
51-60     869
61-70     375
71+       151
Name: count, dtype: int64
```

```
gender_group_counts = df['Gender'].value_counts().sort_index()

# Plotting the distribution
plt.figure(figsize=(10, 6))
gender_group_counts.plot(kind='bar', color='skyblue')
plt.title('Distribution of Customers Across Gender Groups')
plt.xlabel('Gender Groups')
plt.ylabel('Number of Customers')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()

# Optionally, you can also display the counts directly
print("Distribution of customers across different Gender groups:")
print(gender_group_counts)
```




```
Distribution of customers across different Gender groups:
Gender
Female    4543
Male      5457
Name: count, dtype: int64
```

```
# Calculate the number of churned customers
num_churned = df['churned'].sum()

# Calculate the total number of customers
total_customers = len(df)

# Calculate the percentage of churned customers
percentage_churned = (num_churned / total_customers) * 100

print(f"Percentage of customers who have churned:
{percentage_churned:.2f}%")
```

```
Percentage of customers who have churned: 20.37%
```

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report

# Load your churn dataset into a DataFrame (assuming 'df' is your
DataFrame)
# Ensure your dataset has appropriate columns including features and
'churned' as the target variable

# Example features that might impact churn (adjust based on your
dataset)
features = ['RowNumber', 'CustomerId', 'Surname', 'CreditScore',
'Geography',
       'Gender', 'Age', 'Tenure', 'Balance', 'NumOfProducts',
'HasCrCard',
       'IsActiveMember', 'EstimatedSalary']

# Define X (features) and y (target)
X = df[features]
y = df['churned']

# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# Initialize Random Forest classifier
rf_classifier = RandomForestClassifier(random_state=42)

# Fit the model
rf_classifier.fit(X_train, y_train)

# Feature importance scores
feature_importances = rf_classifier.feature_importances_

# Create a DataFrame to display feature importance scores
feature_importance_df = pd.DataFrame({'Feature': features,
```

```
'Importance': feature_importances})
feature_importance_df =
feature_importance_df.sort_values(by='Importance', ascending=False)

# Print top 2 factors contributing to churn
top_factors = feature_importance_df.head(2)
print("Top factors contributing to churn:")
print(top_factors)

# Evaluate model performance on test set
y_pred = rf_classifier.predict(X_test)
print("\nClassification Report:")
print(classification_report(y_test, y_pred))
```

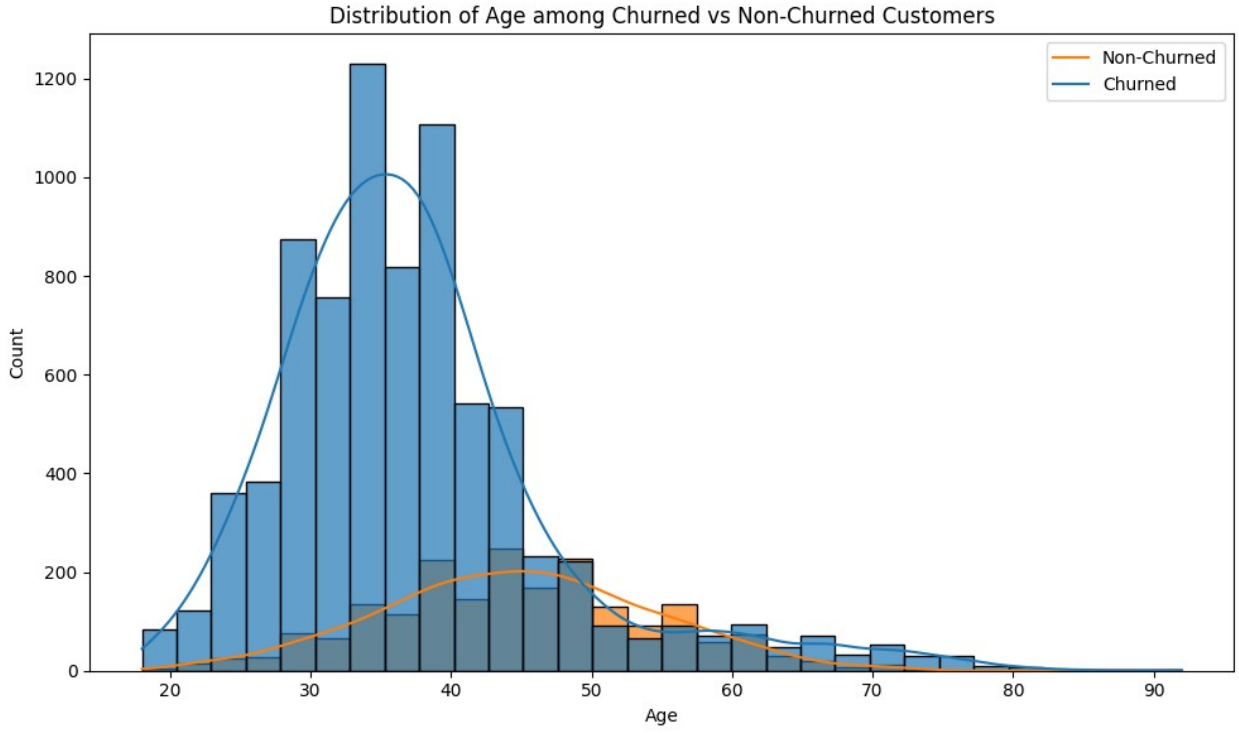
```
---------------------------------------------------------------------------
-----
ValueError                                Traceback (most recent call
last)
~\AppData\Local\Temp\ipykernel_18144\1166849544.py in ?()
     21 # Initialize Random Forest classifier
     22 rf_classifier = RandomForestClassifier(random_state=42)
     23
     24 # Fit the model
---> 25 rf_classifier.fit(X_train, y_train)
     26
     27 # Feature importance scores
     28 feature_importances = rf_classifier.feature_importances_

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
packages\sklearn\base.py in ?(estimator, *args, **kwargs)
   1469                 skip_parameter_validation=(
   1470                     prefer_skip_nested_validation or
global_skip_validation
   1471                 )
   1472             ):
-> 1473                 return fit_method(estimator, *args, **kwargs)

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
packages\sklearn\ensemble\_forest.py in ?(self, X, y, sample_weight)
    359         # Validate or convert input data
    360         if issparse(y):
    361             raise ValueError("sparse multilabel-indicator for
y is not supported.")
    362
--> 363         X, y = self._validate_data(
    364             X,
    365             y,
    366             multi_output=True,

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
```

