

# 1.Problem Statement

The objective of this project is to predict customer churn based on historical service and demographic data. By identifying customers who are likely to leave, the business can take proactive measures to improve retention and reduce revenue loss.

```
In [436... import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.preprocessing import LabelEncoder,StandardScaler
from imblearn.over_sampling import SMOTE
from sklearn.model_selection import train_test_split

from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier,GradientBoostingClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.naive_bayes import CategoricalNB,BernoulliNB,GaussianNB
from xgboost import XGBClassifier
from lightgbm import LGBMClassifier

from sklearn.metrics import accuracy_score,confusion_matrix,classification_report

import warnings
warnings.filterwarnings('ignore')
pd.set_option('display.max_columns',100)
pd.set_option('display.width',120)
```

## 2.Import data

```
In [2]: df = pd.read_csv('WA_Fn-UseC_-Telco-Customer-Churn.csv')
```

```
In [3]: df.shape
```

```
Out[3]: (7043, 21)
```

```
In [5]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
#   Column                Non-Null Count  Dtype
---  -
0   customerID            7043 non-null   object
1   gender                 7043 non-null   object
2   SeniorCitizen          7043 non-null   int64
3   Partner                7043 non-null   object
4   Dependents             7043 non-null   object
5   tenure                 7043 non-null   int64
6   PhoneService           7043 non-null   object
7   MultipleLines           7043 non-null   object
8   InternetService         7043 non-null   object
9   OnlineSecurity          7043 non-null   object
10  OnlineBackup            7043 non-null   object
11  DeviceProtection        7043 non-null   object
12  TechSupport             7043 non-null   object
13  StreamingTV             7043 non-null   object
14  StreamingMovies         7043 non-null   object
15  Contract                7043 non-null   object
16  PaperlessBilling        7043 non-null   object
17  PaymentMethod           7043 non-null   object
18  MonthlyCharges          7043 non-null   float64
19  TotalCharges            7043 non-null   object
20  Churn                   7043 non-null   object
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB
```

## 3. Exploratory Data Analysis

### 3.1 Categorical Data

#### 3.1.1 Total customers

```
In [6]: df['customerID'].nunique()
```

```
Out[6]: 7043
```

Total unique customers 7043.

#### 3.1.2 gender

```
In [9]: df['gender'].value_counts(dropna=False)
```

```
Out[9]: gender
Male      3555
Female    3488
Name: count, dtype: int64
```

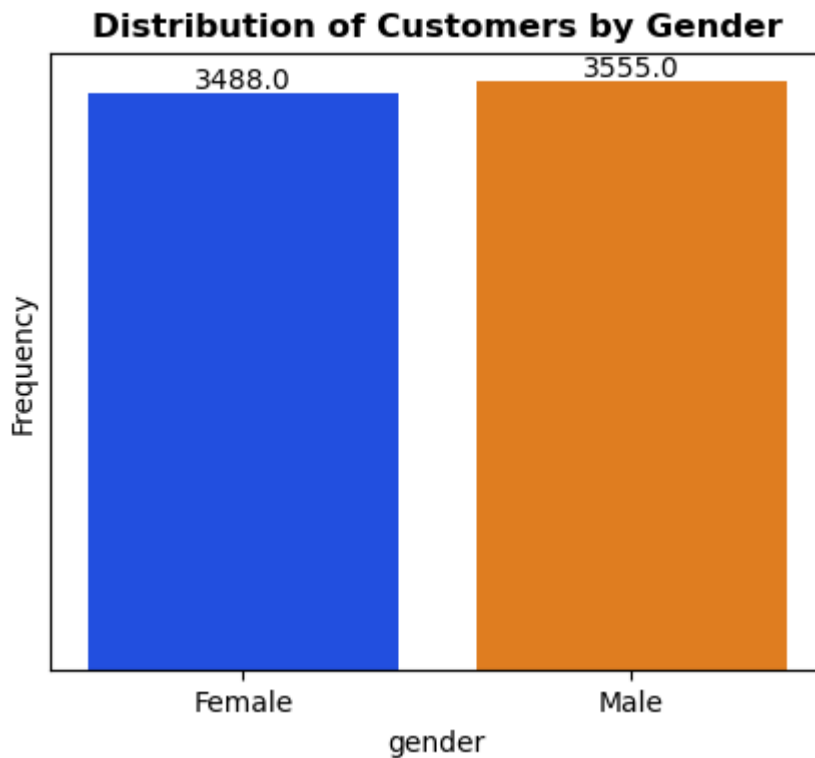
```
In [182... plt.figure(figsize=(5,4))
ax = sns.countplot(x = 'gender',data=df,palette='bright')
for p in ax.patches:
    ax.annotate(
        str(p.get_height()),
        (p.get_x()+p.get_width()/2,p.get_height()),
```

```

        ha = 'center',va='bottom')

plt.title('Distribution of Customers by Gender',fontweight="bold")
plt.yticks([])
plt.ylabel('Frequency')
plt.show()

```



The customer's gender is almost similar; there is not much difference

### 3.1.3 SeniorCitizen

```

In [26]: df['SeniorCitizen'] = df['SeniorCitizen'].map({1:'Yes',0:'No'})

```

```

In [28]: df['SeniorCitizen'].value_counts(dropna=False)

```

```

Out[28]: SeniorCitizen
No      5901
Yes     1142
Name: count, dtype: int64

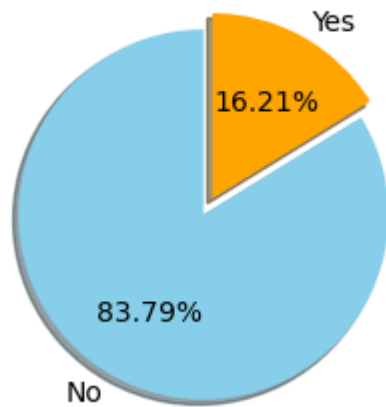
```

```

In [45]: plt.figure(figsize=(3,3))
df_s = df['SeniorCitizen'].value_counts(normalize=True,dropna=False).reset_index
plt.pie(df_s['proportion'],labels=df_s['SeniorCitizen'],autopct='%.2f%',explode
        colors=['skyblue', 'orange'])
plt.title("Senior Citizen Distribution",size=10,pad=10,fontweight="bold")
plt.show()

```

### Senior Citizen Distribution



### 3.1.4 Partner

```
In [54]: df['Partner'].value_counts(dropna=False)
```

```
Out[54]: Partner
No      3641
Yes     3402
Name: count, dtype: int64
```

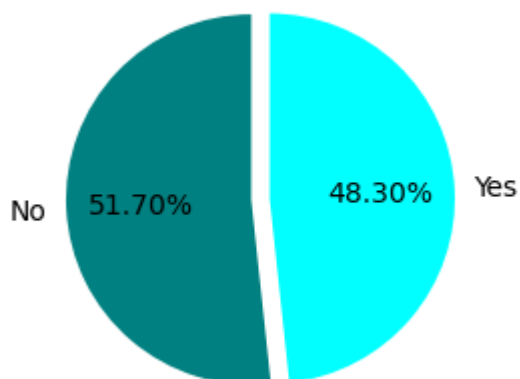
```
In [59]: df_p = df['Partner'].value_counts(normalize=True).reset_index()
df_p
```

```
Out[59]:
```

	Partner	proportion
0	No	0.516967
1	Yes	0.483033

```
In [71]: plt.figure(figsize=(3,3))
plt.pie(df_p['proportion'],labels=df_p['Partner'],autopct='%.2f%',explode=[0,0.
plt.title("Partner Distribution",size=10,pad=10,fontweight="bold")
plt.show()
```

### Partner Distribution



### 3.1.5 Dependents

```
In [72]: df['Dependents'].value_counts(dropna=False)
```

```
Out[72]: Dependents  
No      4933  
Yes     2110  
Name: count, dtype: int64
```

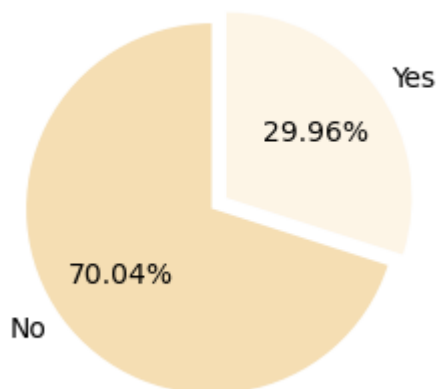
```
In [74]: df['Dependents'].value_counts(normalize=True, dropna=False).reset_index()
```

```
Out[74]:
```

	Dependents	proportion
0	No	0.700412
1	Yes	0.299588

```
In [76]: df_d = df['Dependents'].value_counts(normalize=True, dropna=False).reset_index()  
plt.figure(figsize=(3,3))  
plt.pie(df_d['proportion'], labels=df_d['Dependents'], autopct='%0.2f%%', explode=[0]  
plt.title('Dependents Distribution', size=10, pad=10, fontweight="bold")  
plt.show()
```

**Dependents Distribution**



### 3.1.6 PhoneService

```
In [77]: df['PhoneService'].value_counts()
```

```
Out[77]: PhoneService  
Yes     6361  
No       682  
Name: count, dtype: int64
```

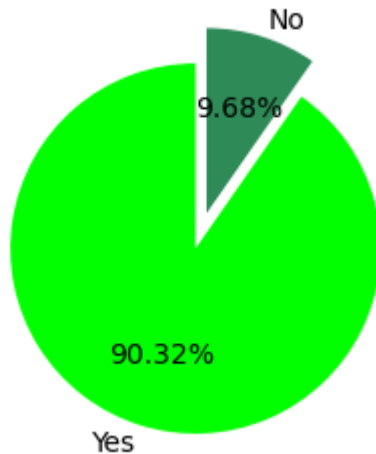
```
In [85]: df_p = df['PhoneService'].value_counts(dropna=False, normalize=True).reset_index()  
df_p['proportion'] = df_p['proportion'] * 100  
df_p
```

Out[85]:

	PhoneService	proportion
0	Yes	90.316626
1	No	9.683374

```
In [96]: plt.figure(figsize=(3,3))
plt.pie(df_p['proportion'],labels=df_p['PhoneService'],autopct='%.2f%',explode=
plt.title('PhoneService Distribution',size=10,pad=10,fontweight='bold')
plt.show()
```

**PhoneService Distribution**



### 3.1.7 MultipleLines

```
In [98]: df['MultipleLines'].value_counts(dropna=False)
```

Out[98]: MultipleLines

No	3390
Yes	2971
No phone service	682

Name: count, dtype: int64

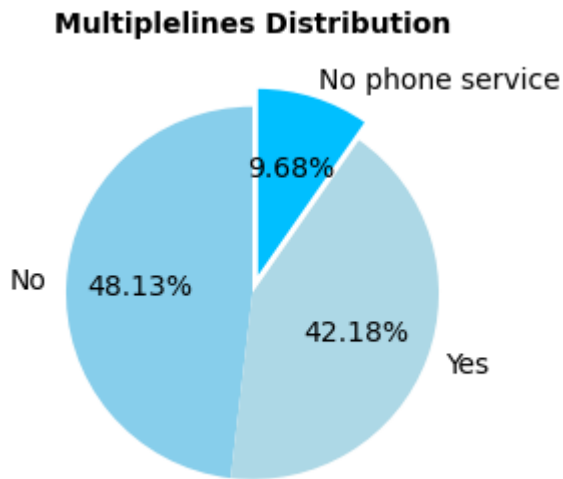
```
In [99]: df['MultipleLines'].value_counts(dropna=False,normalize=True)
```

Out[99]: MultipleLines

No	0.481329
Yes	0.421837
No phone service	0.096834

Name: proportion, dtype: float64

```
In [108... plt.figure(figsize=(3,4))
df_m = df['MultipleLines'].value_counts(dropna=False,normalize=True).reset_index
plt.pie(df_m['proportion'],labels=df_m['MultipleLines'],autopct='%.2f%',explode
startangle=90)
plt.title('Multiplelines Distribution',pad=10,size=10,fontweight='bold')
plt.show()
```



### 3.1.8 InternetService

```
In [110...] df['InternetService'].value_counts(dropna=False)
```

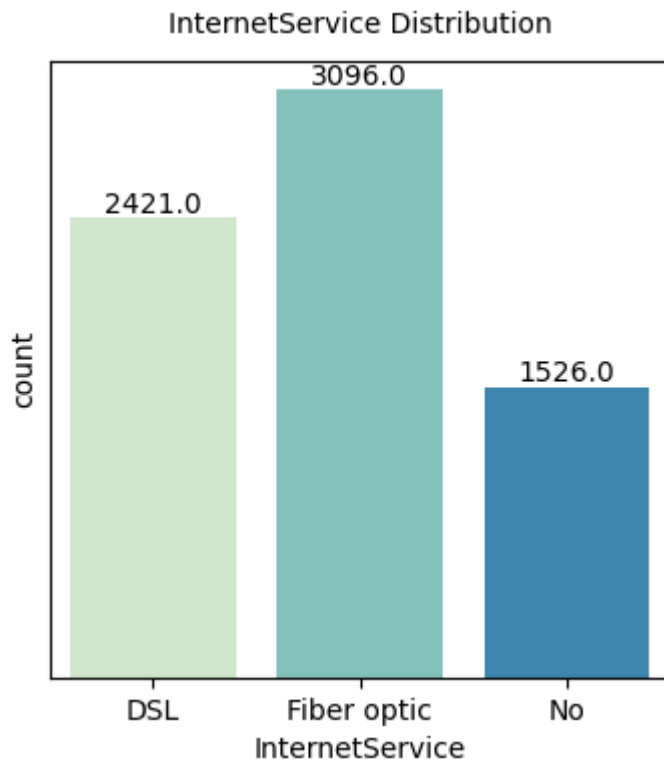
```
Out[110...] InternetService
Fiber optic    3096
DSL            2421
No             1526
Name: count, dtype: int64
```

```
In [112...] df_i = df['InternetService'].value_counts(dropna=False,normalize=True).reset_index()
df_i
```

```
Out[112...]
   InternetService  proportion
0      Fiber optic    0.439585
1           DSL      0.343746
2             No     0.216669
```

```
In [185...] plt.figure(figsize=(4,4))
ax = sns.countplot(x=df['InternetService'],data=df,palette='GnBu')
for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha = 'center',va='bottom'
    )

plt.title('InternetService Distribution',pad=10,size=10)
plt.yticks([])
plt.show()
```



### 3.1.9 OnlineSecurity

```
In [128...] df['OnlineSecurity'].value_counts(dropna=False)
```

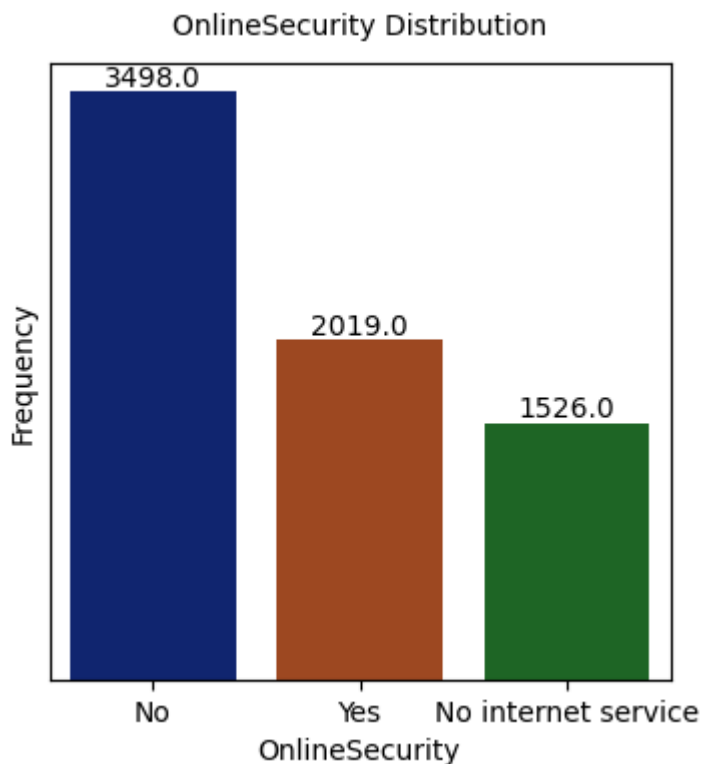
```
Out[128...] OnlineSecurity
No          3498
Yes         2019
No internet service  1526
Name: count, dtype: int64
```

```
In [136...] plt.figure(figsize=(4,4))
ax = sns.countplot(x='OnlineSecurity',data=df,palette='dark')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.yticks([])
plt.ylabel('Frequency')
plt.title('OnlineSecurity Distribution',pad=10,size=10)
plt.show()
```





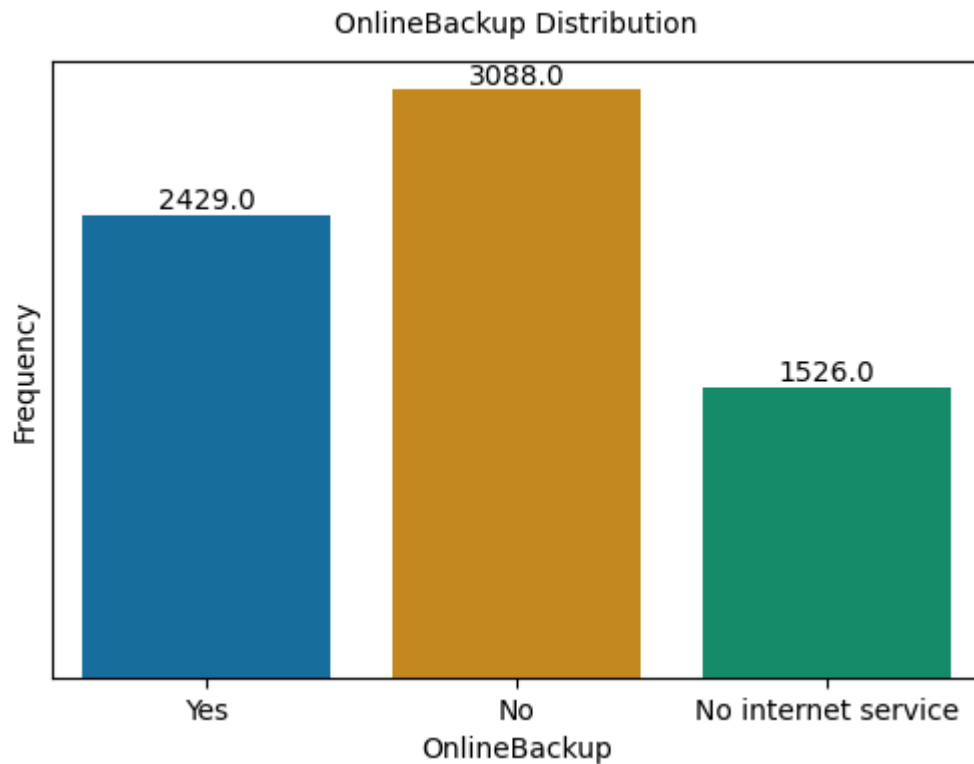
### 3.1.10 OnlineBackup

```
In [137...] df['OnlineBackup'].value_counts(dropna=False)
```

```
Out[137...] OnlineBackup
No                3088
Yes              2429
No internet service 1526
Name: count, dtype: int64
```

```
In [151...] plt.figure(figsize=(6,4))
ax = sns.countplot(x = 'OnlineBackup',data=df,palette='colorblind',orient='y',)
for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('OnlineBackup Distribution',size=10,pad=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```



### 3.1.11 DeviceProtection

```
In [152...] df['DeviceProtection'].value_counts(dropna=False)
```

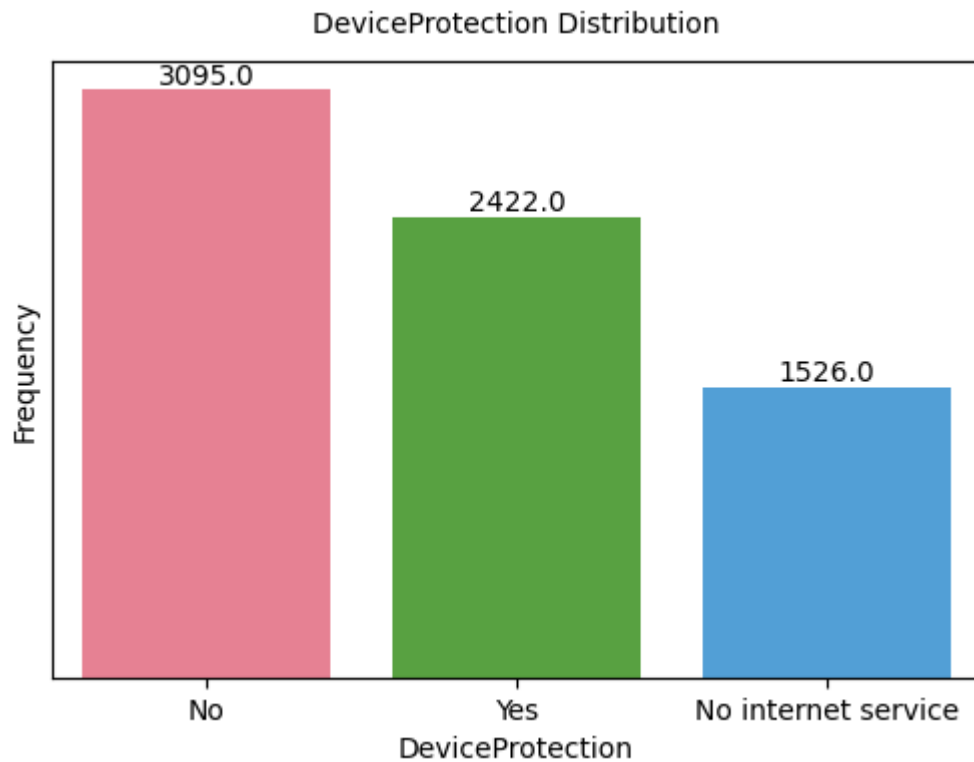
```
Out[152...] DeviceProtection
No          3095
Yes         2422
No internet service 1526
Name: count, dtype: int64
```

```
In [154...] plt.figure(figsize=(6,4))

ax = sns.countplot(x='DeviceProtection',data=df,palette='husl')

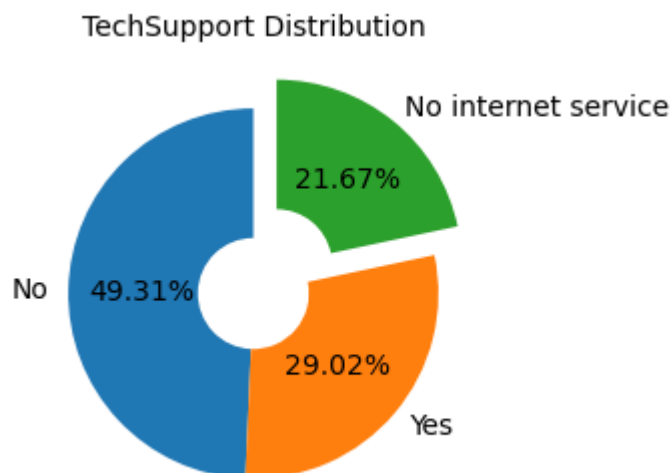
for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('DeviceProtection Distribution',pad=10,size=10)
plt.ylabel('Frequency')
plt.yticks([])
plt.show()
```



### 3.1.12 TechSupport

```
In [176... plt.figure(figsize=(3,3))
counts = df['TechSupport'].value_counts()
plt.pie(counts, labels=counts.index, autopct='%0.2f%%', wedgeprops={'width':0.7},
plt.title("TechSupport Distribution", pad=10, size=10)
plt.show()
```



### 3.1.13 StreamingTV

```
In [177... df['StreamingTV'].value_counts()
```

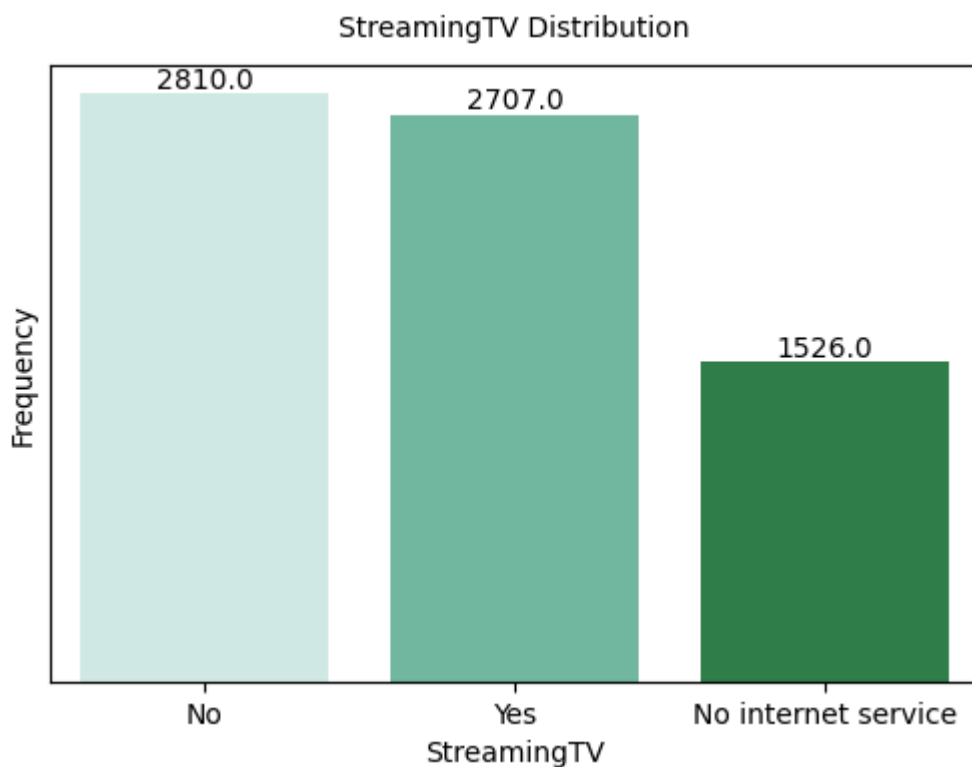
```
Out[177... StreamingTV
No                2810
Yes               2707
No internet service 1526
Name: count, dtype: int64
```

```
In [179... plt.figure(figsize=(6,4))

ax = sns.countplot(x='StreamingTV',data=df,palette='BuGn')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('StreamingTV Distribution',pad=10,size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```



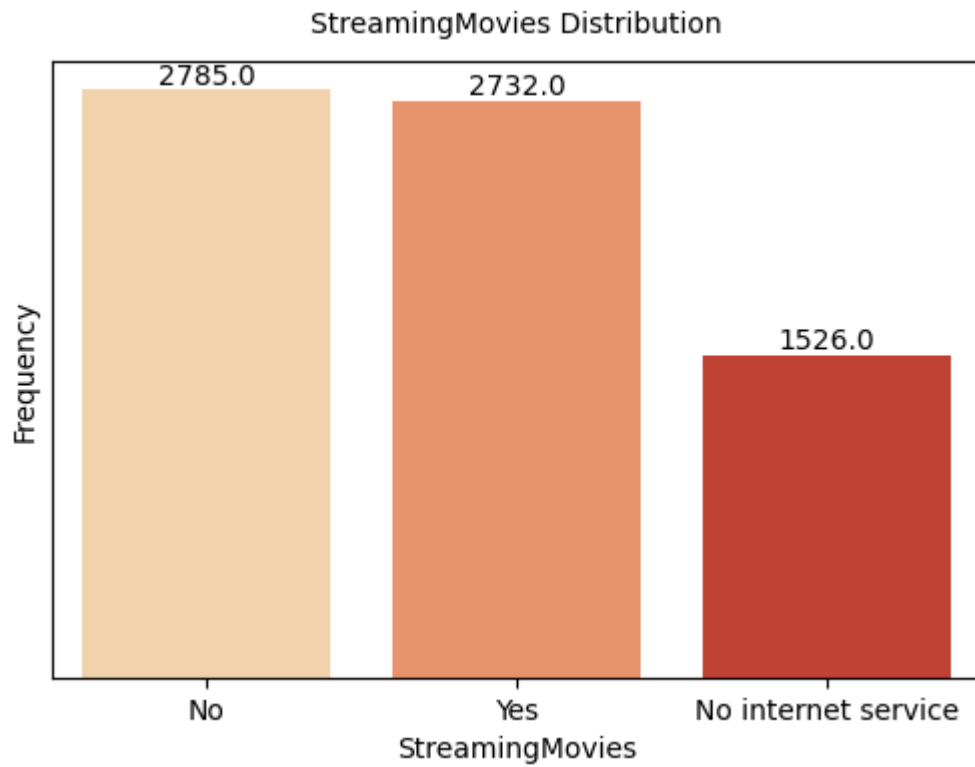
### 3.1.13 StreamingMovies

```
In [188... plt.figure(figsize=(6,4))

ax = sns.countplot(x = 'StreamingMovies',data=df,palette='OrRd')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('StreamingMovies Distribution',pad=10,size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```

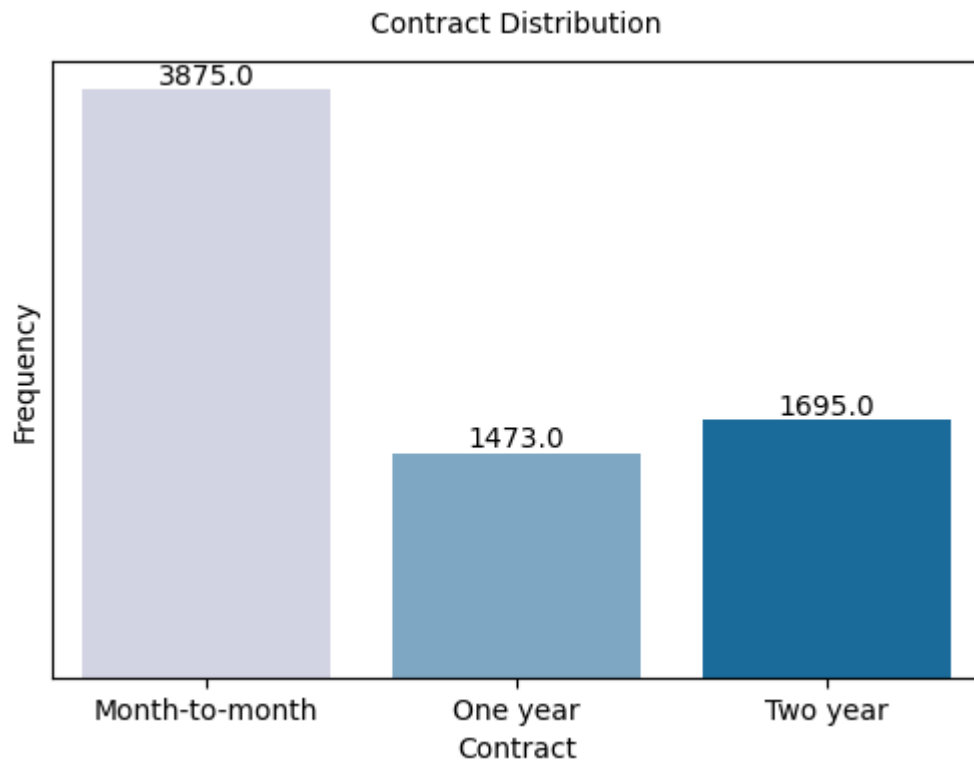


### 3.1.13 Contract

```
In [189... plt.figure(figsize=(6,4))
ax = sns.countplot(x = 'Contract',data=df,palette='PuBu')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('Contract Distribution',pad=10,size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```



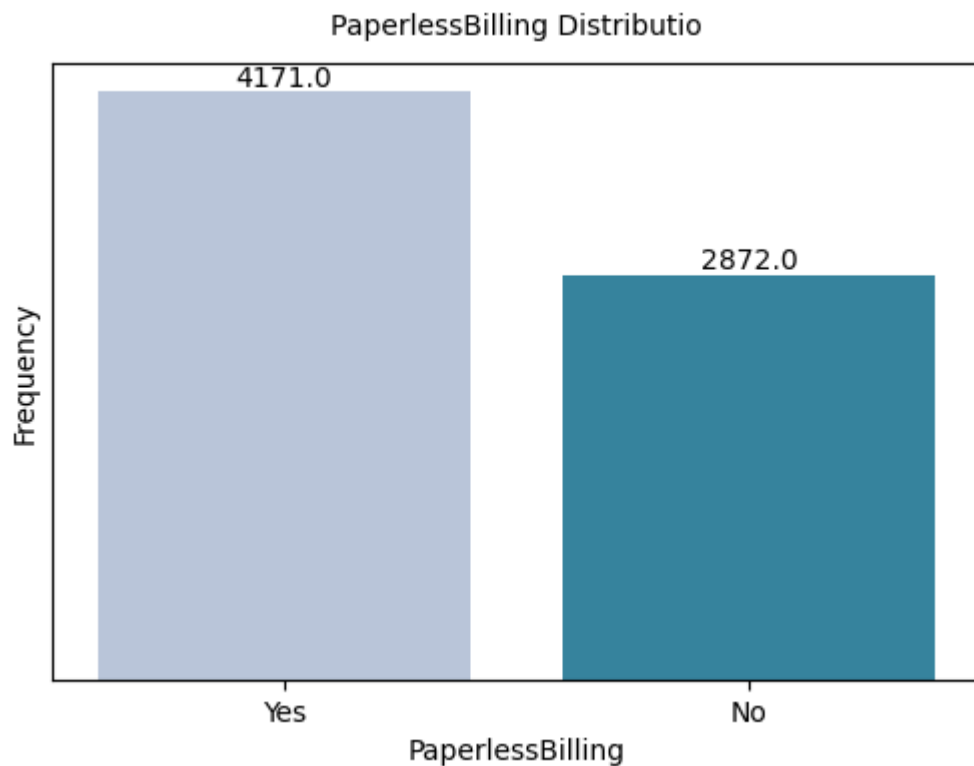
### 3.1.14 PaperlessBilling

In [190...

```
plt.figure(figsize=(6,4))
ax = sns.countplot(x = 'PaperlessBilling',data=df,palette='PuBuGn')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('PaperlessBilling Distributio',pad=10,size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```



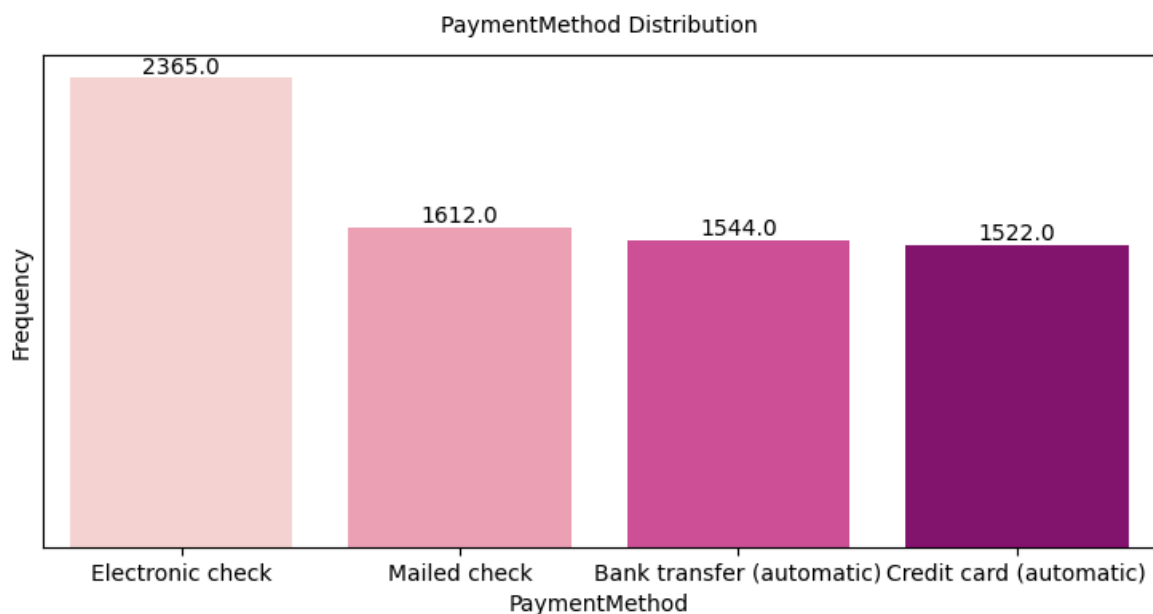
### 3.1.15 PaymentMethod

In [194...

```
plt.figure(figsize=(9,4))
ax = sns.countplot(x = 'PaymentMethod', data=df, palette='RdPu')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center', va='bottom')

plt.title('PaymentMethod Distribution', pad=10, size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```

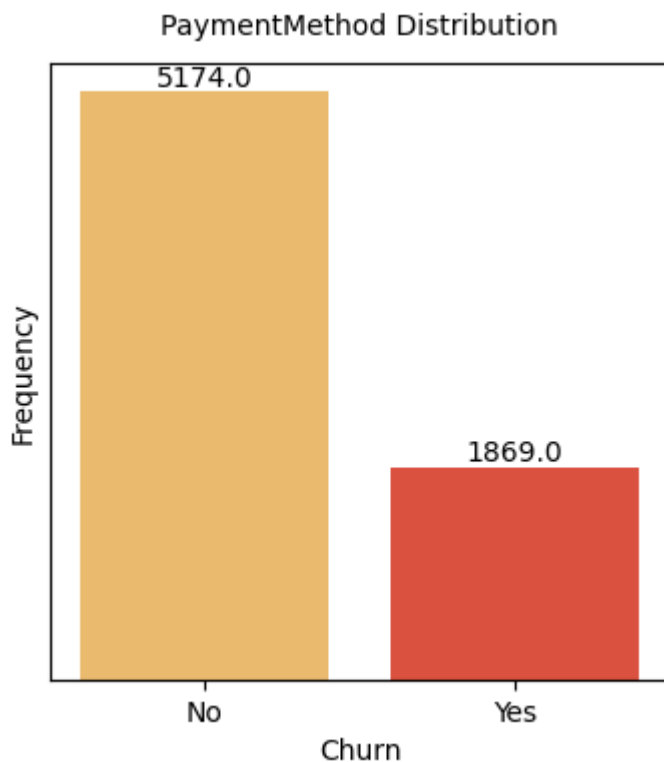


### 3.1.16 Churn

```
In [196... plt.figure(figsize=(4,4))
ax = sns.countplot(x = 'Churn',data=df,palette='YlOrRd')

for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

plt.title('PaymentMethod Distribution',pad=10,size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```



## 3.2 Numerical values

### 3.2.1 tenure

```
In [201... print('Max Tenure in Months:',np.max(df['tenure']))
```

Max Tenure in Months: 72

```
In [202... print('Max Tenure in Months:',np.min(df['tenure']))
```

Max Tenure in Months: 0

It is not possible to have a tenure of zero. That is the region im dropped the tenure 0 columns



```
In [204... df.drop(labels=df[df['tenure'] == 0].index, axis=0, inplace=True)
df[df['tenure'] == 0].index
```

```
Out[204... Index([], dtype='int64')
```

```
In [206... df.describe()
```

```
Out[206...
```

	tenure	MonthlyCharges
count	7032.000000	7032.000000
mean	32.421786	64.798208
std	24.545260	30.085974
min	1.000000	18.250000
25%	9.000000	35.587500
50%	29.000000	70.350000
75%	55.000000	89.862500
max	72.000000	118.750000

```
In [211... df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 7032 entries, 0 to 7042
Data columns (total 21 columns):
#   Column                Non-Null Count  Dtype
---  -
0   customerID            7032 non-null   object
1   gender                 7032 non-null   object
2   SeniorCitizen          7032 non-null   object
3   Partner                7032 non-null   object
4   Dependents             7032 non-null   object
5   tenure                 7032 non-null   int64
6   PhoneService           7032 non-null   object
7   MultipleLines          7032 non-null   object
8   InternetService        7032 non-null   object
9   OnlineSecurity         7032 non-null   object
10  OnlineBackup           7032 non-null   object
11  DeviceProtection       7032 non-null   object
12  TechSupport            7032 non-null   object
13  StreamingTV            7032 non-null   object
14  StreamingMovies        7032 non-null   object
15  Contract               7032 non-null   object
16  PaperlessBilling        7032 non-null   object
17  PaymentMethod          7032 non-null   object
18  MonthlyCharges         7032 non-null   float64
19  TotalCharges           7032 non-null   float64
20  Churn                  7032 non-null   object
dtypes: float64(2), int64(1), object(18)
memory usage: 1.2+ MB
```

```
In [210... df['TotalCharges'] = df['TotalCharges'].astype('float')
```

```
In [214... numerical_cols = ['tenure', 'MonthlyCharges', 'TotalCharges']
df[numerical_cols].describe()
```