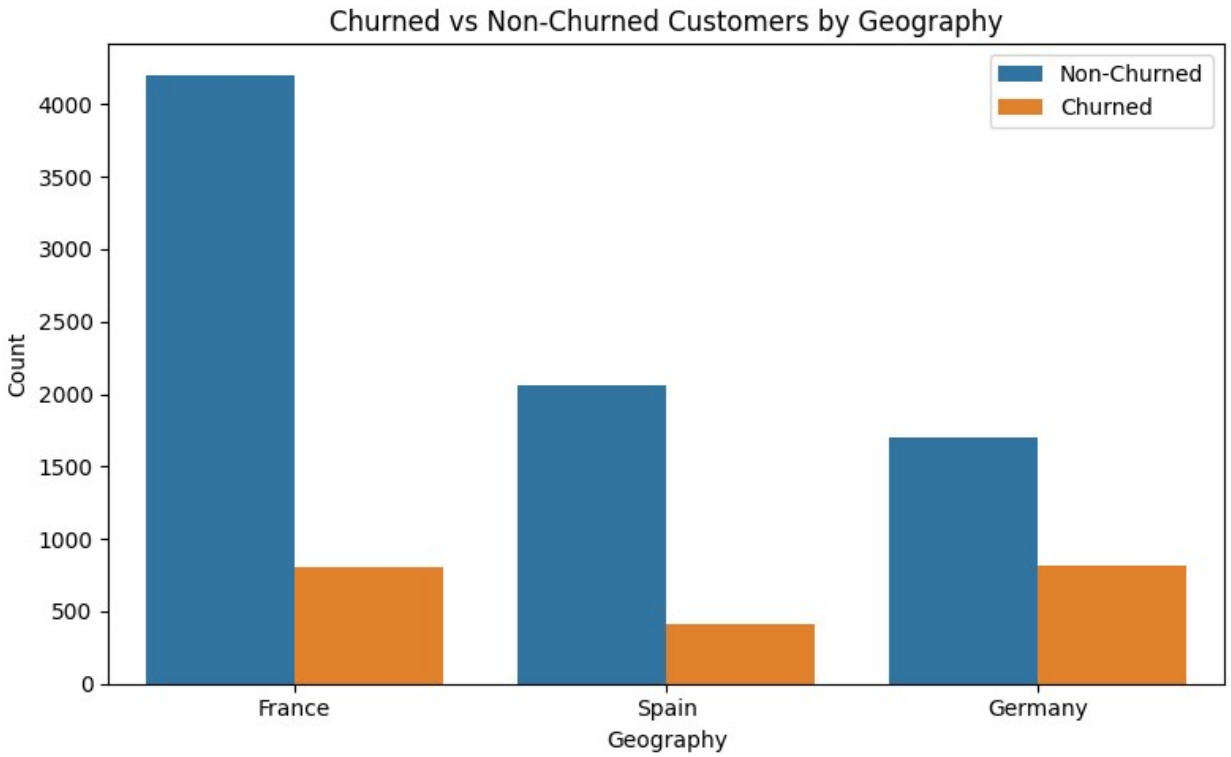
```
packages\sklearn\base.py in ?(self, X, y, reset, validate_separately,
cast_to_ndarray, **check_params)
    646                 if "estimator" not in check_y_params:
    647                     check_y_params = {**default_check_params,
**check_y_params}
    648                 y = check_array(y, input_name="y",
**check_y_params)
    649             else:
--> 650                 X, y = check_X_y(X, y, **check_params)
    651             out = X, y
    652
    653         if not no_val_X and check_params.get("ensure_2d",
True):

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
packages\sklearn\utils\validation.py in ?(X, y, accept_sparse,
accept_large_sparse, dtype, order, copy, force_all_finite, ensure_2d,
allow_nd, multi_output, ensure_min_samples, ensure_min_features,
y_numeric, estimator)
   1269         raise ValueError(
   1270             f"{estimator_name} requires y to be passed, but
the target y is None"
   1271         )
   1272
-> 1273     X = check_array(
   1274         X,
   1275         accept_sparse=accept_sparse,
   1276         accept_large_sparse=accept_large_sparse,

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
packages\sklearn\utils\validation.py in ?(array, accept_sparse,
accept_large_sparse, dtype, order, copy, force_all_finite, ensure_2d,
allow_nd, ensure_min_samples, ensure_min_features, estimator,
input_name)
   1004                             )
   1005                     array = xp.astype(array, dtype,
copy=False)
   1006                 else:
   1007                     array = _asarray_with_order(array,
order=order, dtype=dtype, xp=xp)
-> 1008             except ComplexWarning as complex_warning:
   1009                 raise ValueError(
   1010                     "Complex data not supported\n{}\
n".format(array)
   1011                 ) from complex_warning

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
packages\sklearn\utils\_array_api.py in ?(array, dtype, order, copy,
xp, device)
    742         # Use NumPy API to support order
```

```
    743         if copy is True:
    744             array = numpy.array(array, order=order,
dtype=dtype)
    745         else:
--> 746             array = numpy.asarray(array, order=order,
dtype=dtype)
    747
    748         # At this point array is a NumPy ndarray. We convert
it to an array
    749         # container that is consistent with the input's
namespace.

c:\Users\ASUS\AppData\Local\Programs\Python\Python312\Lib\site-
packages\pandas\core\generic.py in ?(self, dtype, copy)
   2149     def __array__(
   2150         self, dtype: npt.DTypeLike | None = None, copy: bool_t
| None = None
   2151     ) -> np.ndarray:
   2152         values = self._values
-> 2153         arr = np.asarray(values, dtype=dtype)
   2154         if (
   2155             astype_is_view(values.dtype, arr.dtype)
   2156             and using_copy_on_write()

ValueError: could not convert string to float: "P'an"
```

```python
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Assuming 'df' is your DataFrame containing churn data

# Summary statistics and distributions for churned customers
churned_summary = df[df['churned'] == 1].describe(include='all')

# Summary statistics and distributions for non-churned customers
non_churned_summary = df[df['churned'] == 0].describe(include='all')

# Visual comparison of age distribution between churned and non-
churned customers
plt.figure(figsize=(10, 6))
sns.histplot(data=df, x='Age', hue='churned', bins=30, kde=True,
alpha=0.7)
plt.title('Distribution of Age among Churned vs Non-Churned
Customers')
plt.xlabel('Age')
plt.ylabel('Count')
plt.legend(['Non-Churned', 'Churned'])
plt.tight_layout()
plt.show()
```