```
Out[214...      tenure  MonthlyCharges  TotalCharges
count  7032.000000      7032.000000      7032.000000
mean    32.421786         64.798208      2283.300441
std     24.545260         30.085974      2266.771362
min      1.000000         18.250000         18.800000
25%     9.000000         35.587500         401.450000
50%    29.000000         70.350000        1397.475000
75%    55.000000         89.862500        3794.737500
max    72.000000        118.750000        8684.800000
```

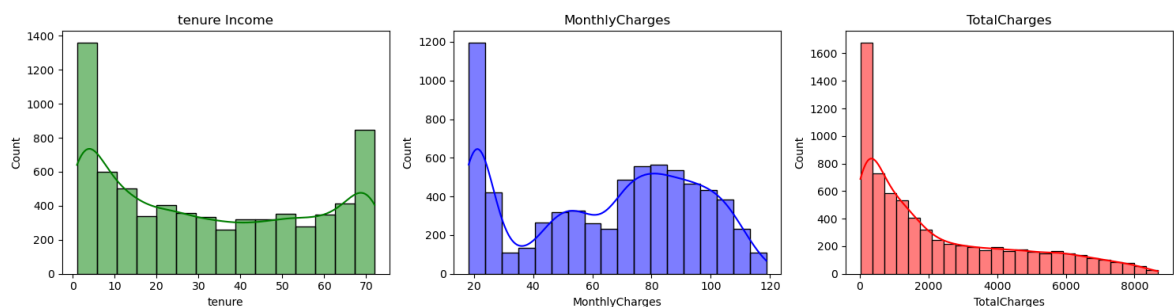
```
In [217... fig, ax = plt.subplots(1, 3, figsize=(15, 4))

# Plot histograms
sns.histplot(data=df, x="tenure", kde=True, ax=ax[0], color='green')
ax[0].set_title("tenure Income")

sns.histplot(data=df, x="MonthlyCharges", kde=True, ax=ax[1], color='blue')
ax[1].set_title("MonthlyCharges")

sns.histplot(data=df, x="TotalCharges", kde=True, ax=ax[2], color='red')
ax[2].set_title("TotalCharges")

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



## 4 Categorical vs Categorical

### 4.1 Gender vs Married

```
In [218... plt.figure(figsize=(4,4))
ct = pd.crosstab(df.gender, df.Churn)
ax = ct.plot(kind='bar', stacked=True, figsize=(7,5), color=['#f64f59', '#12c2e9'])

plt.title('Gender vs Married')
plt.xlabel('Gender')
plt.ylabel('Frequency')
plt.xticks(rotation=0)
```

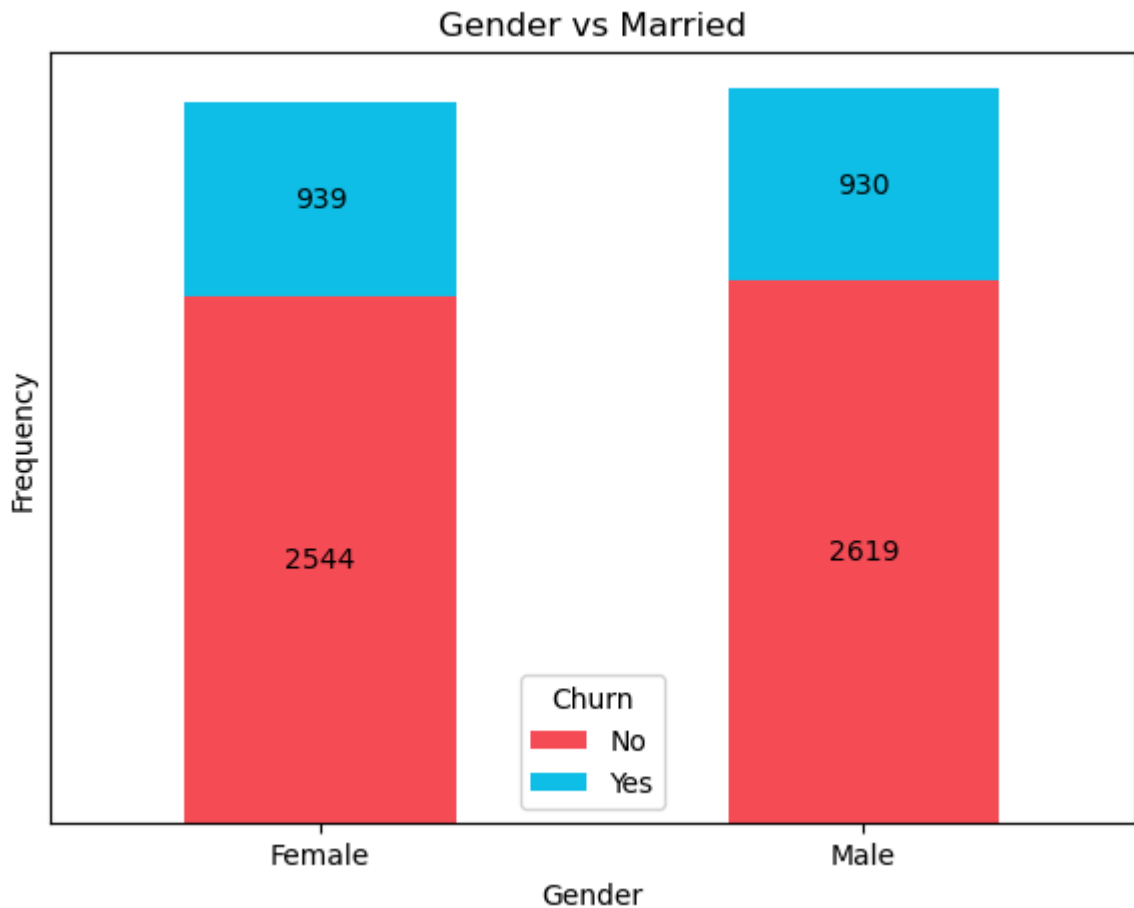
```

for bar in ax.patches:
    width = bar.get_width()
    height = bar.get_height()
    x = bar.get_x()
    y = bar.get_y()

    if height > 0: # avoid labeling empty bars
        ax.text(x + width/2, y + height/2, str(int(height)),
                ha='center', va='center', color='black', fontsize=10)
plt.yticks([])
plt.show()

```

<Figure size 400x400 with 0 Axes>



## 4.2 SeniorCitizen vs Chrun

```

In [249... ct = pd.crosstab(df.Churn,df.SeniorCitizen)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('SeniorCitizen vs Chrun', fontweight='bold',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

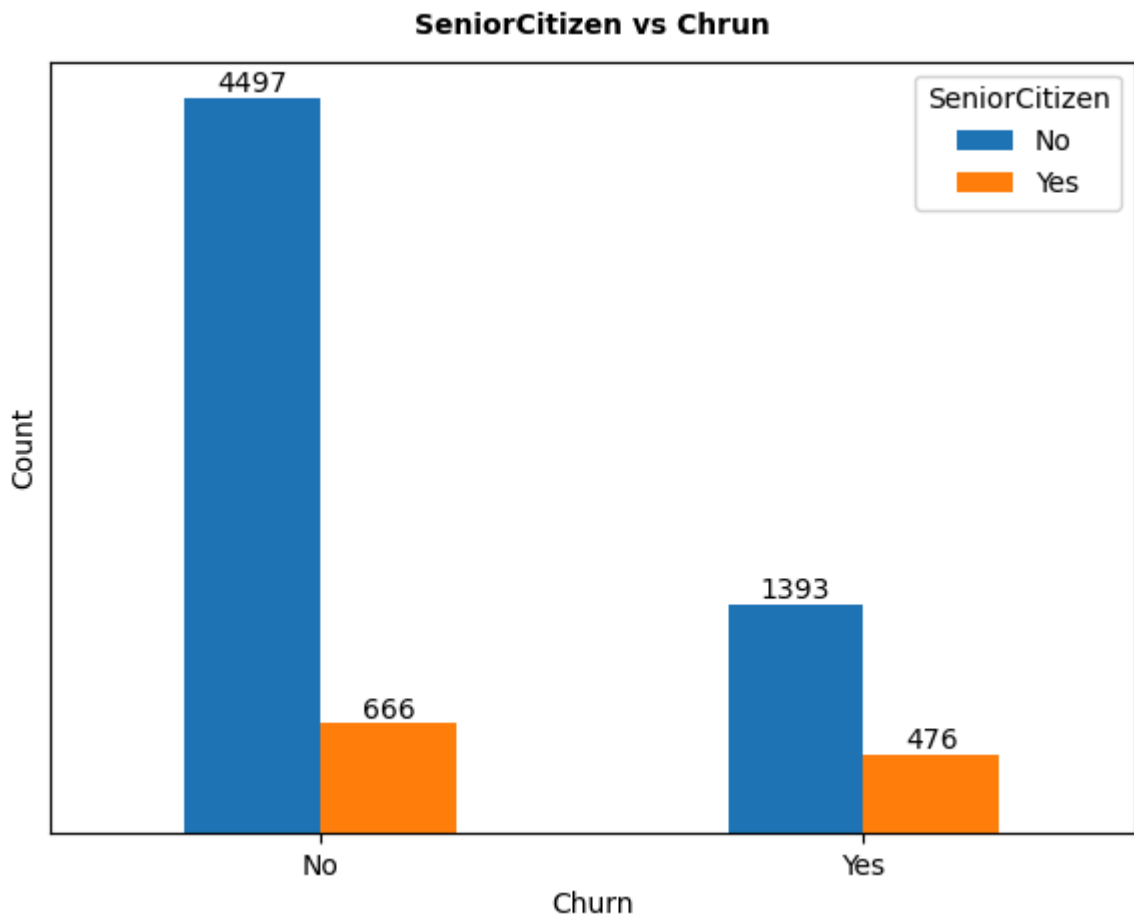
# ✓ Add Labels on each bar
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label

```

```

        ha='center', va='bottom', fontsize=10
    )
plt.yticks([])
plt.show()

```



### 4.3 Partner vs Chrun

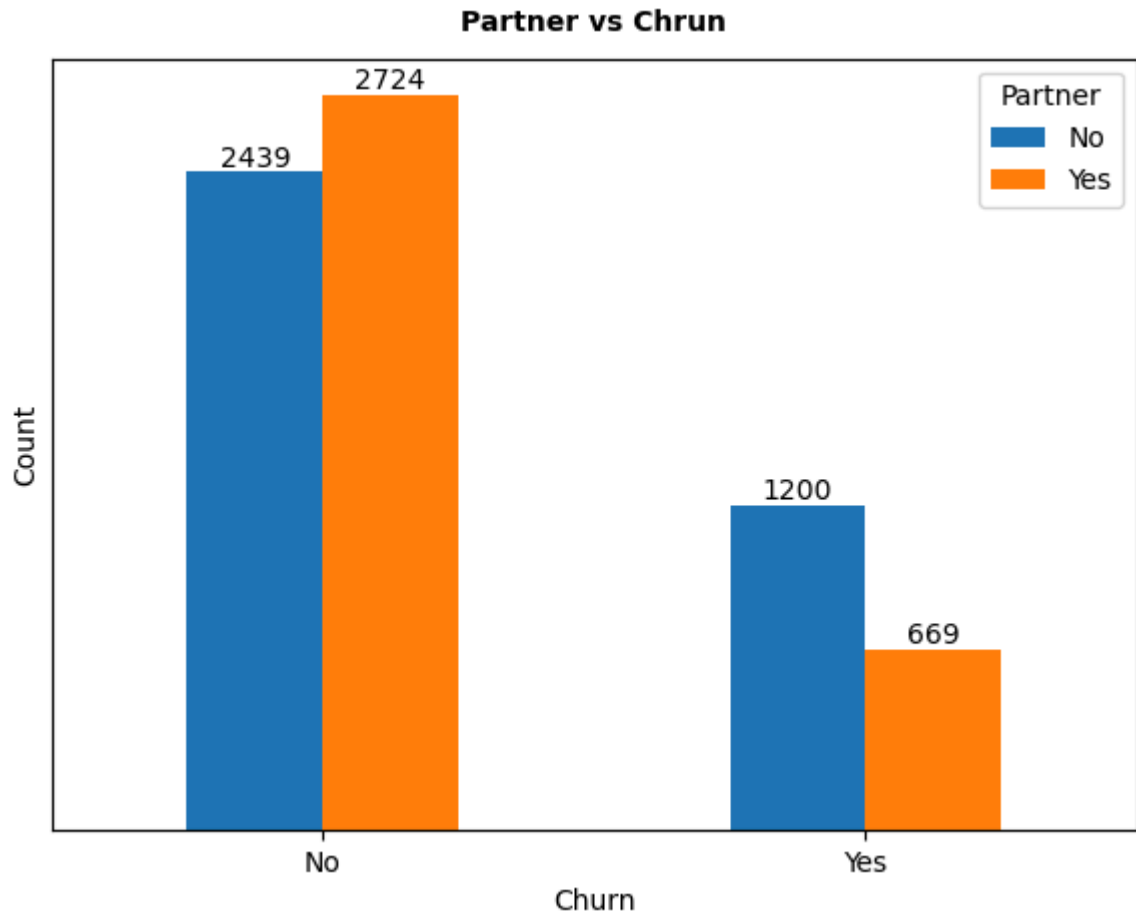
```

In [248... ct = pd.crosstab(df.Churn,df.Partner)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('Partner vs Chrun', fontweight='bold',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

# ✅ Add Labels on each bar
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()

```

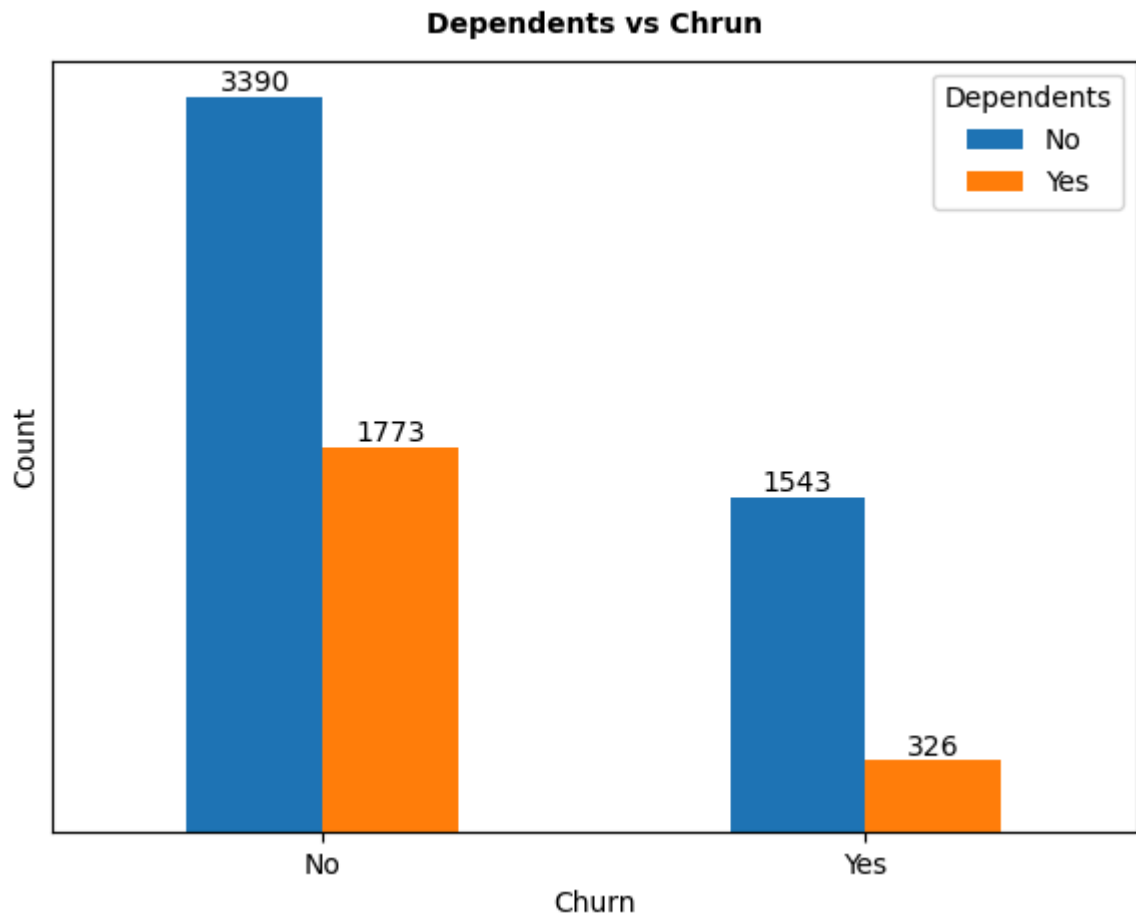


#### 4.4 Dependents vs Chrun

```
In [250... ct = pd.crosstab(df.Churn,df.Dependents)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('Dependents vs Chrun', fontweight='bold',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

# ✅ Add Labels on each bar
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```

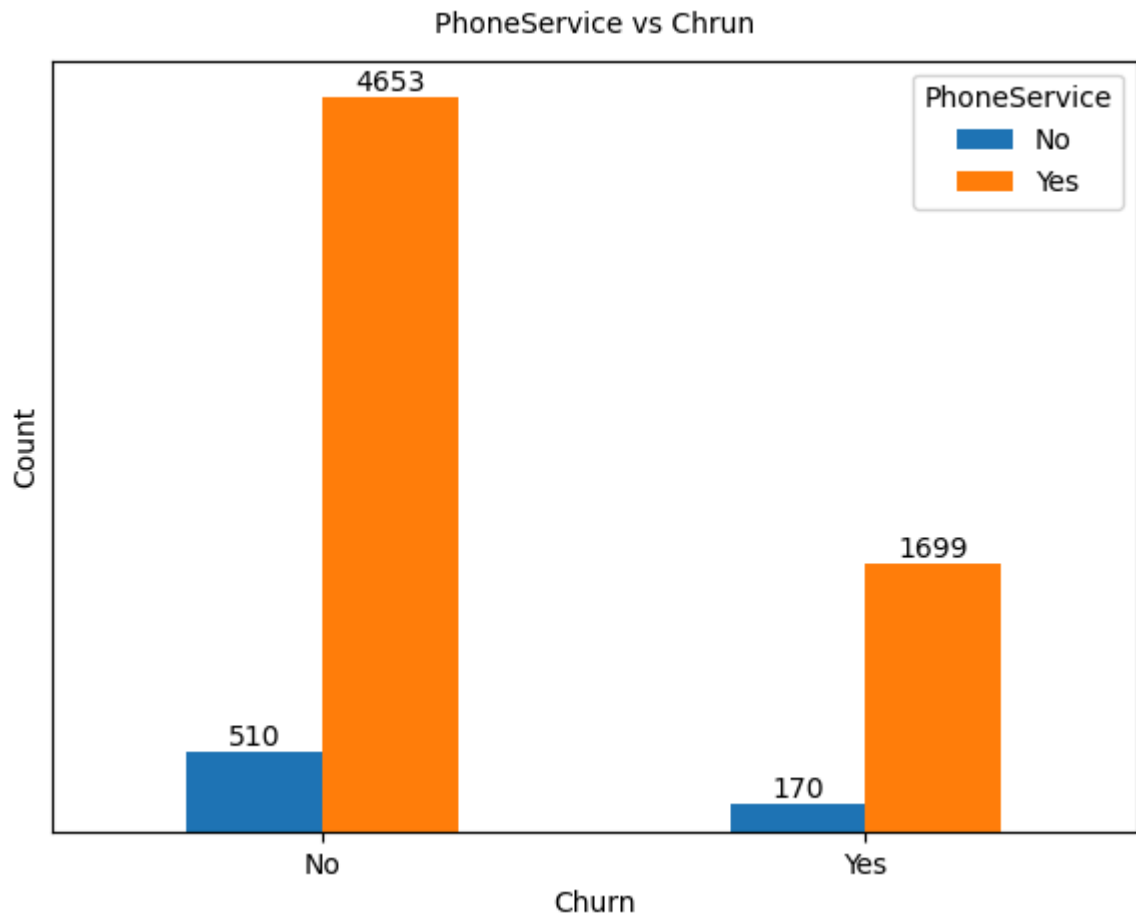


#### 4.4 PhoneService vs Chrun

```
In [251... ct = pd.crosstab(df.Churn,df.PhoneService)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('PhoneService vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

# ✅ Add Labels on each bar
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```

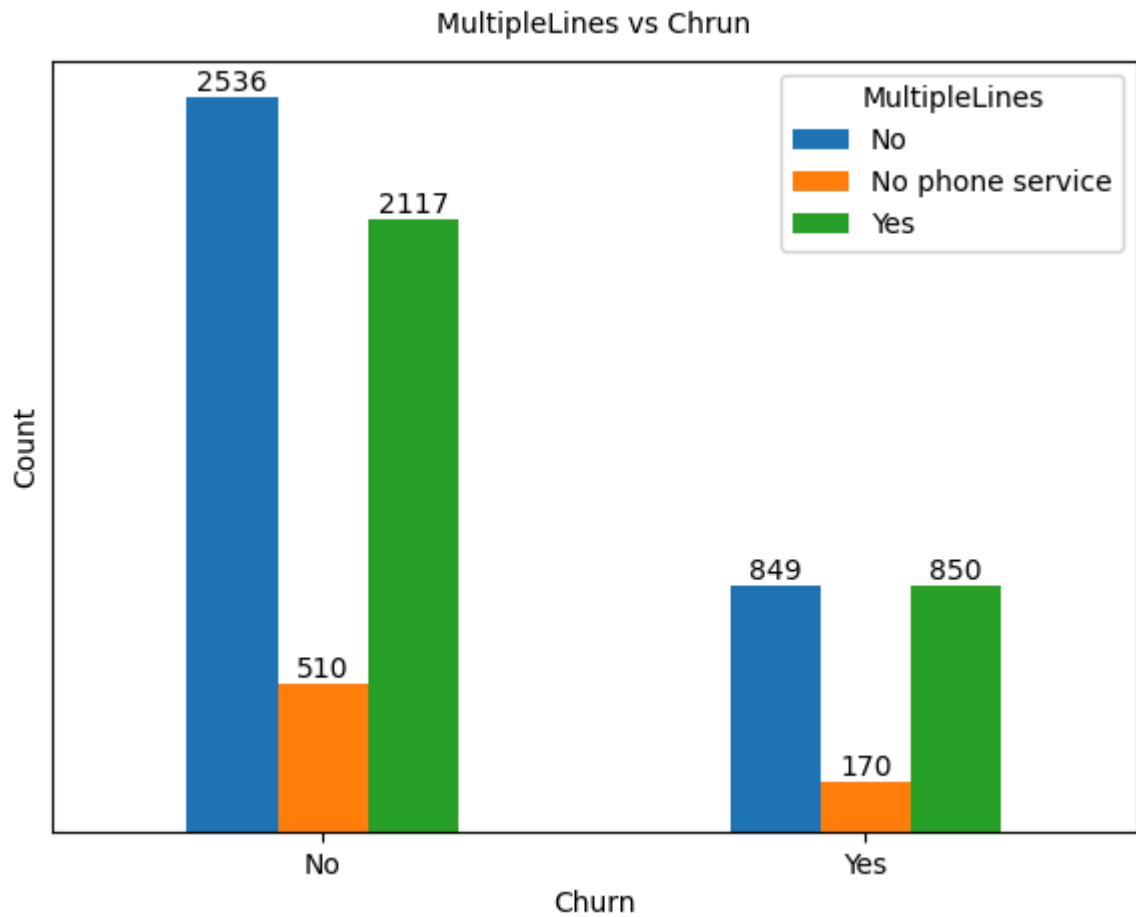


## 4.5 MultipleLines vs Chrun

```
In [252... ct = pd.crosstab(df.Churn,df.MultipleLines)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('MultipleLines vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

# ✅ Add Labels on each bar
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



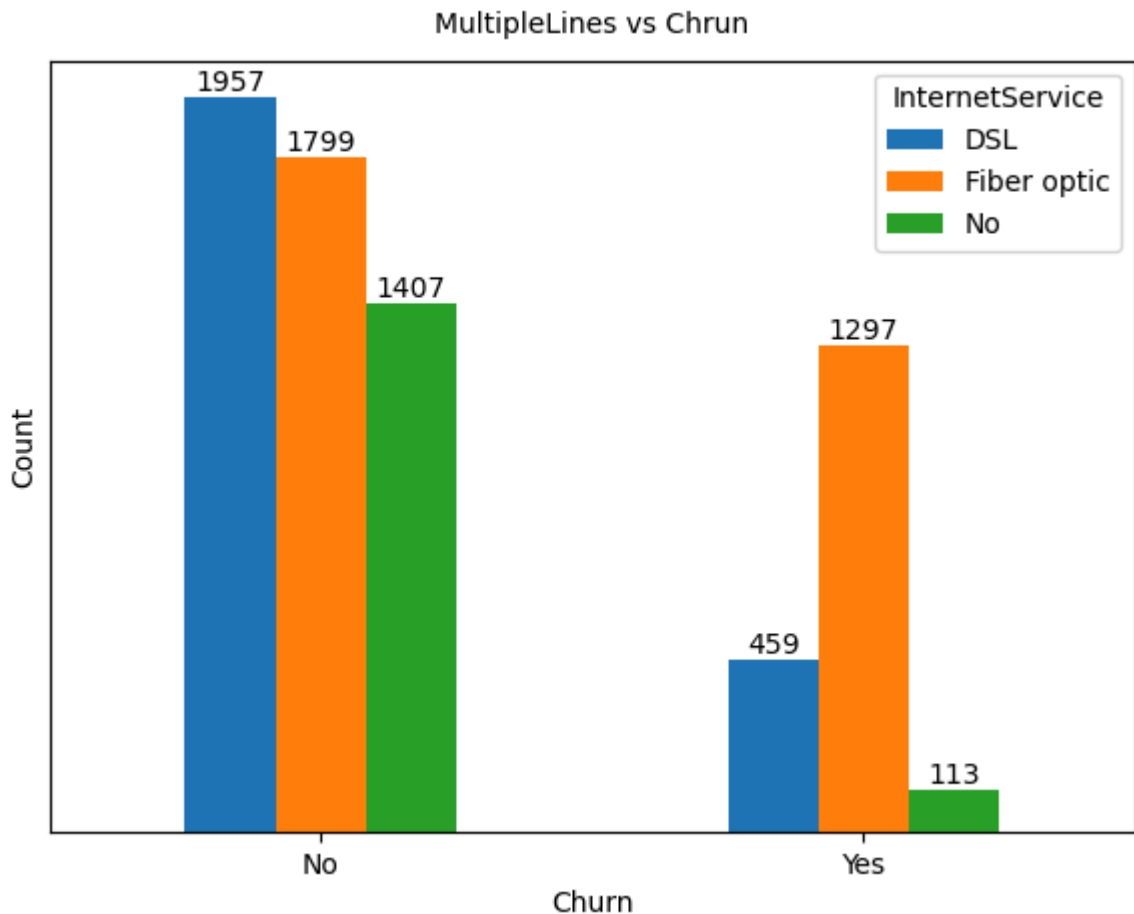
## 4.6 InternetService vs Chrun

```
In [253... ct = pd.crosstab(df.Churn,df.InternetService)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('MultipleLines vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```





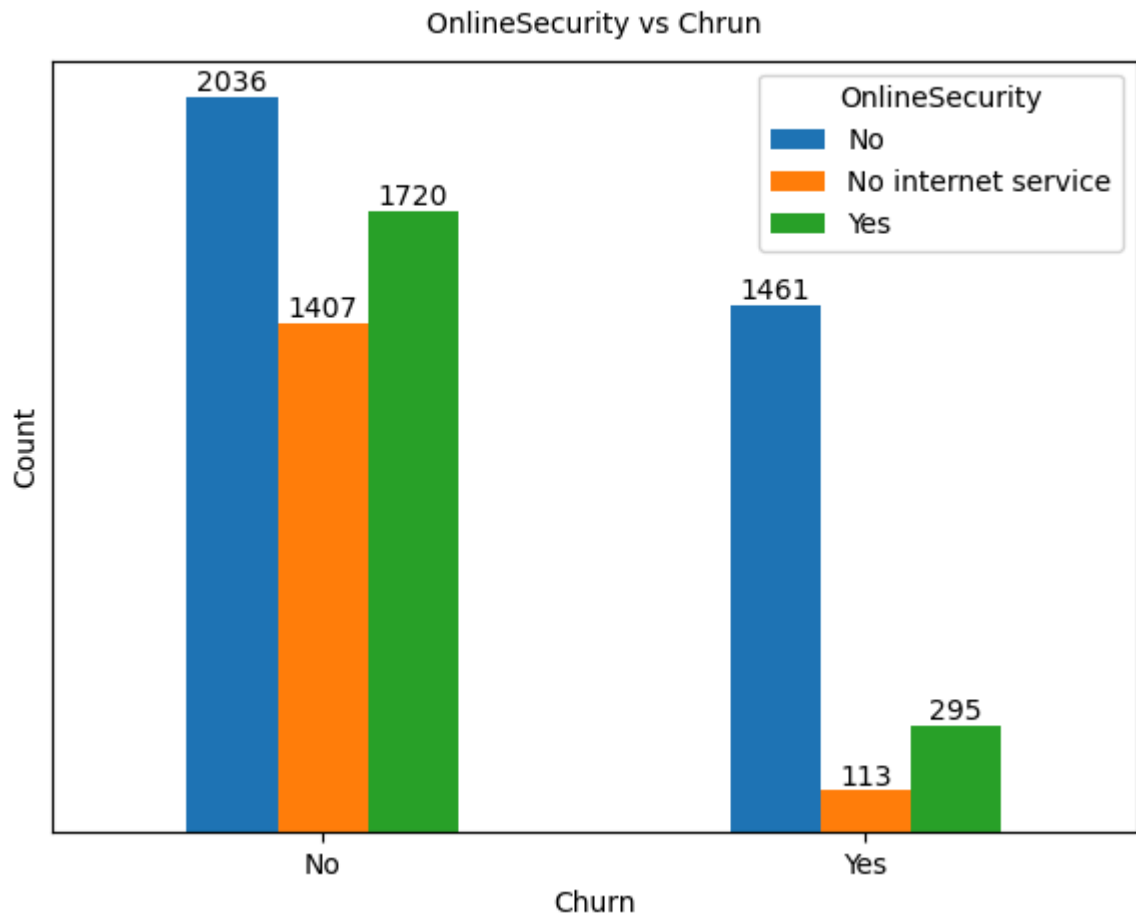
## 4.6 OnlineSecurity vs Chrun

In [254...

```
ct = pd.crosstab(df.Churn,df.OnlineSecurity)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('OnlineSecurity vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```

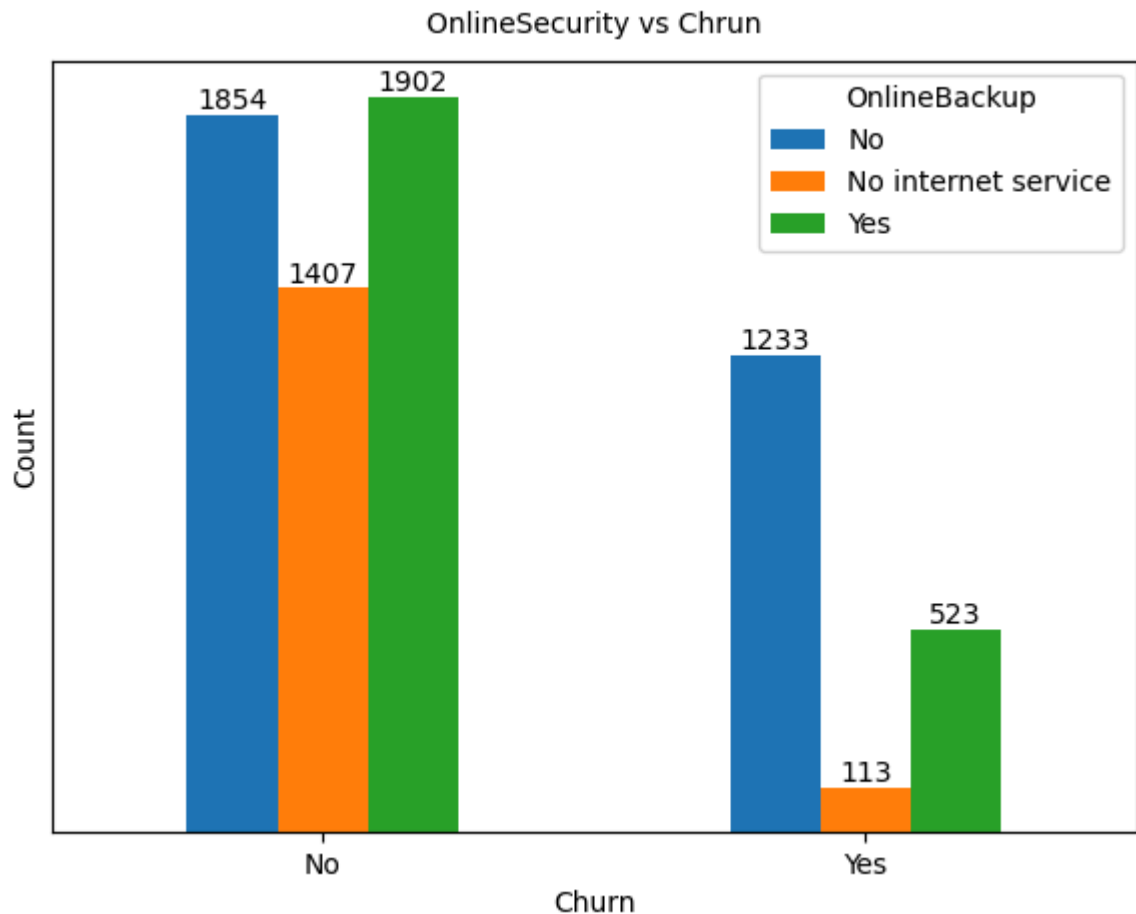


## 4.7 OnlineBackup vs Chrun

```
In [255... ct = pd.crosstab(df.Churn,df.OnlineBackup)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('OnlineSecurity vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```

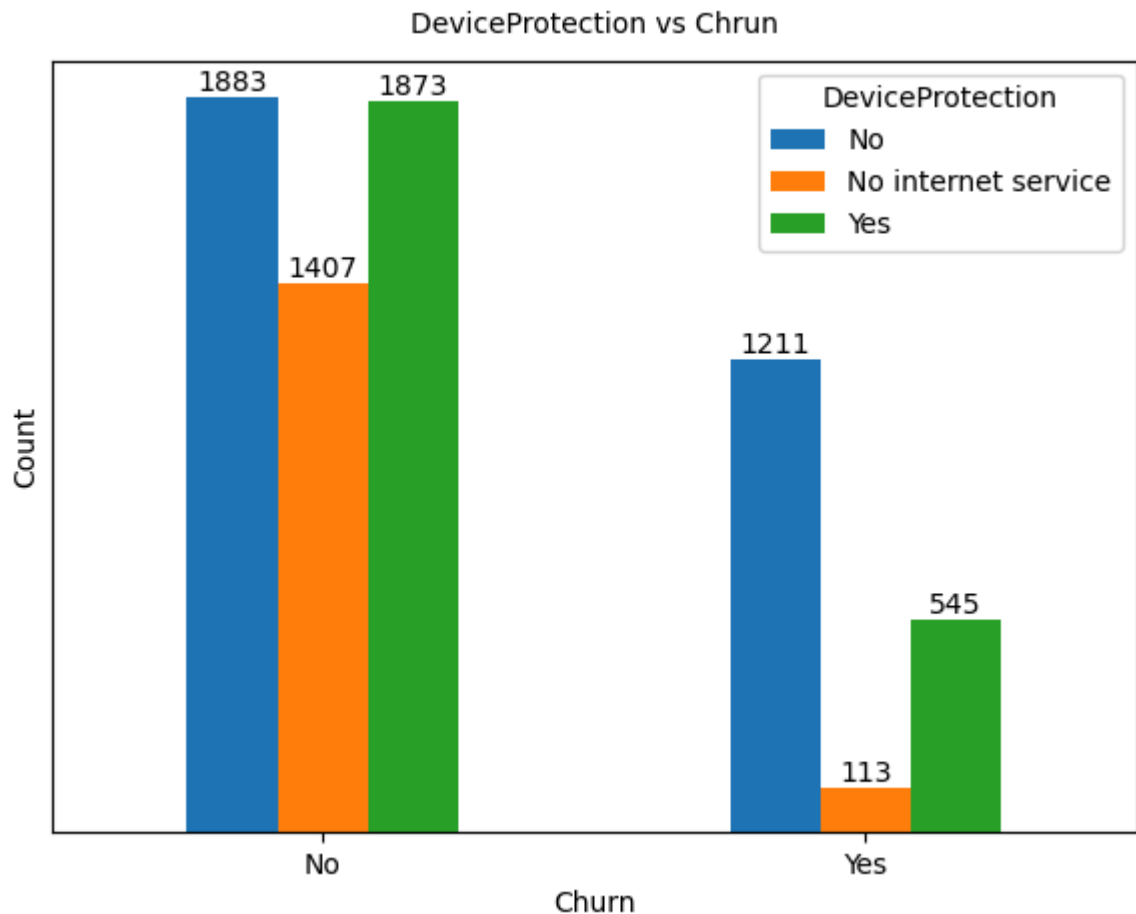


## 4.8 DeviceProtection vs Chrun

```
In [257... ct = pd.crosstab(df.Churn,df.DeviceProtection)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('DeviceProtection vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



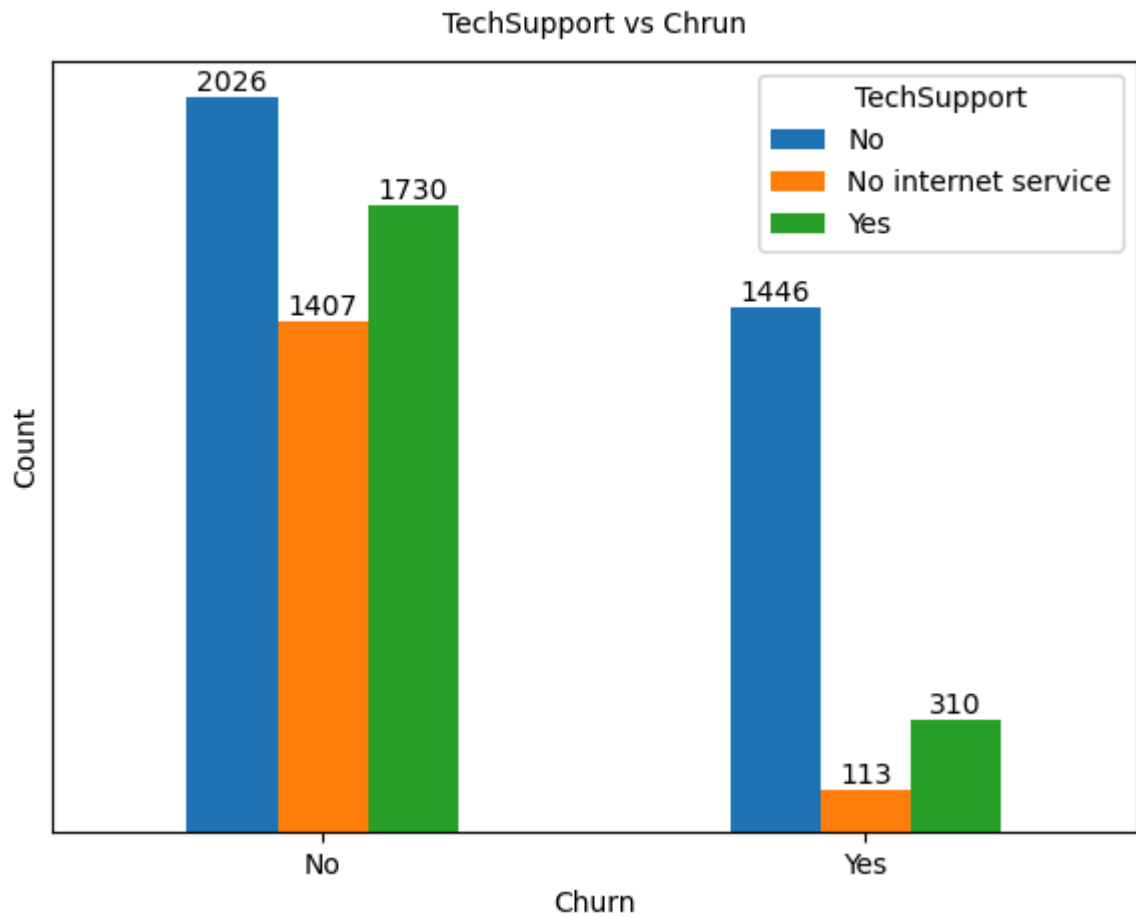
## 4.9 TechSupport vs Chrun

In [258...