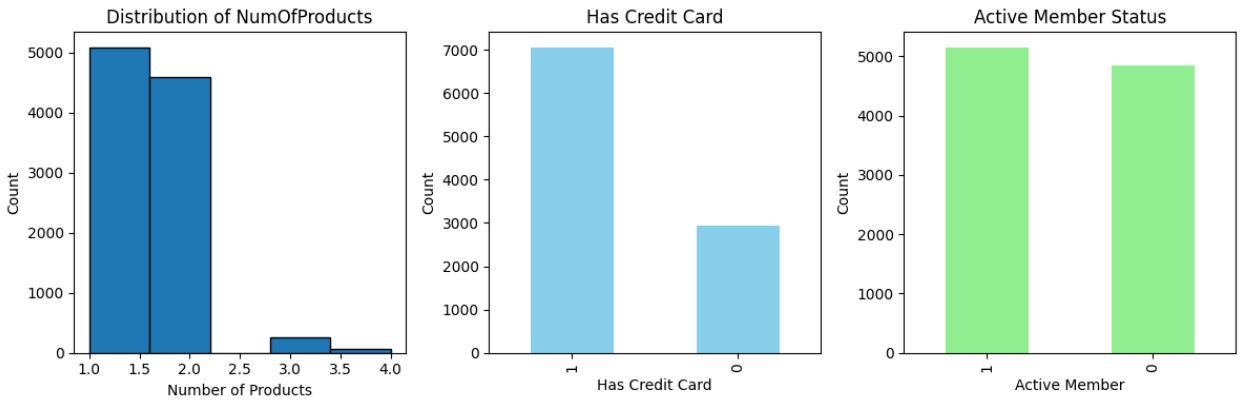
```
# Compare categorical variables like Geography using a bar plot
plt.figure(figsize=(8, 5))
sns.countplot(data=df, x='Geography', hue='churned')
plt.title('Churned vs Non-Churned Customers by Geography')
plt.xlabel('Geography')
plt.ylabel('Count')
plt.legend(['Non-Churned', 'Churned'])
plt.tight_layout()
plt.show()

# Statistical tests (e.g., t-tests, chi-square tests) if applicable

# Feature importance analysis using machine learning models if
applicable
```