```
ct = pd.crosstab(df.Churn, df.TechSupport)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('TechSupport vs Chrun', pad=10, size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



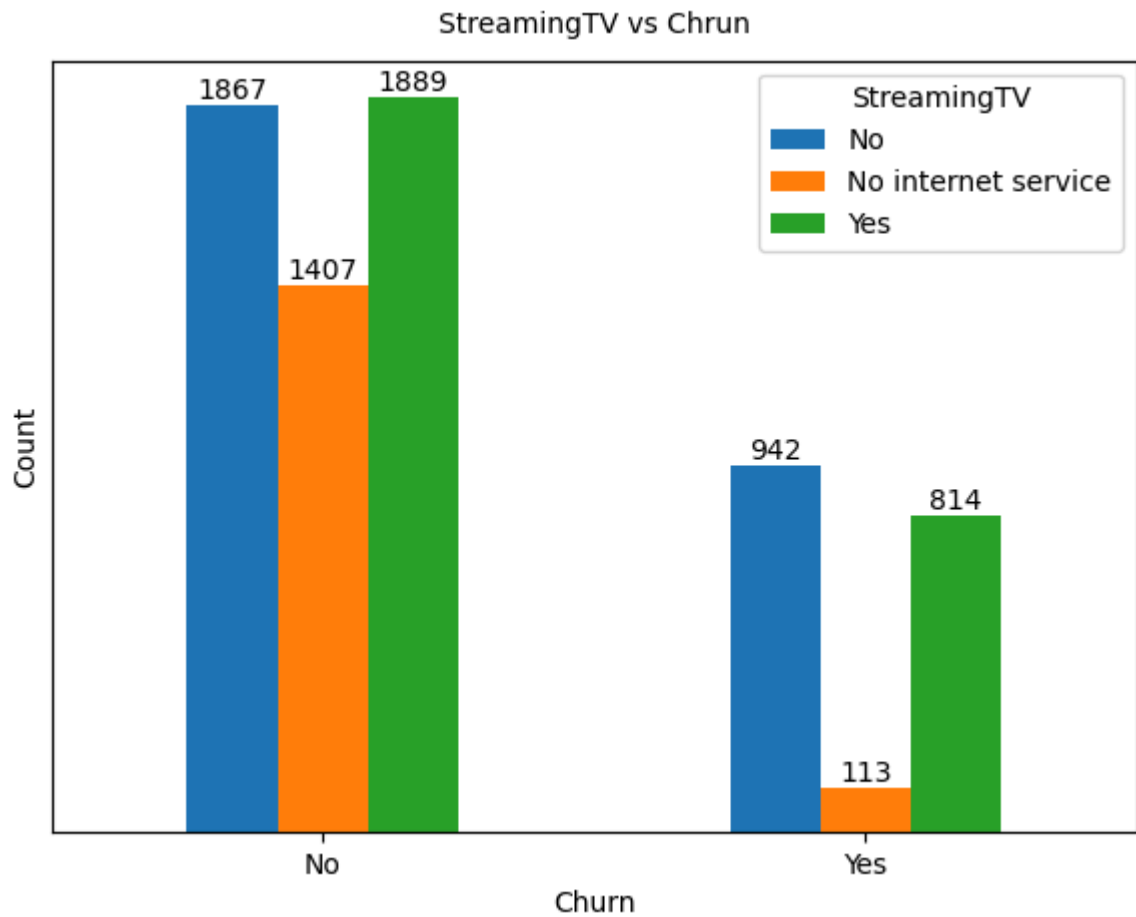
## 4.10 StreamingTV vs Chrun

In [259...

```
ct = pd.crosstab(df.Churn,df.StreamingTV)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('StreamingTV vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



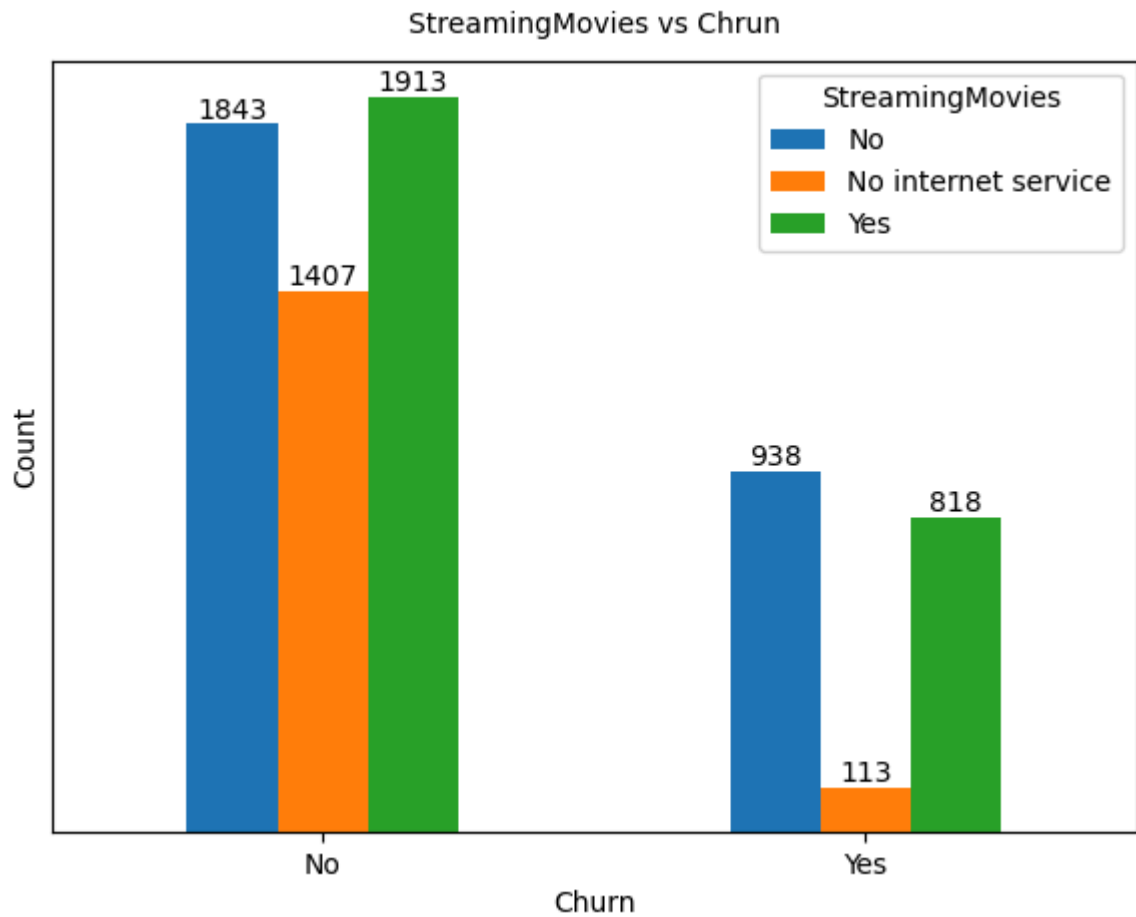
## 4.10 StreamingMovies vs Chrun

In [260...

```
ct = pd.crosstab(df.Churn,df.StreamingMovies)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('StreamingMovies vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



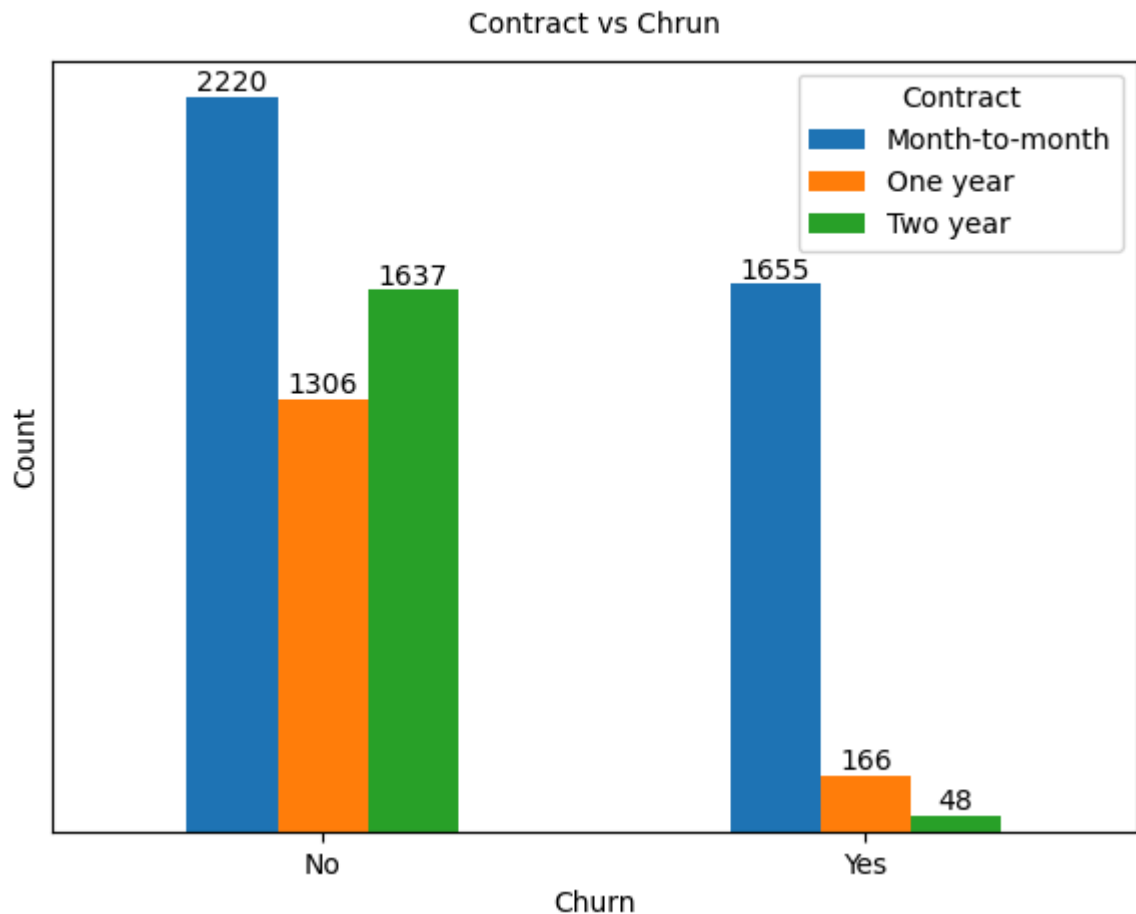
## 4.11 Contract vs Chrun

In [261...

```
ct = pd.crosstab(df.Churn,df.Contract)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('Contract vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



## 4.11 PaperlessBilling vs Chrun

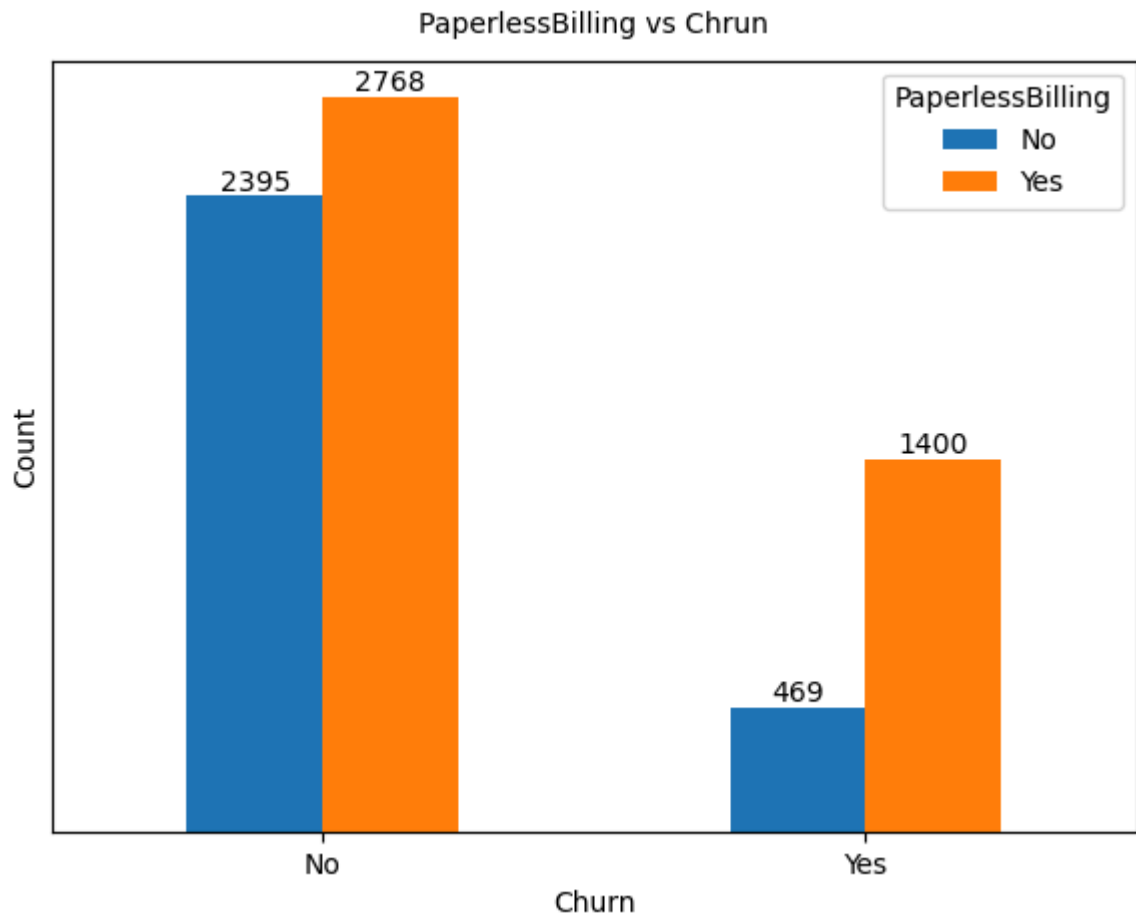
In [262...

```
ct = pd.crosstab(df.Churn,df.PaperlessBilling)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('PaperlessBilling vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```





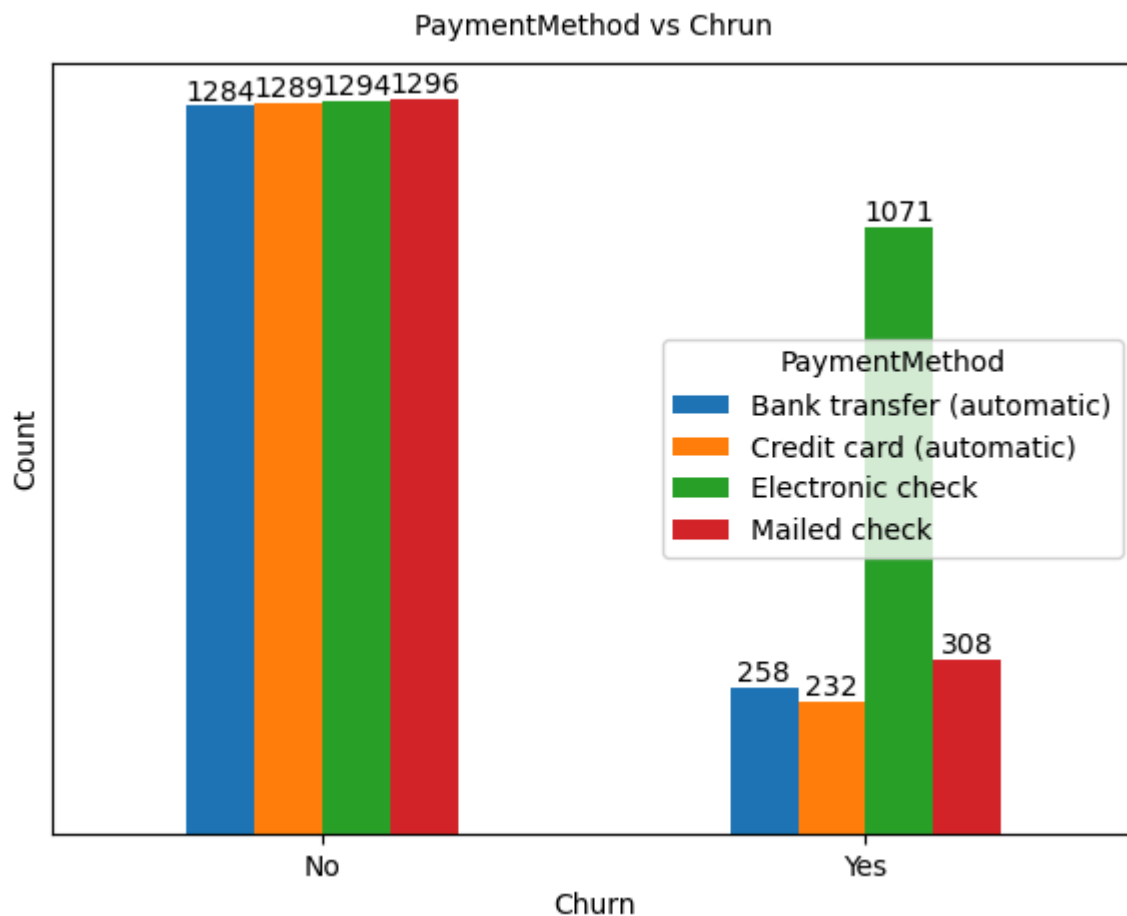
## 4.12 PaymentMethod vs Chrun

In [263...

```
ct = pd.crosstab(df.Churn,df.PaymentMethod)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('PaymentMethod vs Chrun',pad=10,size=10)
#plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

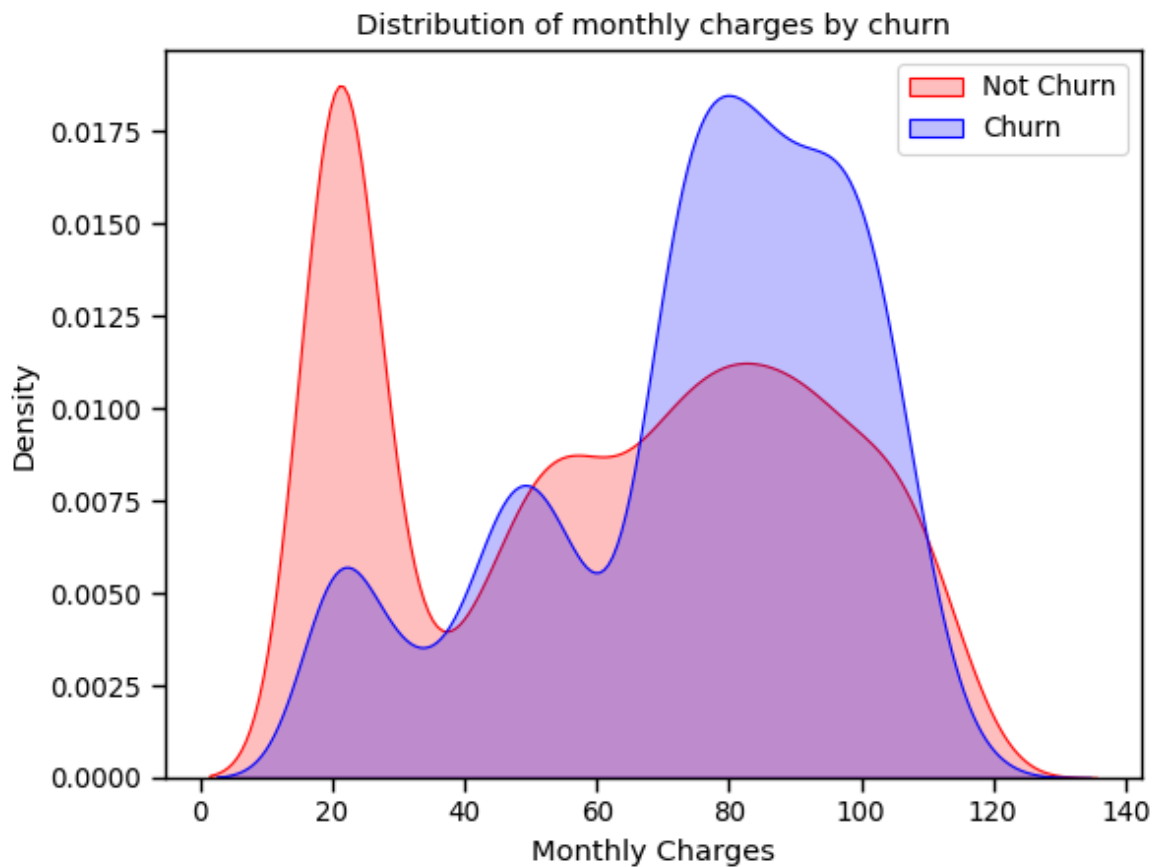
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
            ha='center', va='bottom', fontsize=10
        )
plt.yticks([])
plt.show()
```



### 4.13 Distribution of monthly charges by churn

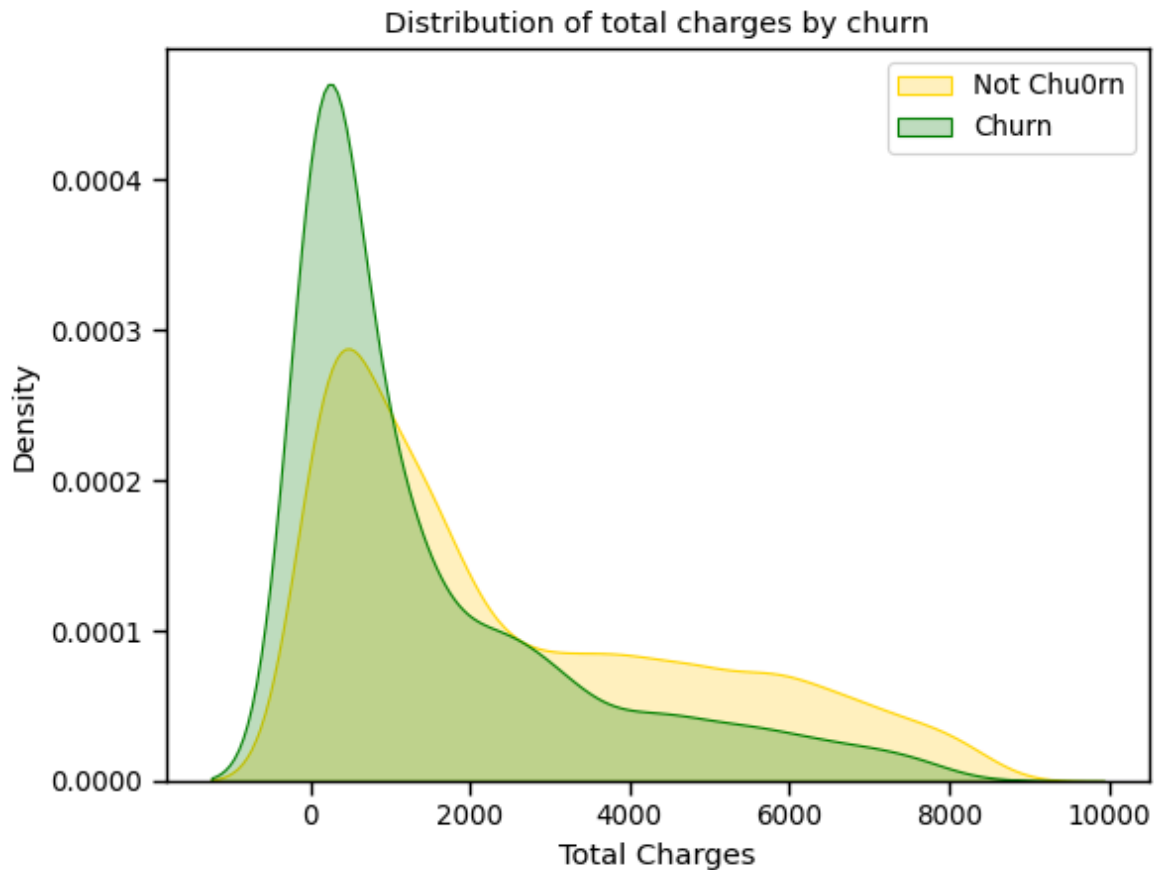
In [264...

```
sns.set_context("paper", font_scale=1.1)
ax = sns.kdeplot(df.MonthlyCharges[(df["Churn"] == 'No') ], color="Red", shade =
ax = sns.kdeplot(df.MonthlyCharges[(df["Churn"] == 'Yes') ], ax =ax, color="Blue"
ax.legend(["Not Churn", "Churn"], loc='upper right');
ax.set_ylabel('Density');
ax.set_xlabel('Monthly Charges');
ax.set_title('Distribution of monthly charges by churn');
```



#### 4.14 Distribution of total charges by churn

```
In [265... ax = sns.kdeplot(df.TotalCharges[(df["Churn"] == 'No') ],color="Gold", shade = True)
ax = sns.kdeplot(df.TotalCharges[(df["Churn"] == 'Yes') ],ax =ax, color="Green",
ax.legend(["Not Churn","Churn"],loc='upper right');
ax.set_ylabel('Density');
ax.set_xlabel('Total Charges');
ax.set_title('Distribution of total charges by churn');
```



## 5.Data Preprocessing

```
In [297...] df = pd.read_csv('WA_Fn-UseC_-Telco-Customer-Churn.csv')
```

```
In [298...] df.drop(labels=df[df['tenure'] == 0].index, axis=0, inplace=True)
df[df['tenure'] == 0].index
```

```
Out[298...] Index([], dtype='int64')
```

```
In [299...] df['TotalCharges'] = df['TotalCharges'].astype('float64')
```

### drop the unwanted columns

```
In [300...] df.drop(columns=['customerID'],inplace=True)
```

### Encoding

```
In [301...] df = pd.get_dummies(df, drop_first=True)
df = df.astype('int')
```

### Creating Dependent and Independent Variables

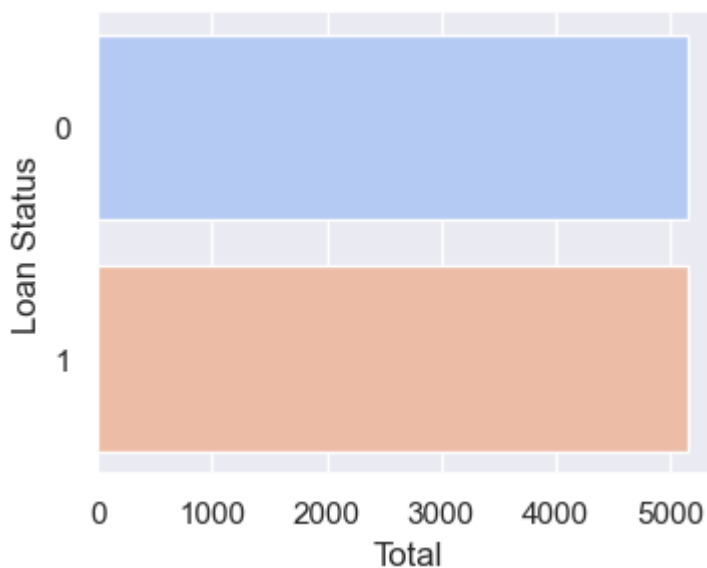
```
In [291...] X = df.drop(columns='Churn_Yes', axis=1)
y = df['Churn_Yes']
```

## SMOTE Technique

In previous exploration, it can be seen that the number between approved and rejected loan is imbalanced. In this section, oversampling technique will be used to avoid overfitting,

```
In [303... X, y = SMOTE().fit_resample(X, y)
```

```
In [304... plt.figure(figsize=(4,3))
sns.set_theme(style="darkgrid")
sns.countplot(y=y, data=df, palette="coolwarm")
plt.ylabel('Loan Status')
plt.xlabel('Total')
plt.show()
```



## Splitting data

```
In [305... X_train,X_test,y_train,y_test = train_test_split(X,y,random_state=0,test_size=0.
```

## Scaling data

```
In [311... sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

## Features Selection

```
In [339... rf = RandomForestClassifier(random_state=42)
rf.fit(X, y)

importances = rf.feature_importances_

rf_df = pd.DataFrame({
    'Feature': X.columns,
    'Importance': importances
```

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

```
rf_df
```

Out[339...

	Feature	Importance
3	TotalCharges	0.145851
1	tenure	0.142196
2	MonthlyCharges	0.106652
13	OnlineSecurity_Yes	0.062697
25	Contract_Two year	0.061405
19	TechSupport_Yes	0.053042
24	Contract_One year	0.044592
6	Dependents_Yes	0.028944
15	OnlineBackup_Yes	0.026630
10	InternetService_Fiber optic	0.026080
27	PaymentMethod_Credit card (automatic)	0.025331
4	gender_Male	0.024613
5	Partner_Yes	0.022859
26	PaperlessBilling_Yes	0.021039
17	DeviceProtection_Yes	0.020809
29	PaymentMethod_Mailed check	0.019563
28	PaymentMethod_Electronic check	0.017477
9	MultipleLines_Yes	0.015274
0	SeniorCitizen	0.015136
18	TechSupport_No internet service	0.014257
21	StreamingTV_Yes	0.014170
23	StreamingMovies_Yes	0.014132
16	DeviceProtection_No internet service	0.013137
20	StreamingTV_No internet service	0.012092
12	OnlineSecurity_No internet service	0.011958
14	OnlineBackup_No internet service	0.011389
11	InternetService_No	0.009881
22	StreamingMovies_No internet service	0.007903
7	PhoneService_Yes	0.006060
8	MultipleLines_No phone service	0.004832

```
In [340... top_features = rf_df['Feature'].head(10).values
print("Selected Top Features:", top_features)

# Create final X
X_selected = X[top_features]
```

Selected Top Features: ['TotalCharges' 'tenure' 'MonthlyCharges' 'OnlineSecurity\_Yes'

'Contract\_Two year' 'TechSupport\_Yes' 'Contract\_One year'  
'Dependents\_Yes' 'OnlineBackup\_Yes' 'InternetService\_Fiber optic']

**After selecting the top features, again split the data.**

```
In [365... X_train, X_test, y_train, y_test = train_test_split(X_selected, y, test_size=0.3)
```

## LogisticRegression

```
In [366... model = LogisticRegression(max_iter=1000)
model.fit(X_train, y_train)

print("Train Score:", model.score(X_train, y_train))
print("Test Score:", model.score(X_test, y_test))
```

Train Score: 0.7991145545102379

Test Score: 0.8102001291155584

```
In [367... y_pred = model.predict(X_test)
```

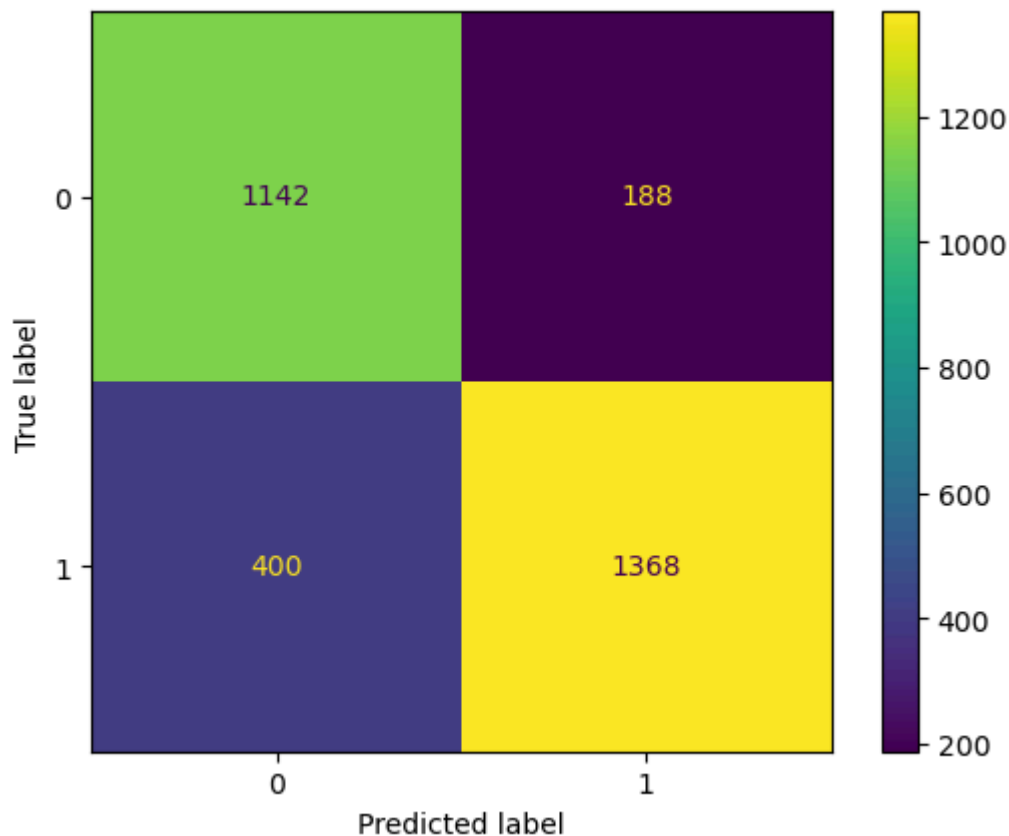
```
In [368... accuracy_score(y_pred,y_test)
```

```
Out[368... 0.8102001291155584
```

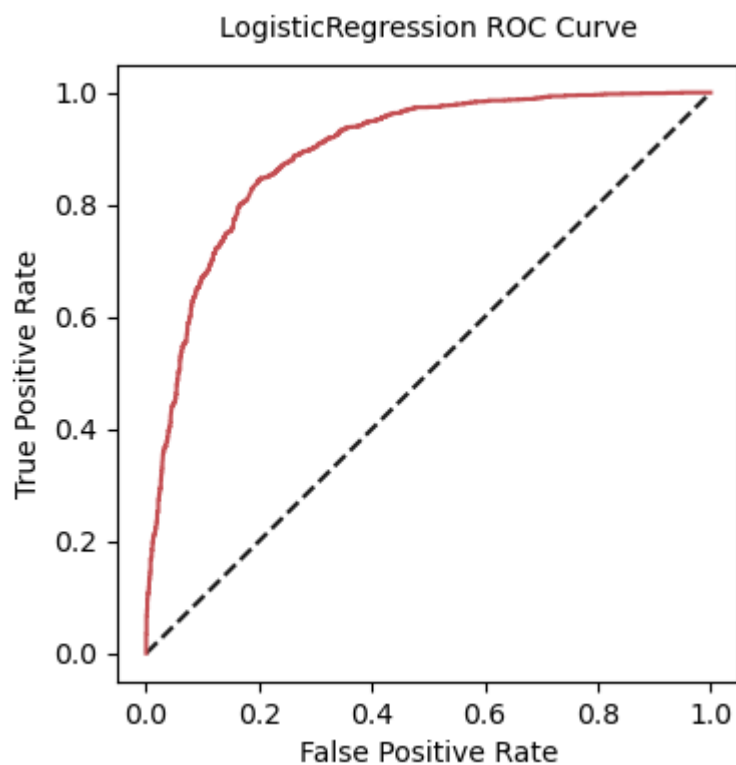
```
In [369... print(classification_report(y_pred,y_test))
```

	precision	recall	f1-score	support
0	0.74	0.86	0.80	1330
1	0.88	0.77	0.82	1768
accuracy			0.81	3098
macro avg	0.81	0.82	0.81	3098
weighted avg	0.82	0.81	0.81	3098

```
In [370... ConfusionMatrixDisplay.from_predictions(y_pred,y_test)
plt.show()
```



```
In [378... plt.figure(figsize=(4,4))
y_lg_pred_prob = model.predict_proba(X_test)[: ,1]
fpr_rf, tpr_rf, thresholds = roc_curve(y_test, y_lg_pred_prob)
plt.plot([0, 1], [0, 1], 'k--' )
plt.plot(fpr_rf, tpr_rf, label='Random Forest',color = "r")
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('LogisticRegression ROC Curve',fontsize=10,pad=10,size=10)
plt.show();
```





## KNN

```
In [393... knn_model = KNeighborsClassifier()
knn_model.fit(X_train,y_train)
predicted_y = knn_model.predict(X_test)
accuracy_knn = knn_model.score(X_test,y_test)
print("KNN accuracy:",accuracy_knn)
```

KNN accuracy: 0.7640413169786959

```
In [394... print("Train Score:", knn_model.score(X_train, y_train))
print("Test Score:", knn_model.score(X_test, y_test))
```

Train Score: 0.8180686220254566

Test Score: 0.7640413169786959

```
In [395... y_pred = knn_model.predict(X_test)
```

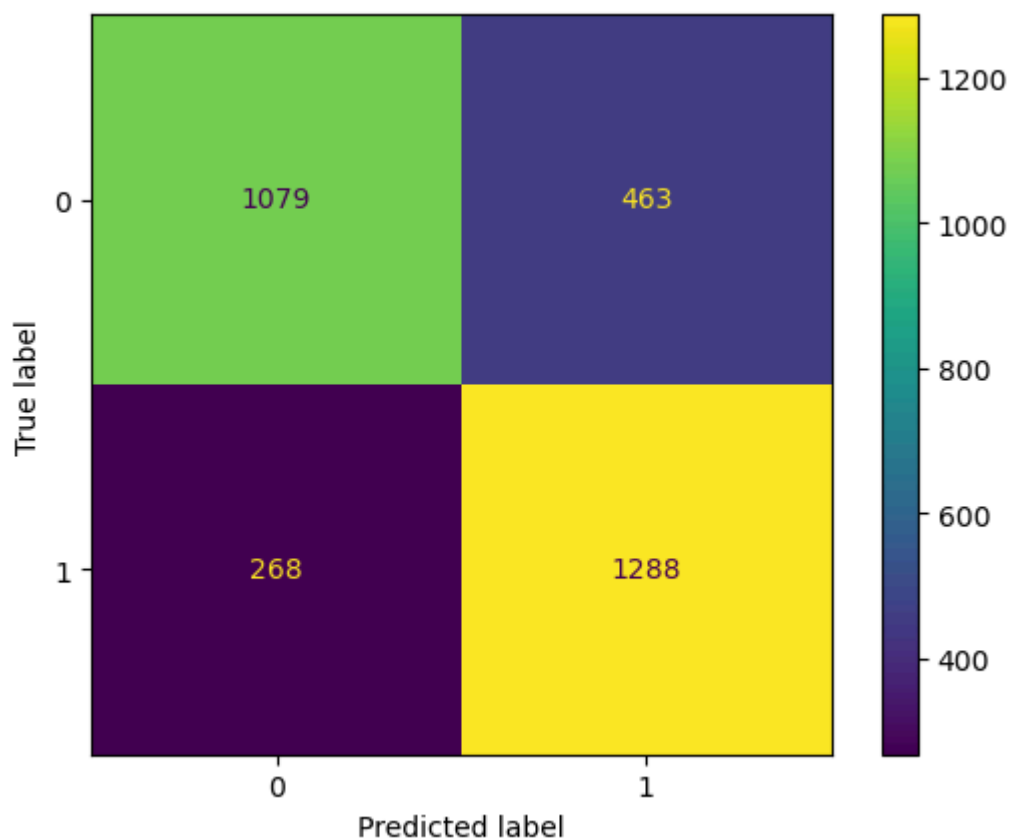
```
In [396... accuracy_score(y_pred,y_test)
```

Out[396... 0.7640413169786959

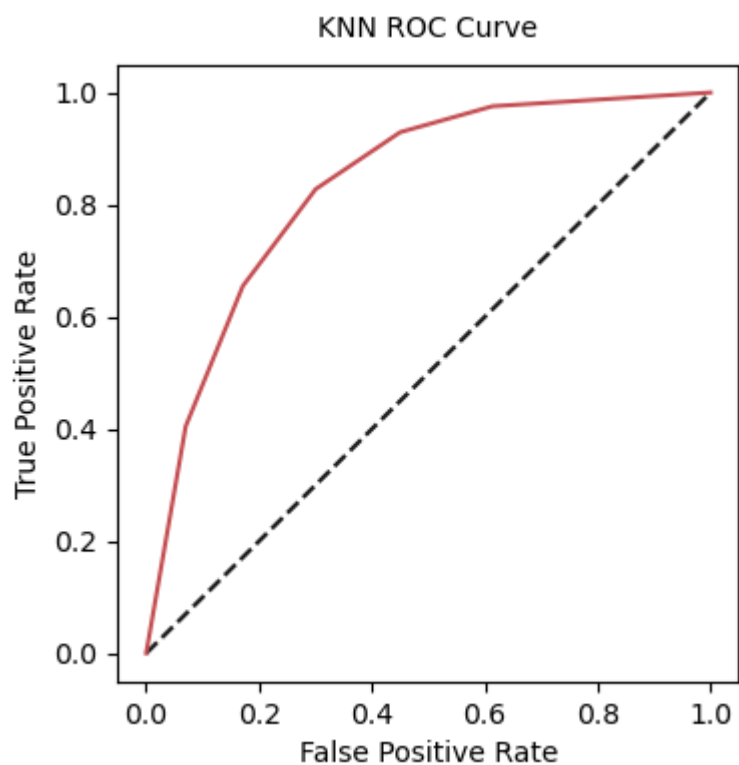
```
In [397... print(classification_report(y_pred,y_test))
```

	precision	recall	f1-score	support
0	0.70	0.80	0.75	1347
1	0.83	0.74	0.78	1751
accuracy			0.76	3098
macro avg	0.76	0.77	0.76	3098
weighted avg	0.77	0.76	0.77	3098

```
In [398... ConfusionMatrixDisplay.from_predictions(y_test,y_pred)
plt.show()
```