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

# Assuming 'df' is your DataFrame with the provided columns

# Calculate summary statistics
num_products_stats = df['NumOfProducts'].describe()
has_credit_card_counts = df['HasCrCard'].value_counts()
active_member_counts = df['IsActiveMember'].value_counts()

# Plotting
plt.figure(figsize=(12, 4))

# Plot for NumOfProducts
plt.subplot(1, 3, 1)
plt.hist(df['NumOfProducts'], bins=5, edgecolor='black')
plt.title('Distribution of NumOfProducts')
plt.xlabel('Number of Products')
plt.ylabel('Count')

# Plot for HasCrCard
plt.subplot(1, 3, 2)
has_credit_card_counts.plot(kind='bar', color='skyblue')
plt.title('Has Credit Card')
plt.xlabel('Has Credit Card')
plt.ylabel('Count')
```

```python
# Plot for IsActiveMember
plt.subplot(1, 3, 3)
active_member_counts.plot(kind='bar', color='lightgreen')
plt.title('Active Member Status')
plt.xlabel('Active Member')
plt.ylabel('Count')

plt.tight_layout()
plt.show()

# Display summary statistics
print("Summary statistics for NumOfProducts:")
print(num_products_stats)
print("\nCounts for HasCrCard:")
print(has_credit_card_counts)
print("\nCounts for IsActiveMember:")
print(active_member_counts)
```



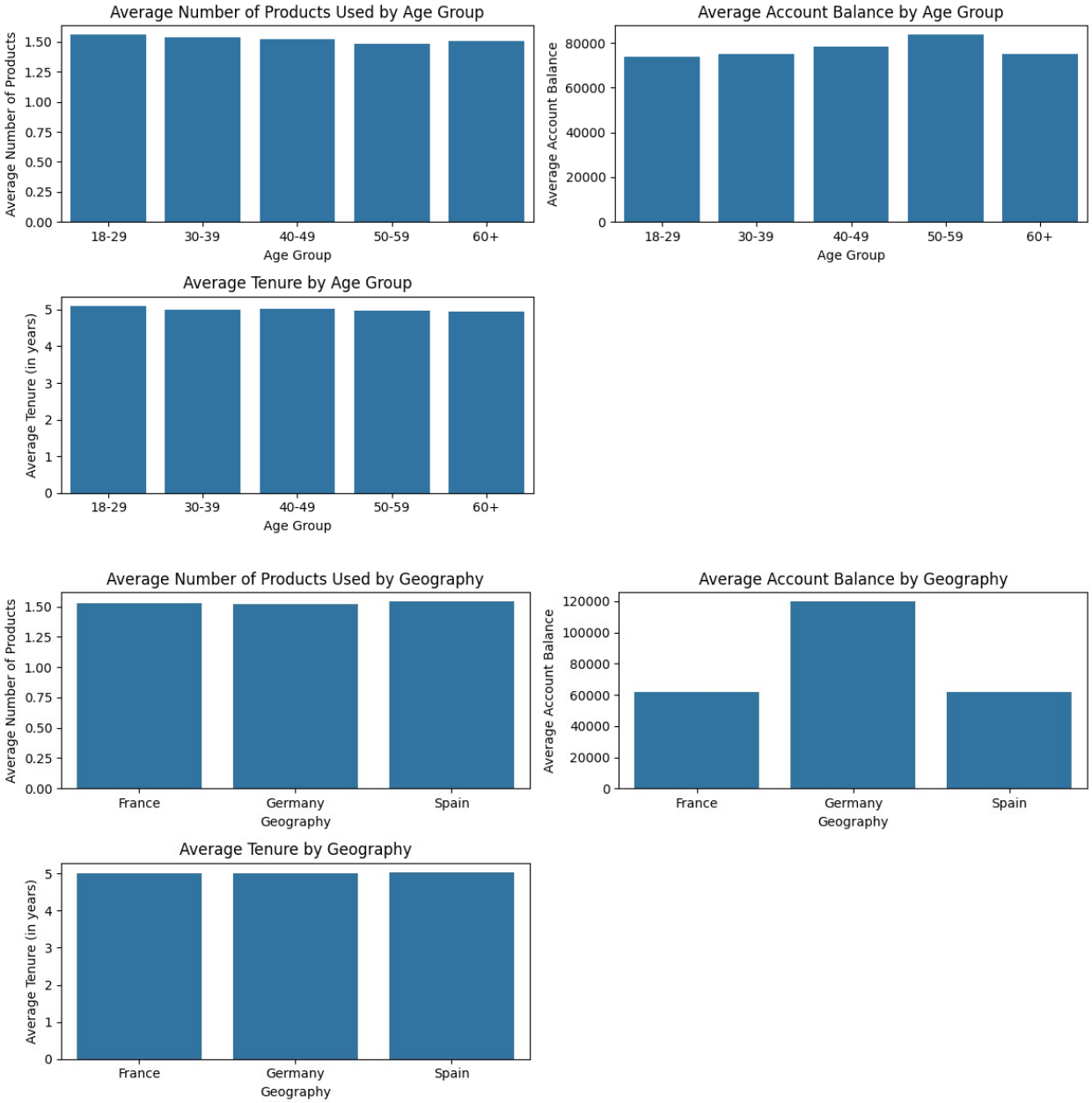

```
Summary statistics for NumOfProducts:
count    10000.000000
mean         1.530200
std          0.581654
min          1.000000
25%          1.000000
50%          1.000000
75%          2.000000
max          4.000000
Name: NumOfProducts, dtype: float64

Counts for HasCrCard:
HasCrCard
1    7055
0    2945
Name: count, dtype: int64
```

```
Counts for IsActiveMember:
IsActiveMember
1    5151
0    4849
Name: count, dtype: int64
```

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Load your dataset
# Assuming 'df' is your DataFrame with the provided columns

# Segment customers based on age groups
bins = [18, 30, 40, 50, 60, 100]  # Define age bins
labels = ['18-29', '30-39', '40-49', '50-59', '60+']  # Labels for age
groups
df['AgeGroup'] = pd.cut(df['Age'], bins=bins, labels=labels,
right=False)

# Analyze usage patterns by age group
age_group_usage = df.groupby('AgeGroup').agg({
    'NumOfProducts': 'mean',
    'Balance': 'mean',
    'Tenure': 'mean'
}).reset_index()

# Plotting usage patterns by age group
plt.figure(figsize=(12, 6))
plt.subplot(2, 2, 1)
sns.barplot(x='AgeGroup', y='NumOfProducts', data=age_group_usage)
plt.title('Average Number of Products Used by Age Group')
plt.xlabel('Age Group')
plt.ylabel('Average Number of Products')

plt.subplot(2, 2, 2)
sns.barplot(x='AgeGroup', y='Balance', data=age_group_usage)
plt.title('Average Account Balance by Age Group')
plt.xlabel('Age Group')
plt.ylabel('Average Account Balance')

plt.subplot(2, 2, 3)
sns.barplot(x='AgeGroup', y='Tenure', data=age_group_usage)
plt.title('Average Tenure by Age Group')
plt.xlabel('Age Group')
plt.ylabel('Average Tenure (in years)')

plt.tight_layout()
plt.show()
```

```
# Segment customers based on geography
geo_usage = df.groupby('Geography').agg({
    'NumOfProducts': 'mean',
    'Balance': 'mean',
    'Tenure': 'mean'
}).reset_index()

# Plotting usage patterns by geography
plt.figure(figsize=(12, 6))
plt.subplot(2, 2, 1)
sns.barplot(x='Geography', y='NumOfProducts', data=geo_usage)
plt.title('Average Number of Products Used by Geography')
plt.xlabel('Geography')
plt.ylabel('Average Number of Products')

plt.subplot(2, 2, 2)
sns.barplot(x='Geography', y='Balance', data=geo_usage)
plt.title('Average Account Balance by Geography')
plt.xlabel('Geography')
plt.ylabel('Average Account Balance')

plt.subplot(2, 2, 3)
sns.barplot(x='Geography', y='Tenure', data=geo_usage)
plt.title('Average Tenure by Geography')
plt.xlabel('Geography')
plt.ylabel('Average Tenure (in years)')

plt.tight_layout()
plt.show()
```

```
C:\Users\ASUS\AppData\Local\Temp\ipykernel_18144\2465525849.py:14:
FutureWarning: The default of observed=False is deprecated and will be
changed to True in a future version of pandas. Pass observed=False to
retain current behavior or observed=True to adopt the future default
and silence this warning.
  age_group_usage = df.groupby('AgeGroup').agg({
```

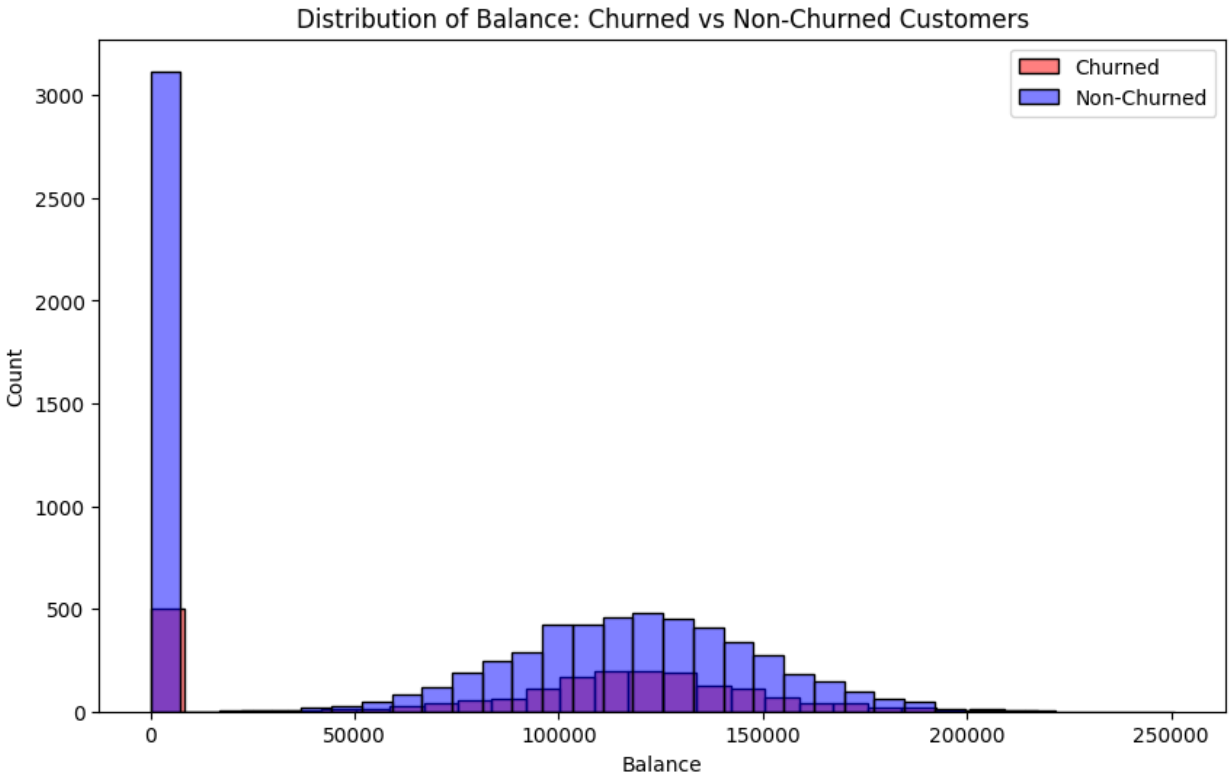


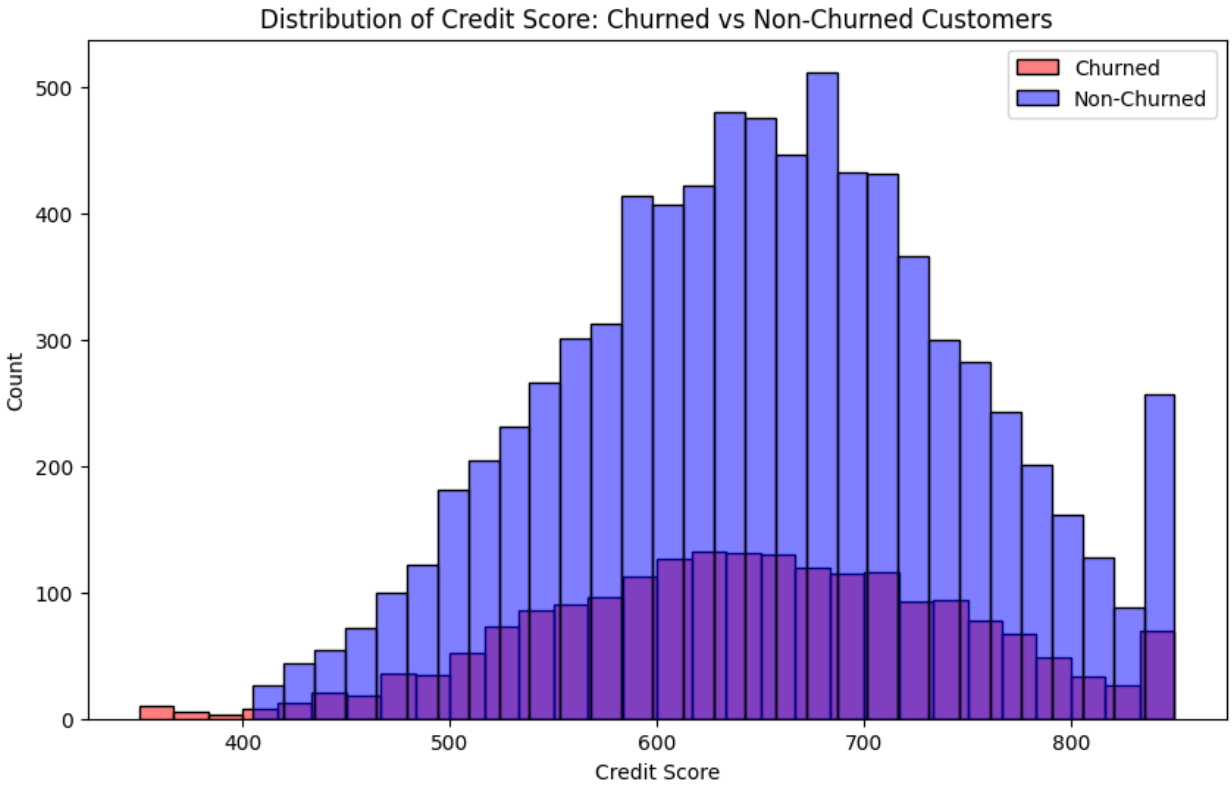

```
df['Balance'].mean()
```

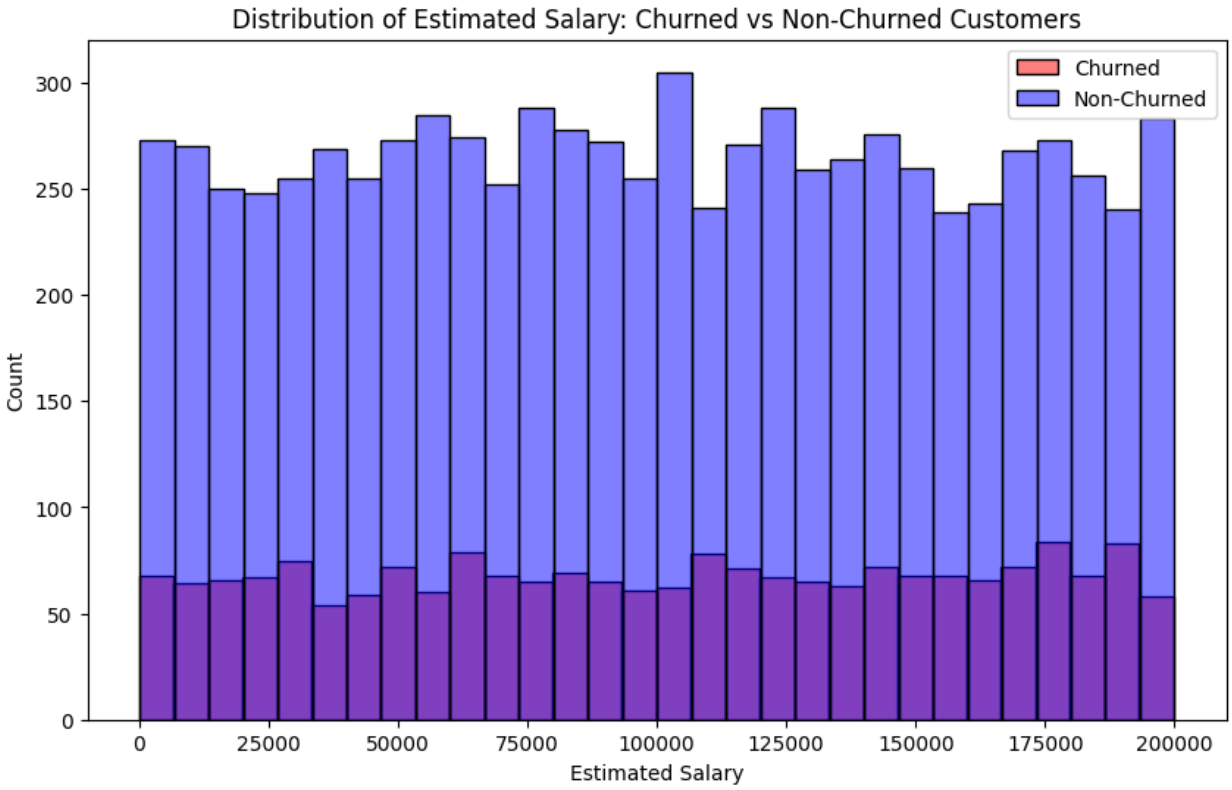
```
np.float64(76485.889288)
```

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Load your dataset
# Assuming 'df' is your DataFrame with the provided columns

# Separate churned and non-churned customers
```

```
churned_customers = df[df['churned'] == 1]
non_churned_customers = df[df['churned'] == 0]

# Compare 'Balance' between churned and non-churned customers
plt.figure(figsize=(10, 6))
sns.histplot(churned_customers['Balance'], bins=30, color='red',
alpha=0.5, label='Churned')
sns.histplot(non_churned_customers['Balance'], bins=30, color='blue',
alpha=0.5, label='Non-Churned')
plt.title('Distribution of Balance: Churned vs Non-Churned Customers')
plt.xlabel('Balance')
plt.legend()
plt.show()

# Compare 'CreditScore' between churned and non-churned customers
plt.figure(figsize=(10, 6))
sns.histplot(churned_customers['CreditScore'], bins=30, color='red',
alpha=0.5, label='Churned')
sns.histplot(non_churned_customers['CreditScore'], bins=30,
color='blue', alpha=0.5, label='Non-Churned')
plt.title('Distribution of Credit Score: Churned vs Non-Churned
Customers')
plt.xlabel('Credit Score')
plt.legend()
plt.show()

# Compare 'EstimatedSalary' between churned and non-churned customers
plt.figure(figsize=(10, 6))
sns.histplot(churned_customers['EstimatedSalary'], bins=30,
color='red', alpha=0.5, label='Churned')
sns.histplot(non_churned_customers['EstimatedSalary'], bins=30,
color='blue', alpha=0.5, label='Non-Churned')
plt.title('Distribution of Estimated Salary: Churned vs Non-Churned
Customers')
plt.xlabel('Estimated Salary')
plt.legend()
plt.show()

# Statistical comparison (t-tests) if needed
from scipy.stats import ttest_ind

# Example of t-test for 'Balance'
balance_churned = churned_customers['Balance']
balance_non_churned = non_churned_customers['Balance']
t_stat, p_value = ttest_ind(balance_churned, balance_non_churned)
print(f'T-test results for Balance: t-statistic = {t_stat}, p-value =
{p_value}')
```


Distribution of Balance: Churned vs Non-Churned Customers
Churned
Non-Churned
Count
Balance
0
500
1000
1500
2000
2500
3000
0
50000
100000
150000
200000
250000


Distribution of Credit Score: Churned vs Non-Churned Customers
Churned
Non-Churned
Count
Credit Score
0
100
200
300
400
500
400
500
600
700
800




```
T-test results for Balance: t-statistic = 11.936240300013841, p-value
= 1.2755633191525477e-32
```

```python
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, roc_auc_score
from sklearn.preprocessing import StandardScaler

# Load your dataset
# Assuming 'df' is your DataFrame with the provided columns

# Select relevant features and target variable
features = ['CreditScore', 'Age', 'Balance', 'NumOfProducts',
'HasCrCard', 'IsActiveMember', 'EstimatedSalary']
target = 'churned'

# Create X (features) and y (target)
X = df[features]
y = df[target]

# Handle categorical variables if any (not needed for this example
with numerical and binary features)

# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
```

```
test_size=0.2, random_state=42)

# Standardize features if necessary (for models like logistic
regression)
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Initialize and train a logistic regression model
logreg = LogisticRegression(random_state=42)
logreg.fit(X_train_scaled, y_train)

# Predict churn on the test set
y_pred = logreg.predict(X_test_scaled)
y_pred_proba = logreg.predict_proba(X_test_scaled)[:, 1]  #
Probability of churn

# Evaluate model performance
print("Classification Report:")
print(classification_report(y_test, y_pred))

# Calculate ROC AUC score
auc_score = roc_auc_score(y_test, y_pred_proba)
print(f"\nROC AUC Score: {auc_score:.4f}")

# Feature importance (coefficients for logistic regression)
feature_importance = pd.DataFrame({'Feature': features, 'Importance':
logreg.coef_[0]})
feature_importance = feature_importance.sort_values(by='Importance',
ascending=False)

print("\nFeature Importance:")
print(feature_importance)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.82      0.97      0.89      1607
           1       0.54      0.15      0.23       393

    accuracy                           0.81      2000
   macro avg       0.68      0.56      0.56      2000
weighted avg       0.77      0.81      0.76      2000


ROC AUC Score: 0.7566

Feature Importance:
           Feature  Importance
1              Age    0.755802
2          Balance    0.300973
```

```
6  EstimatedSalary    0.022070
4        HasCrCard   -0.004163
3    NumOfProducts   -0.017437
0      CreditScore   -0.062560
5   IsActiveMember   -0.536130
```

```
import pandas as pd
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report, roc_auc_score,
confusion_matrix

# Load your dataset
# Assuming 'df' is your DataFrame with the provided columns

# Select relevant features and target variable
features = ['CreditScore', 'Age', 'Balance', 'NumOfProducts',
'IsActiveMember', 'EstimatedSalary']
target = 'churned'

# Create X (features) and y (target)
X = df[features]
y = df[target]

# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# Initialize Random Forest classifier
rf_classifier = RandomForestClassifier(random_state=42)

# Optionally, perform hyperparameter tuning using GridSearchCV
param_grid = {
    'n_estimators': [50, 100, 200],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}
grid_search = GridSearchCV(rf_classifier, param_grid, cv=5,
scoring='accuracy', n_jobs=-1)
grid_search.fit(X_train, y_train)

# Fit the model with best parameters from GridSearchCV
best_rf = grid_search.best_estimator_
best_rf.fit(X_train, y_train)

# Predict churn on the test set
y_pred = best_rf.predict(X_test)
y_pred_proba = best_rf.predict_proba(X_test)[:, 1]  # Probability of
churn
```

```python
# Evaluate model performance
print("Classification Report:")
print(classification_report(y_test, y_pred))

# Calculate ROC AUC score
auc_score = roc_auc_score(y_test, y_pred_proba)
print(f"\nROC AUC Score: {auc_score:.4f}")

# Confusion matrix
print("\nConfusion Matrix:")
print(confusion_matrix(y_test, y_pred))

# Feature importance
feature_importances = pd.DataFrame({'Feature': features, 'Importance':
best_rf.feature_importances_})
feature_importances = feature_importances.sort_values(by='Importance',
ascending=False)

print("\nFeature Importance:")
print(feature_importances)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.87      0.97      0.92      1607
           1       0.75      0.41      0.53       393

    accuracy                           0.86      2000
   macro avg       0.81      0.69      0.72      2000
weighted avg       0.85      0.86      0.84      2000


ROC AUC Score: 0.8478

Confusion Matrix:
[[1552   55]
 [ 232  161]]

Feature Importance:
           Feature  Importance
1              Age    0.376864
3    NumOfProducts    0.278613
2          Balance    0.099520
5  EstimatedSalary    0.084168
4   IsActiveMember    0.081072
0      CreditScore    0.079762
```