```
In [399... plt.figure(figsize=(4,4))
y_log_knn_prob = knn_model.predict_proba(X_test)[:,-1]
fpr_knn,tpr_knn,thresholds = roc_curve(y_test,y_log_knn_prob )
plt.plot([0,1],[0,1], 'k--')
plt.plot(fpr_knn,tpr_knn,label='KNN',color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('KNN ROC Curve',fontsize=10,pad=10,size=10)
plt.show()
```



# RandomForestClassifier

```
In [400... model_rf = RandomForestClassifier()
model_rf.fit(X_train,y_train)
```

```
Out[400... ▼ RandomForestClassifier ⓘ ?
```

```
RandomForestClassifier()
```

```
In [401... print('Train Score:',model_rf.score(X_train,y_train))
print('Test Score:',model_rf.score(X_test,y_test))
```

Train Score: 0.9798007747648035

Test Score: 0.828921885087153

```
In [402... y_pred = model_rf.predict(X_test)
```

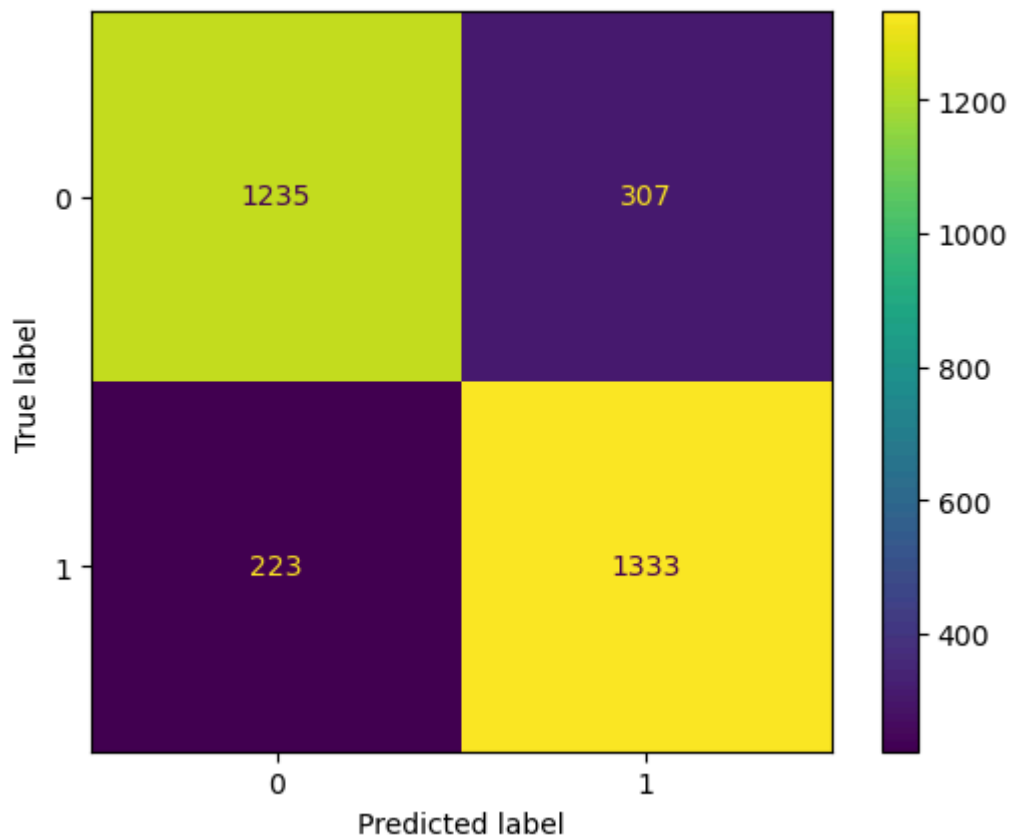
```
In [403... accuracy_score(y_pred,y_test)
```

```
Out[403... 0.828921885087153
```

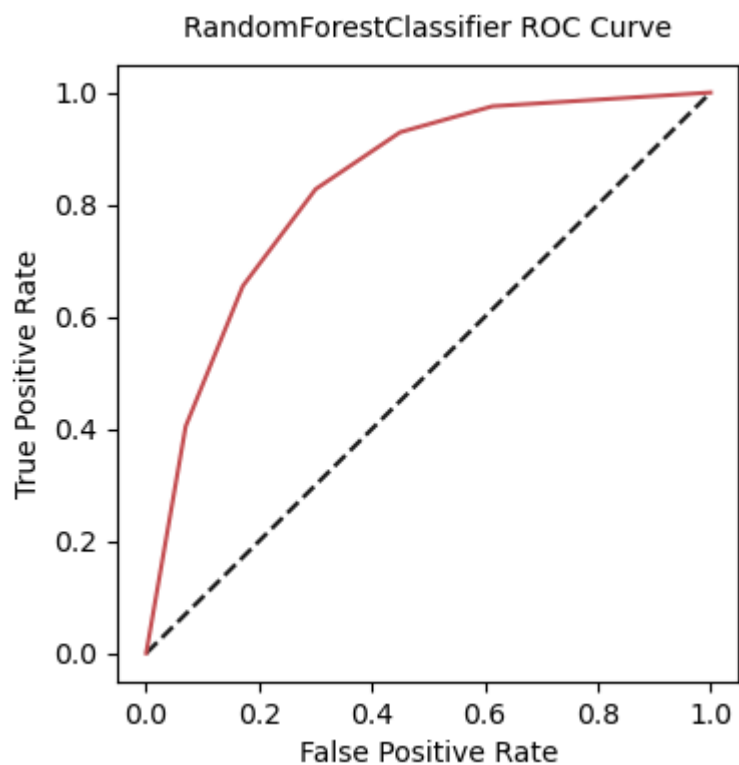
```
In [404... print(classification_report(y_pred,y_test))
```

	precision	recall	f1-score	support
0	0.80	0.85	0.82	1458
1	0.86	0.81	0.83	1640
accuracy			0.83	3098
macro avg	0.83	0.83	0.83	3098
weighted avg	0.83	0.83	0.83	3098

```
In [405... ConfusionMatrixDisplay.from_predictions(y_test,y_pred)
plt.show()
```



```
In [406... plt.figure(figsize=(4,4))
proba_rf = model_rf.predict_proba(X_test)[:,-1]
fpr_rf, tpr_rf, threshold = roc_curve(y_test, proba_rf)
plt.plot([0,1],[0,1], 'k--')
plt.plot(fpr_knn, tpr_knn, label='RF', color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('RandomForestClassifier ROC Curve', fontsize=10, pad=10, size=10)
plt.show()
```



# Decision Tree Classifier

```
In [415... model_dt = DecisionTreeClassifier(criterion='entropy',min_samples_split=100)
model_dt.fit(X_train,y_train)
```

```
Out[415... DecisionTreeClassifier
DecisionTreeClassifier(criterion='entropy', min_samples_split=100)
```

```
In [416... print("The Train Score:",model_dt.score(X_train,y_train))
print("The Test Score:",model_dt.score(X_test,y_test))
```

The Train Score: 0.8263696734919757

The Test Score: 0.8185926404131698

```
In [417... y_pred_dt = model_dt.predict(X_test)
```

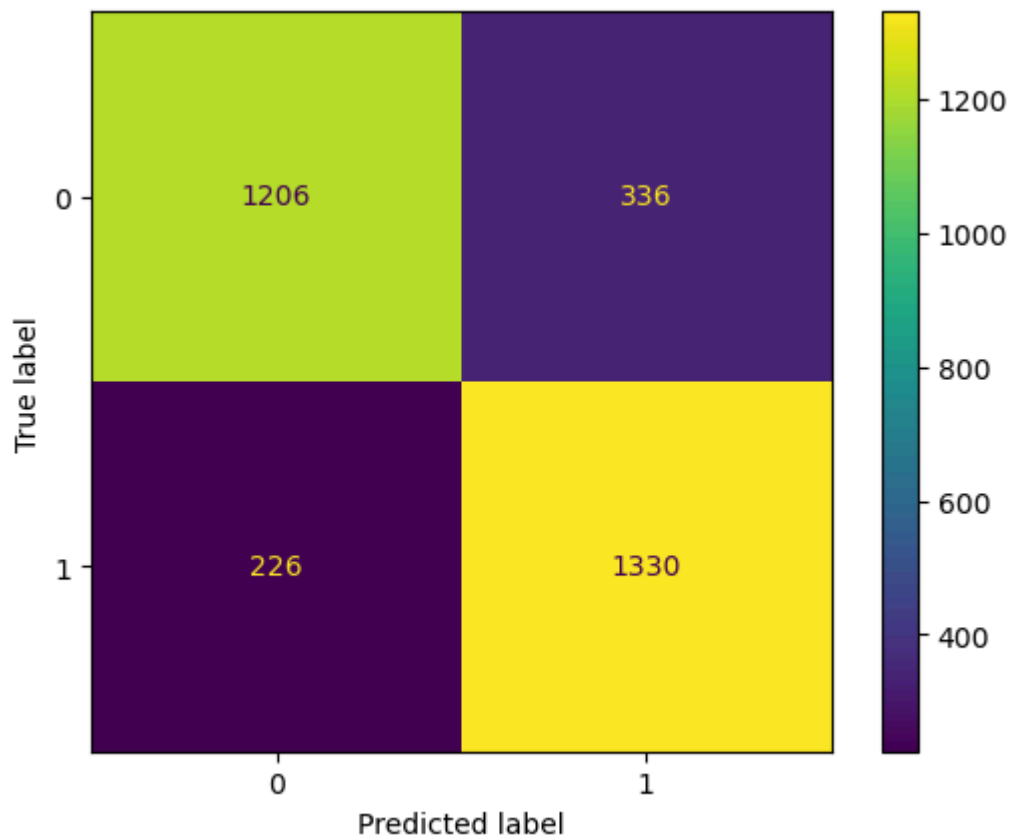
```
In [418... accuracy_score(y_test,y_pred_dt)
```

```
Out[418... 0.8185926404131698
```

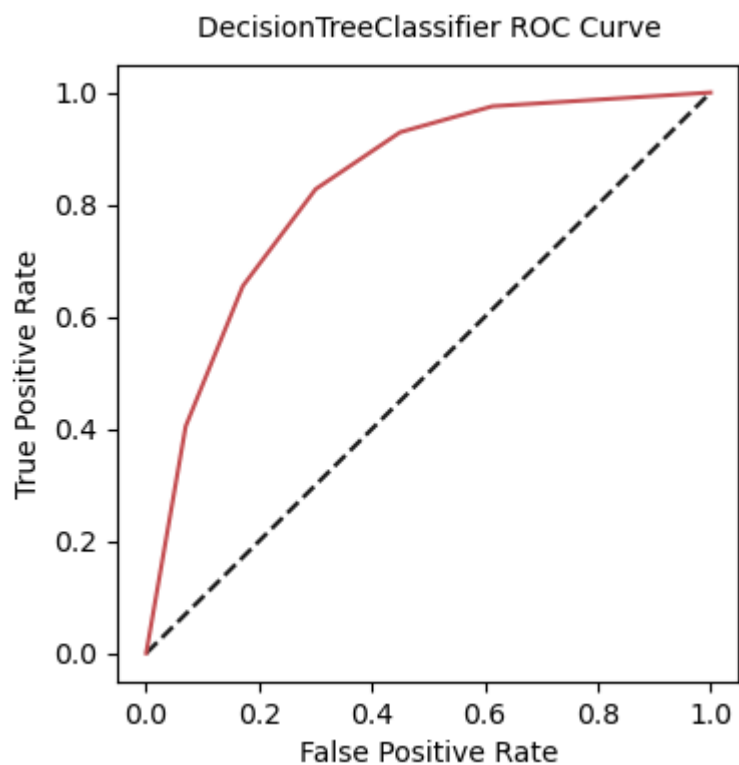
```
In [419... print(classification_report(y_test,y_pred_dt))
```

	precision	recall	f1-score	support
0	0.84	0.78	0.81	1542
1	0.80	0.85	0.83	1556
accuracy			0.82	3098
macro avg	0.82	0.82	0.82	3098
weighted avg	0.82	0.82	0.82	3098

```
In [420... ConfusionMatrixDisplay.from_predictions(y_test,y_pred_dt)
plt.show()
```



```
In [431... plt.figure(figsize=(4,4))
proba_rf = model_dt.predict_proba(X_test)[: ,1]
fpr_rf, tpr_rf, threshold = roc_curve(y_test, proba_rf)
plt.plot([0,1],[0,1], 'k--')
plt.plot(fpr_knn, tpr_knn, label='RF', color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('DecisionTreeClassifier ROC Curve', fontsize=10, pad=10, size=10)
plt.show()
```



# SVM

```
In [454...] svc = SVC(kernel='rbf', probability=True, max_iter=1000)
            svc.fit(X_train, y_train)
```

```
Out[454...] SVC
            SVC(max_iter=1000, probability=True)
```

```
In [455...] print('The Train Score:',svc.score(X_train,y_train))
            print('The Test Score:',svc.score(X_test,y_test))
```

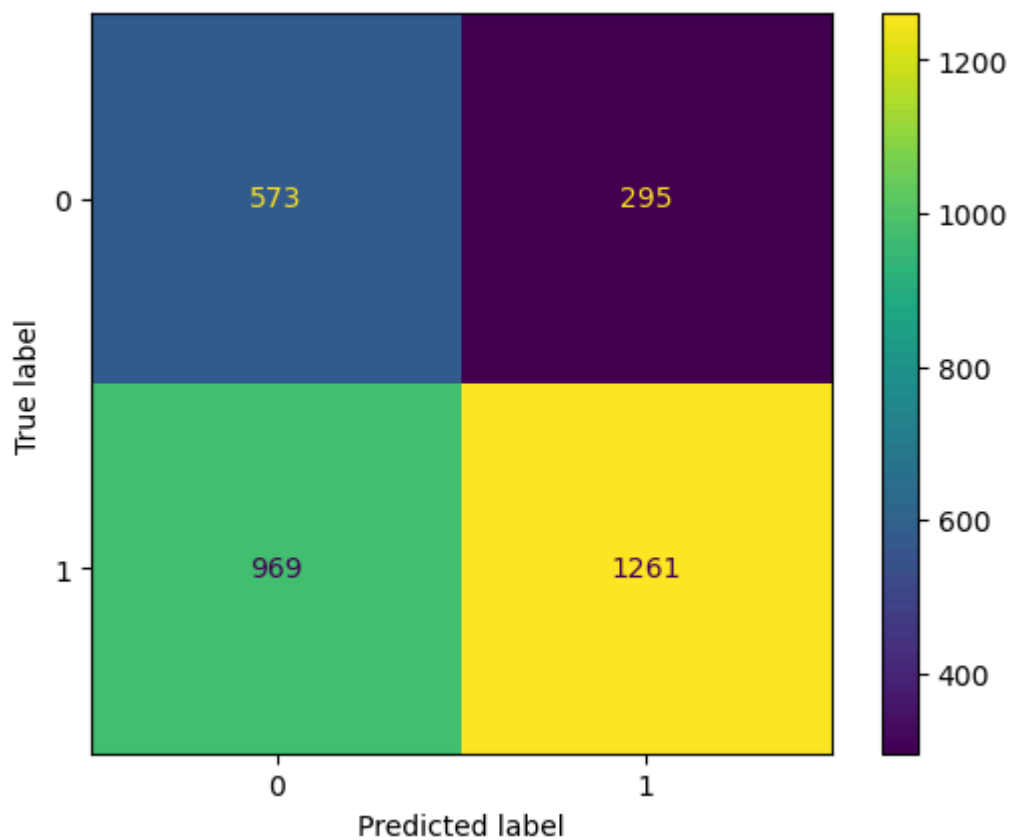
The Train Score: 0.5820420586607638  
The Test Score: 0.591994835377663

```
In [456...] y_pred_sv = svc.predict(X_test)
```

```
In [457...] accuracy_score(y_pred_sv,y_test)
```

```
Out[457...] 0.591994835377663
```

```
In [458...] ConfusionMatrixDisplay.from_predictions(y_pred_sv,y_test)
            plt.show()
```

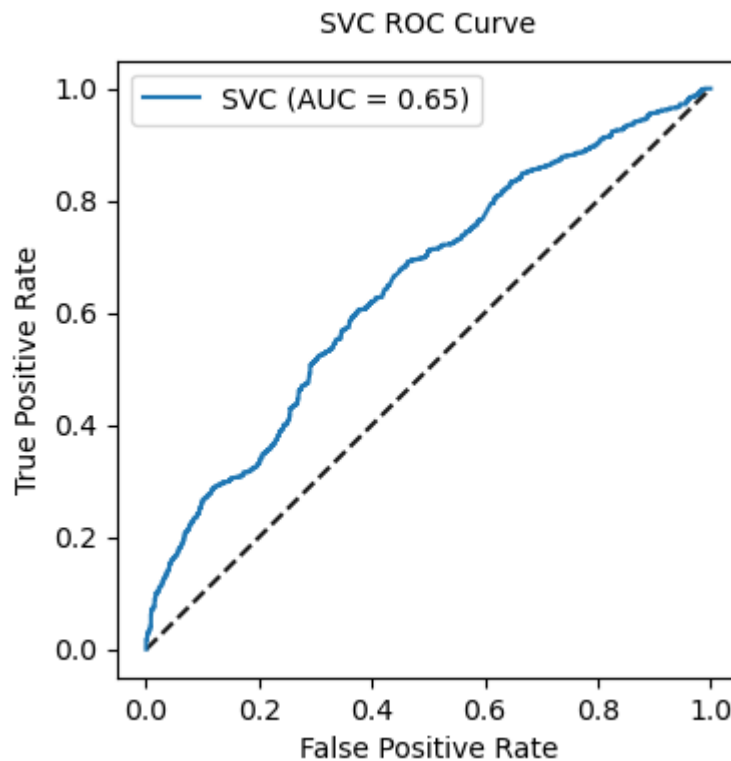


```
In [459...] plt.figure(figsize=(4,4))
            proba_svc = svc.predict_proba(X_test)[: , 1]
            fpr_svc, tpr_svc, threshold = roc_curve(y_test, proba_svc)
            auc_svc = auc(fpr_svc, tpr_svc)

            plt.plot([0,1],[0,1], 'k--')
```

```
plt.plot(fpr_svc, tpr_svc, label=f'SVC (AUC = {auc_svc:.2f})')

plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('SVC ROC Curve', fontsize=10, pad=10)
plt.legend()
plt.show()
```



## Naive Bayes

In [437...

```
NB = GaussianNB()
NB.fit(X_train,y_train)

y_pred_NB = NB.predict(X_test)

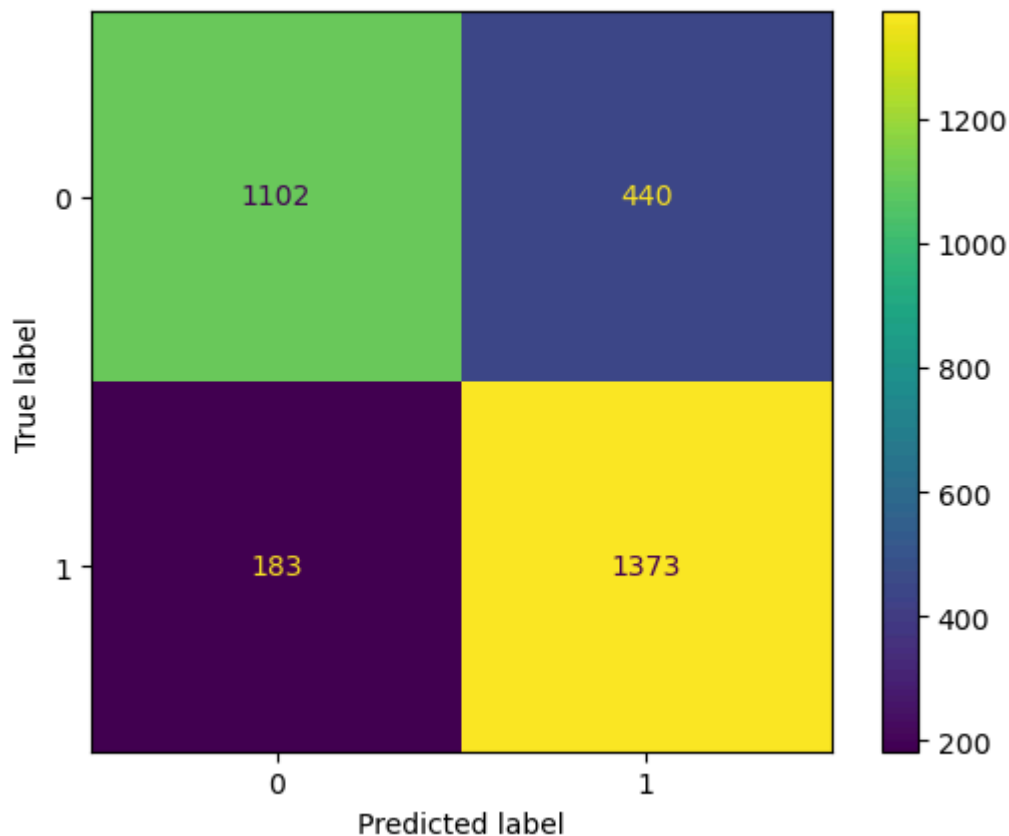
print('accuracy_score:',accuracy_score(y_test,y_pred_NB))
print(classification_report(y_test,y_pred_NB))

ConfusionMatrixDisplay.from_predictions(y_test, y_pred_NB)
plt.show()
```

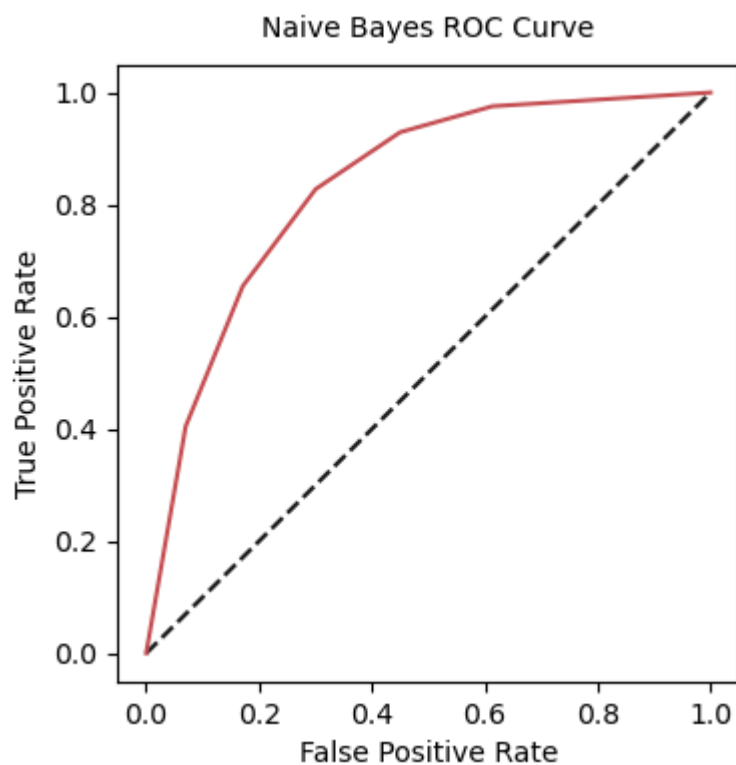
```
accuracy_score: 0.7989025177533893
```

	precision	recall	f1-score	support
0	0.86	0.71	0.78	1542
1	0.76	0.88	0.82	1556
accuracy			0.80	3098
macro avg	0.81	0.80	0.80	3098
weighted avg	0.81	0.80	0.80	3098





```
In [439... plt.figure(figsize=(4,4))
proba_rf = NB.predict_proba(X_test)[: ,1]
fpr_rf, tpr_rf, thersold = roc_curve(y_test, proba_rf)
plt.plot([0,1],[0,1], 'k--')
plt.plot(fpr_knn, tpr_knn, label='RF', color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Naive Bayes ROC Curve', fontsize=10, pad=10, size=10)
plt.show()
```



# XGBClassifier

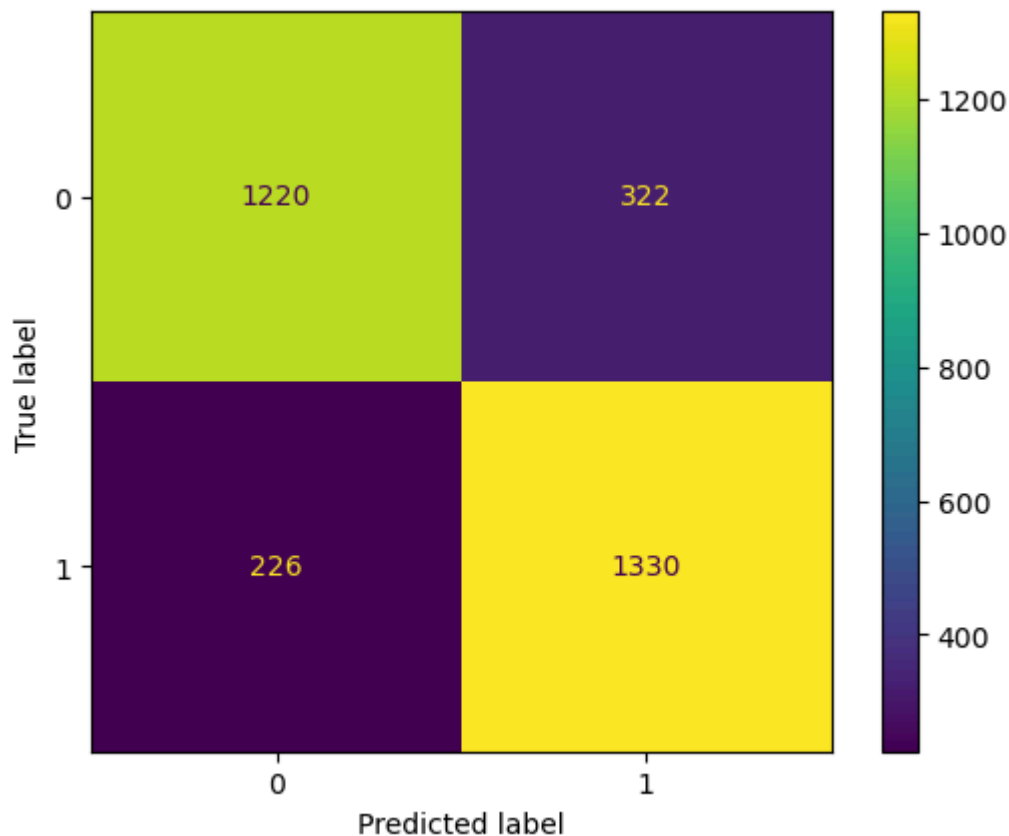
```
In [440... xgb = XGBClassifier(eval_metric='logloss', use_label_encoder=False, learning_rate
xgb.fit(X_train,y_train)
y_pred_xgb = xgb.predict(X_test)
print("Test Accuracy - XGBoost:", accuracy_score(y_test, y_pred_xgb))

print(classification_report(y_test,y_pred_xgb))

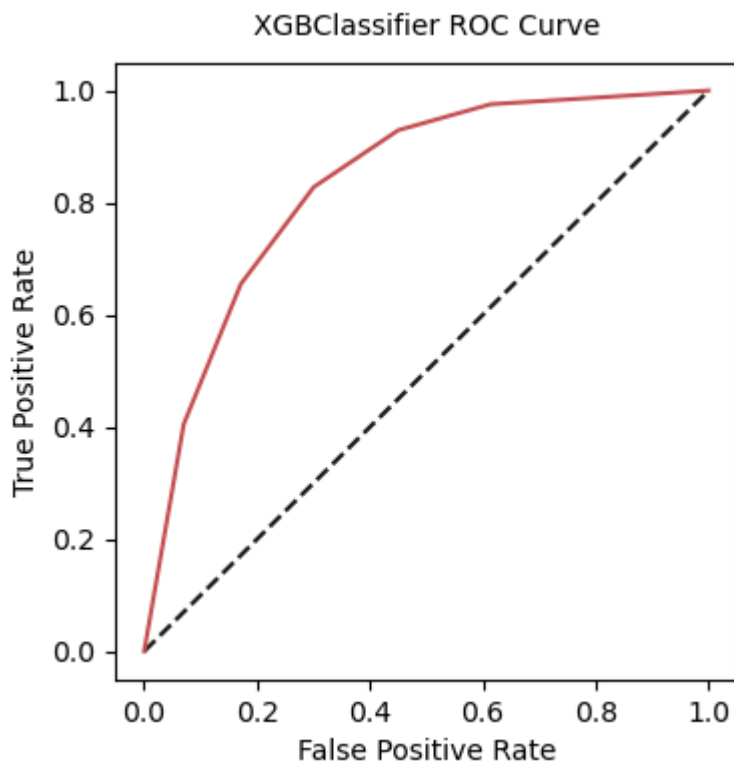
ConfusionMatrixDisplay.from_predictions(y_test,y_pred_xgb)
plt.show()
```

Test Accuracy - XGBoost: 0.8231116849580374

	precision	recall	f1-score	support
0	0.84	0.79	0.82	1542
1	0.81	0.85	0.83	1556
accuracy			0.82	3098
macro avg	0.82	0.82	0.82	3098
weighted avg	0.82	0.82	0.82	3098



```
In [441... plt.figure(figsize=(4,4))
proba_rf = xgb.predict_proba(X_test)[: ,1]
fpr_rf, tpr_rf, thersold = roc_curve(y_test, proba_rf)
plt.plot([0,1],[0,1], 'k--')
plt.plot(fpr_knn, tpr_knn, label='RF', color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('XGBClassifier ROC Curve', fontsize=10, pad=10, size=10)
plt.show()
```



## LGBMClassifier

```
In [442... lgb = LGBMClassifier(colsample_bytree = 1.0, learning_rate = 0.1, max_depth = 9
lgb.fit(X_train,y_train)

y_pred_lgb = lgb.predict(X_test)

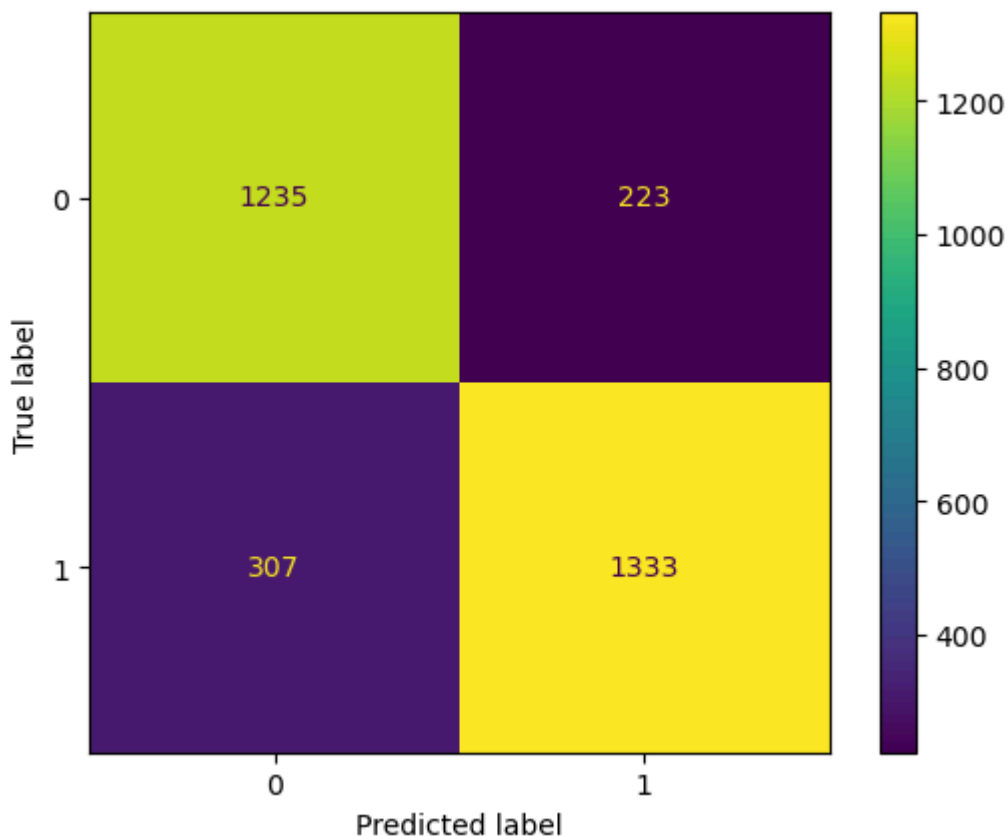
print('accuracy_score:',accuracy_score(y_test,y_pred_lgb))

print(classification_report(y_pred_lgb,y_test))

ConfusionMatrixDisplay.from_predictions(y_pred,y_test)
plt.show()
```

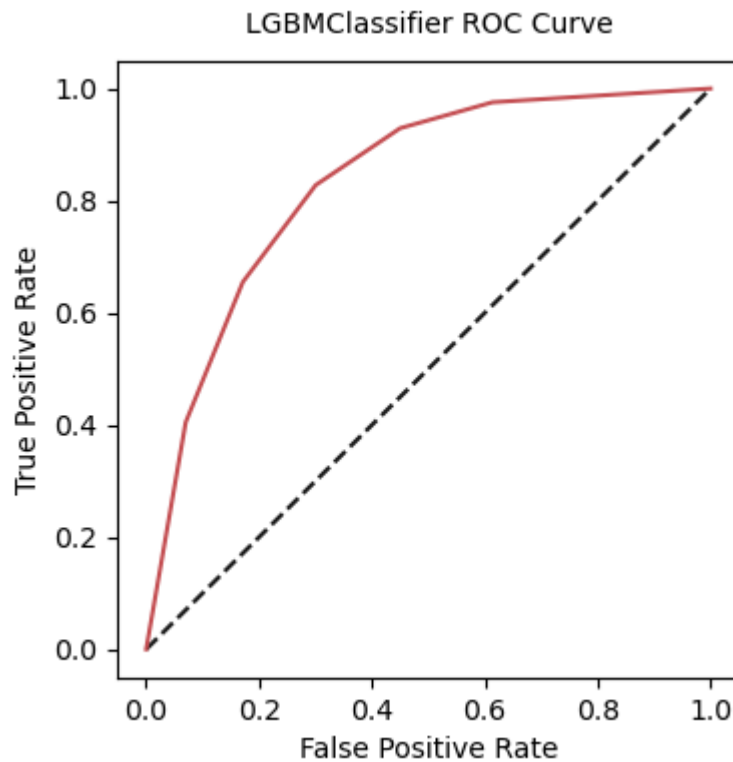
```
[LightGBM] [Warning] Found whitespace in feature_names, replace with underlines
[LightGBM] [Info] Number of positive: 3607, number of negative: 3621
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of testing
was 0.001687 seconds.
You can set `force_row_wise=true` to remove the overhead.
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 443
[LightGBM] [Info] Number of data points in the train set: 7228, number of used fe
atures: 10
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.499032 -> initscore=-0.003874
[LightGBM] [Info] Start training from score -0.003874
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
accuracy_score: 0.8340865074241446
```

	precision	recall	f1-score	support
0	0.79	0.86	0.83	1416
1	0.88	0.81	0.84	1682
accuracy			0.83	3098
macro avg	0.83	0.84	0.83	3098
weighted avg	0.84	0.83	0.83	3098



In [460...

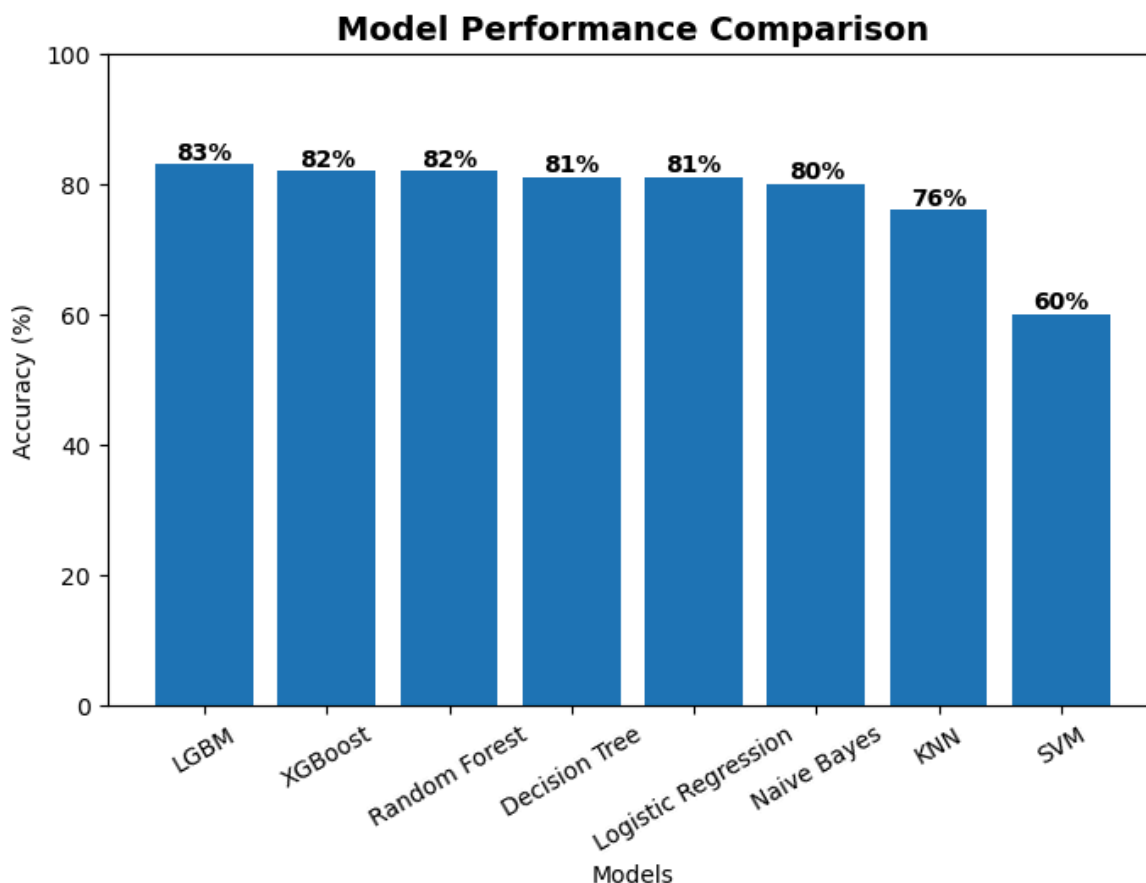
```
plt.figure(figsize=(4,4))
proba_rf = lgb.predict_proba(X_test)[: ,1]
fpr_rf, tpr_rf, thersold = roc_curve(y_test, proba_rf)
plt.plot([0,1],[0,1], 'k--')
plt.plot(fpr_knn, tpr_knn, label='RF', color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('LGBMClassifier ROC Curve', fontsize=10, pad=10, size=10)
plt.show()
```



## Ranking Table

In [462...

```
# Model scores
models = ['LGBM', 'XGBoost', 'Random Forest', 'Decision Tree', 'Logistic Regress
scores = [83, 82, 82, 81, 81, 80, 76, 60]
# Plot
plt.figure(figsize=(8,5))
bars = plt.bar(models, scores)
# Add labels on top of each bar
for bar in bars:
    height = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, height, str(height)+'%', ha='cente
# Chart formatting
plt.title('Model Performance Comparison', fontsize=14, fontweight='bold')
plt.xlabel('Models')
plt.ylabel('Accuracy (%)')
plt.ylim(0, 100)
plt.xticks(rotation=30)
plt.show()
```



## Conclusion

- After evaluating multiple machine learning models for customer churn prediction, the results clearly show that tree-based ensemble models outperform traditional classifiers. Among all models, the LGBM Classifier delivered the highest accuracy of 83%, closely followed by XGBoost and Random Forest with 82% each. These models are better at capturing complex, non-linear relationships in the data, which is common in churn behavior.
- Models such as Logistic Regression, Naive Bayes, and Decision Tree performed moderately well, indicating that there are still noticeable linear patterns in the data. However, KNN and SVM showed significantly lower performance, making them less suitable choices for this dataset without heavy tuning.
- Overall, based on accuracy and model stability, LGBM is recommended as the final model for deployment. It provides the best balance of performance, speed, and generalization.

## PREDICT NEW CUSTOMER

```
In [469... new_customer = {  
    'TotalCharges': 350,  
    'tenure': 12,
```

```
'MonthlyCharges': 650.7,  
'OnlineSecurity_Yes': 0,  
'Contract_Two year': 0,  
'TechSupport_Yes': 1,  
'Contract_One year': 1,  
'Dependents_Yes': 0,  
'OnlineBackup_Yes': 1,  
'InternetService_Fiber optic': 1  
}  
  
new_data = pd.DataFrame([new_customer])  
  
prediction = lgb.predict(new_data)[0]  
probability = lgb.predict_proba(new_data)[:, 1][0]  
  
if prediction == 1:  
    print("Result: Customer WILL Churn")  
else:  
    print("Result: Customer will NOT Churn")  
  
print("Churn Probability:", round(probability, 2))
```

Result: Customer WILL Churn  
Churn Probability: 0.75

In [ ]: