

# 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
```

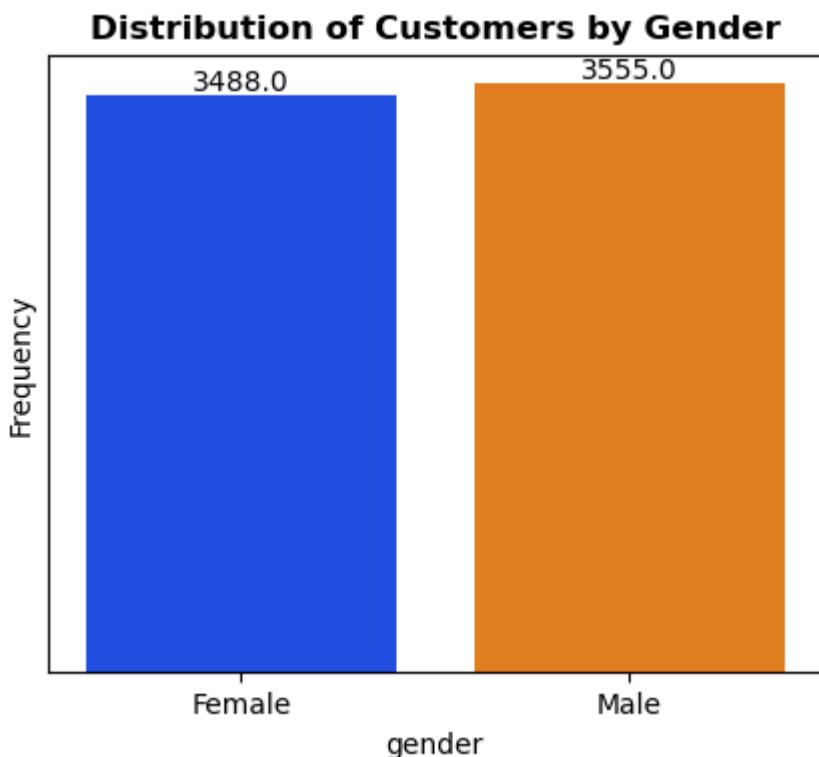
```
In [182...]: plt.figure(figsize=(5,4))
ax = sns.countplot(x = 'gender', data=df, palette='bright')
for p in ax.patches:
    ax.annotate(
        str(p.get_height()),
        (p.get_x() + p.get_width() / 2, p.get_height()),
```

```

        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

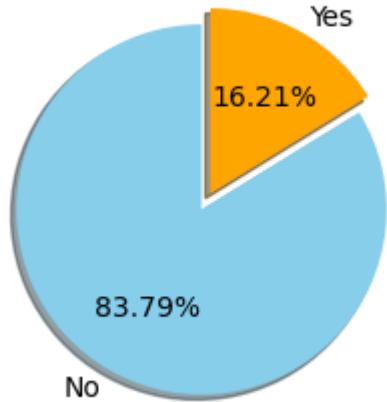
```
In [26]: df['SeniorCitizen'] = df['SeniorCitizen'].map({1:'Yes', 0:'No'})
```

```
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)
```

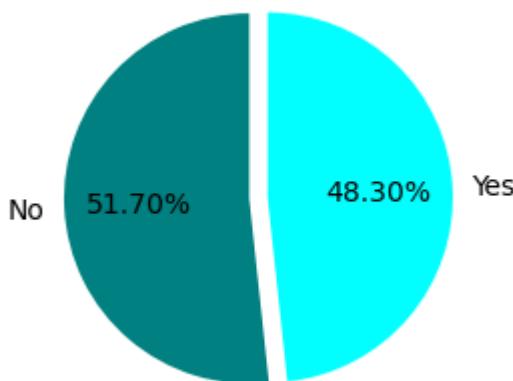
```
Out[54]: Partner
No      3641
Yes     3402
Name: count, dtype: int64
```

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

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
```

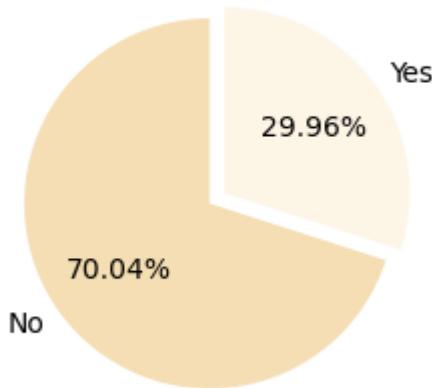
```
In [74]: df['Dependents'].value_counts(normalize=True,dropna=False).reset_index()
```

```
Out[74]: Dependents proportion
```

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='%.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
```

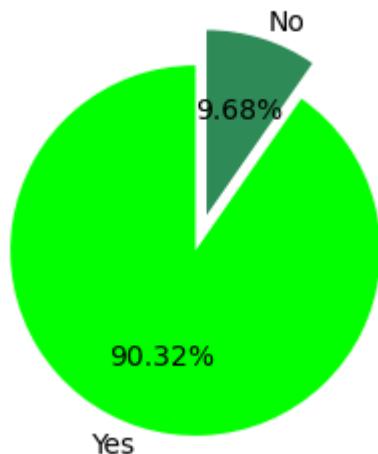
Out[85]: **PhoneService proportion**

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)`

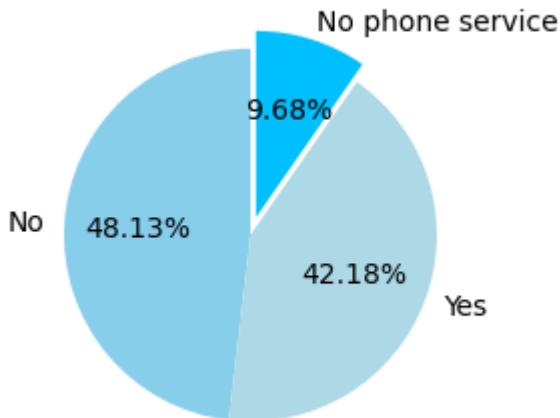
Out[99]: `MultipleLines`

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()
```

### Multiplelines Distribution



### 3.1.8 InternetService

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

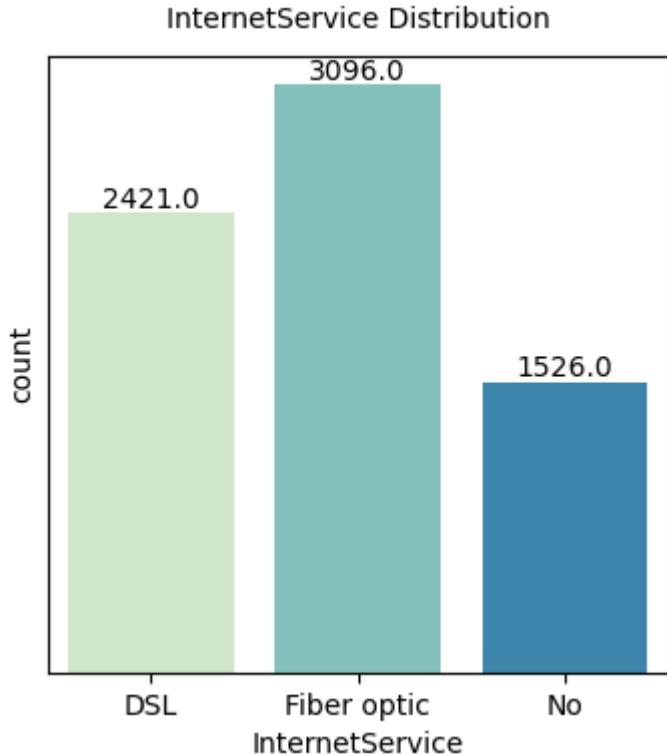
```
Out[110]:
InternetService
Fiber optic    3096
DSL            2421
No             1526
Name: count, dtype: int64
```

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

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

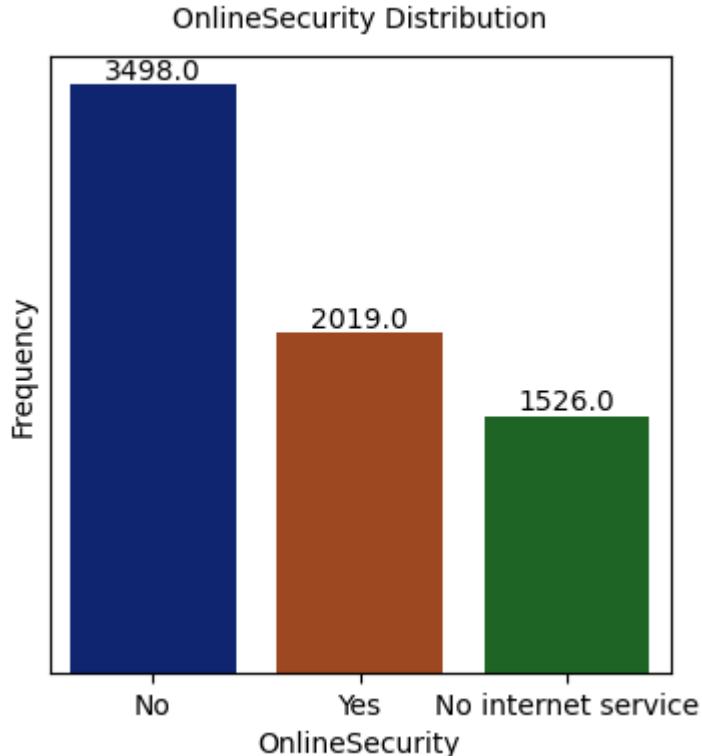
```
In [128...]: df['OnlineSecurity'].value_counts(dropna=False)
```

```
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()
```



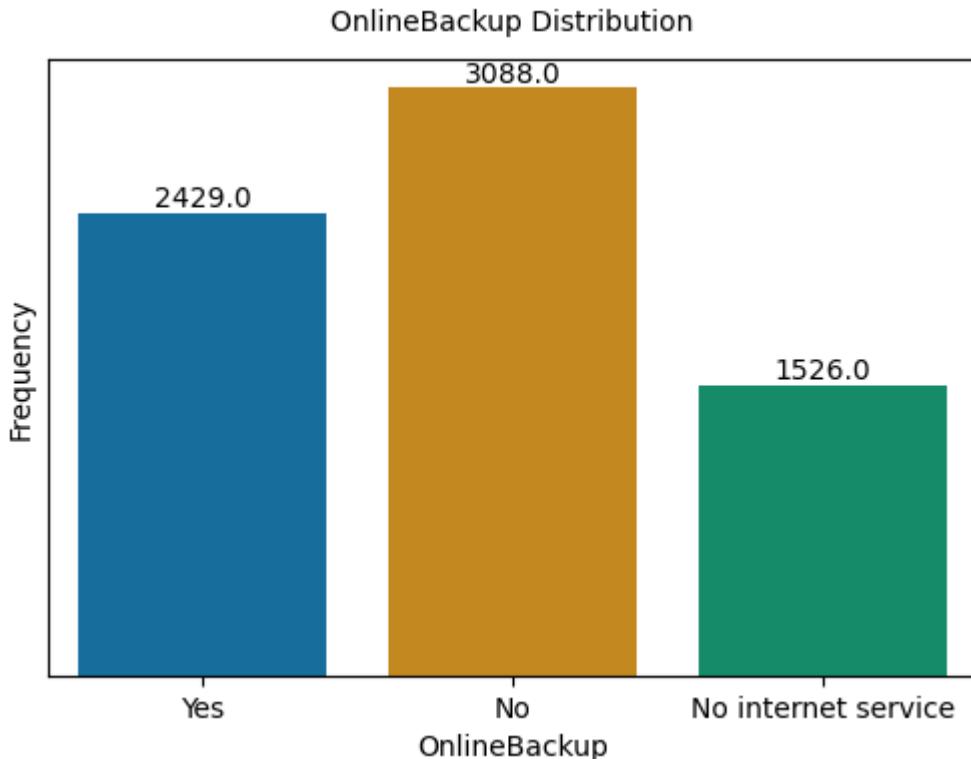
### 3.1.10 OnlineBackup

```
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)
```

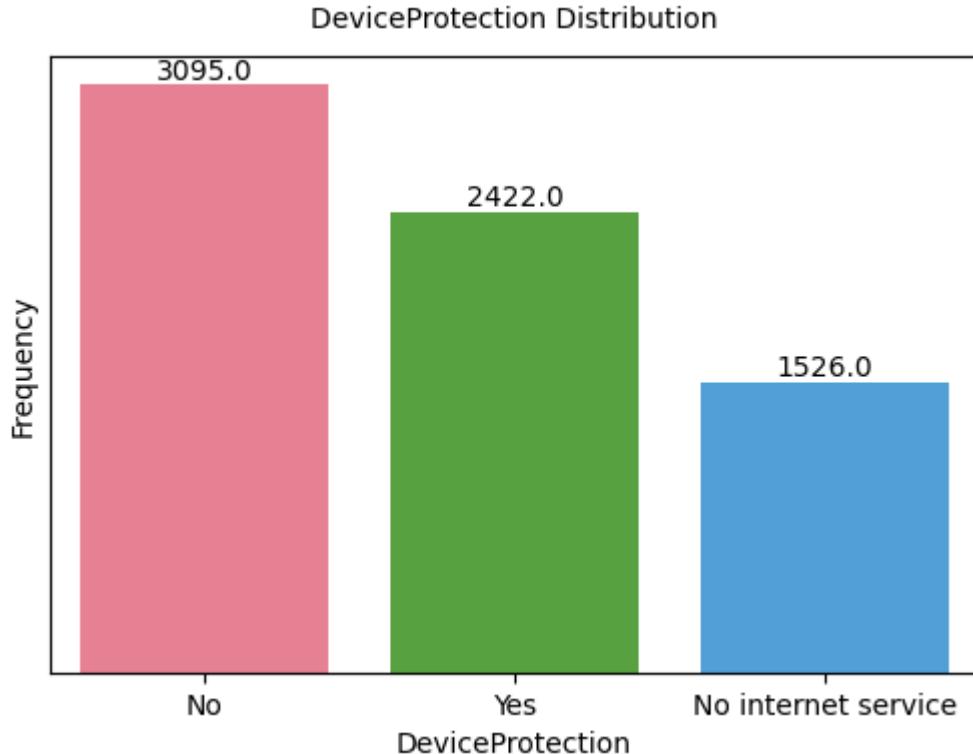
```
Out[152...]: DeviceProtection
No                 3095
Yes                2422
No internet service    1526
Name: count, dtype: int64
```

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

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

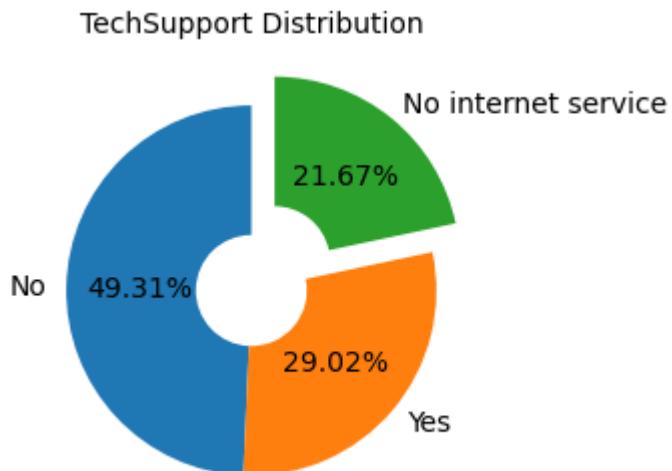
for i in ax.patches:
    ax.annotate(
        str(i.get_height()),
        (i.get_x()+i.get_width()/2,i.get_height()),
        ha='center',va='bottom')

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='%.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()
```

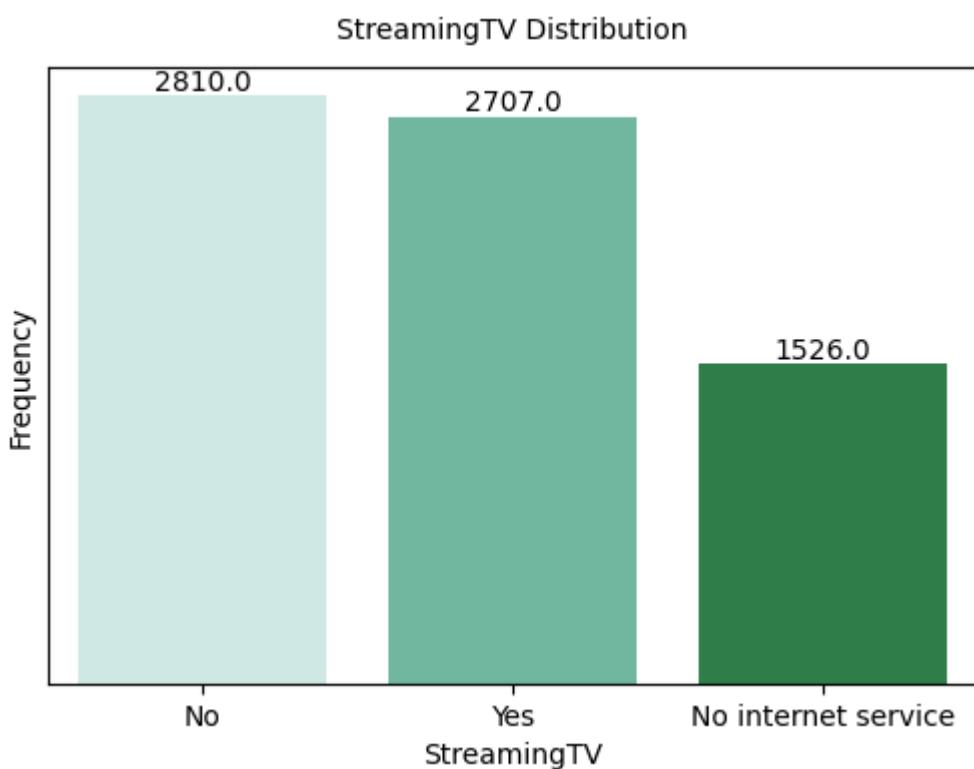
```
Out[177...]: StreamingTV
No                  2810
Yes                 2707
No internet service 1526
Name: count, dtype: int64
```

```
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()
```

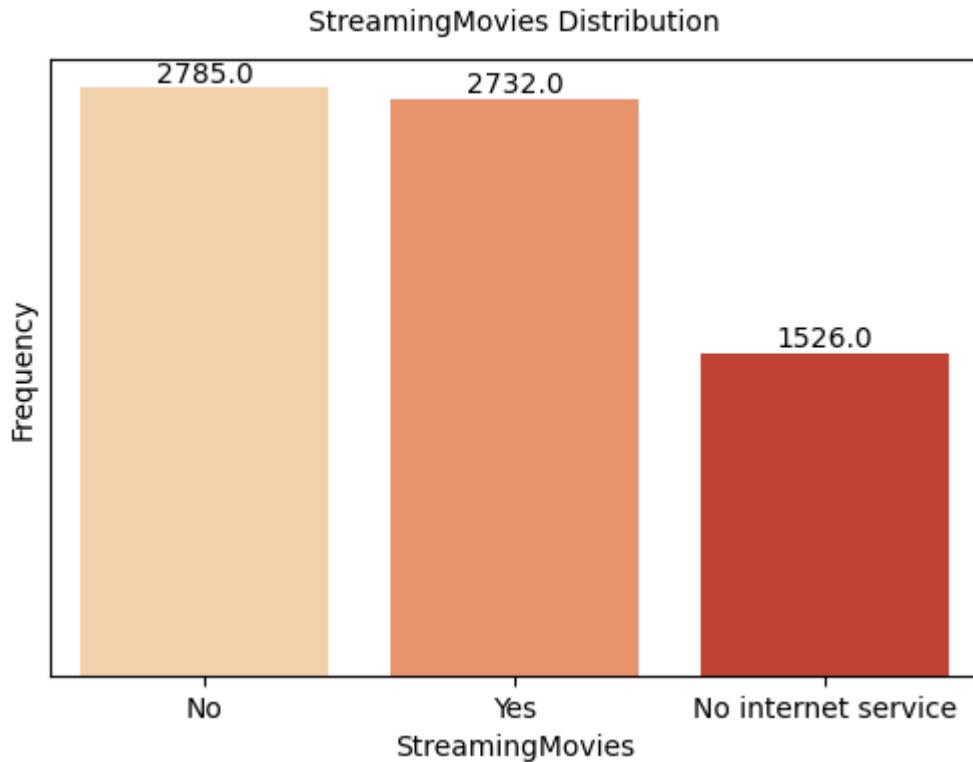


### 3.1.13 StreamingMovies

```
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()
```

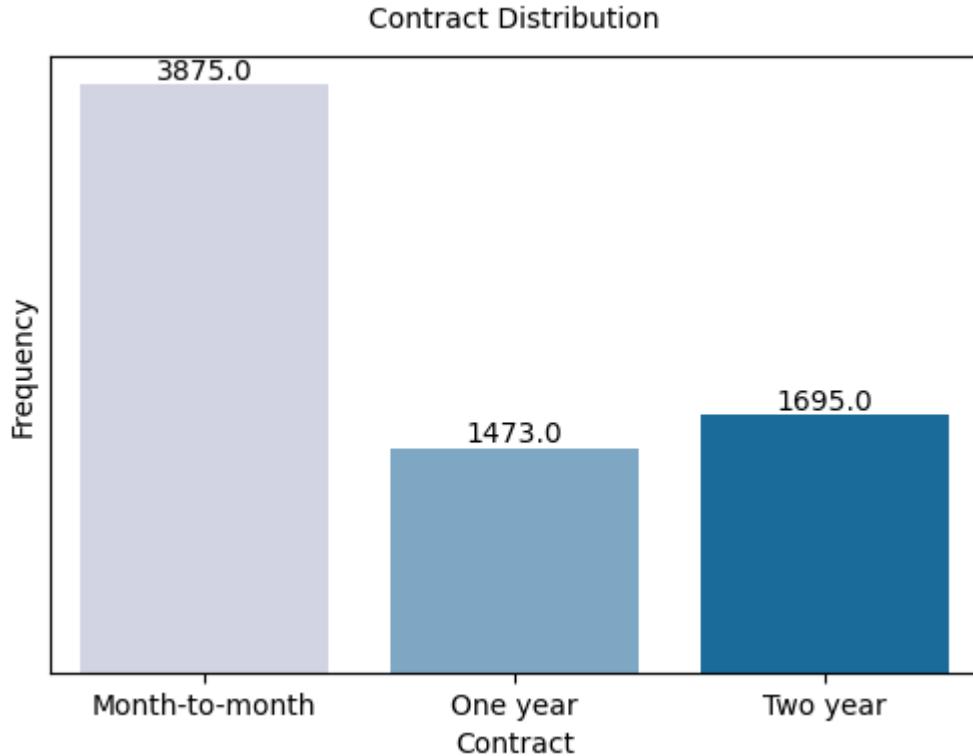


#### 3.1.13 Contract

```
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()
```



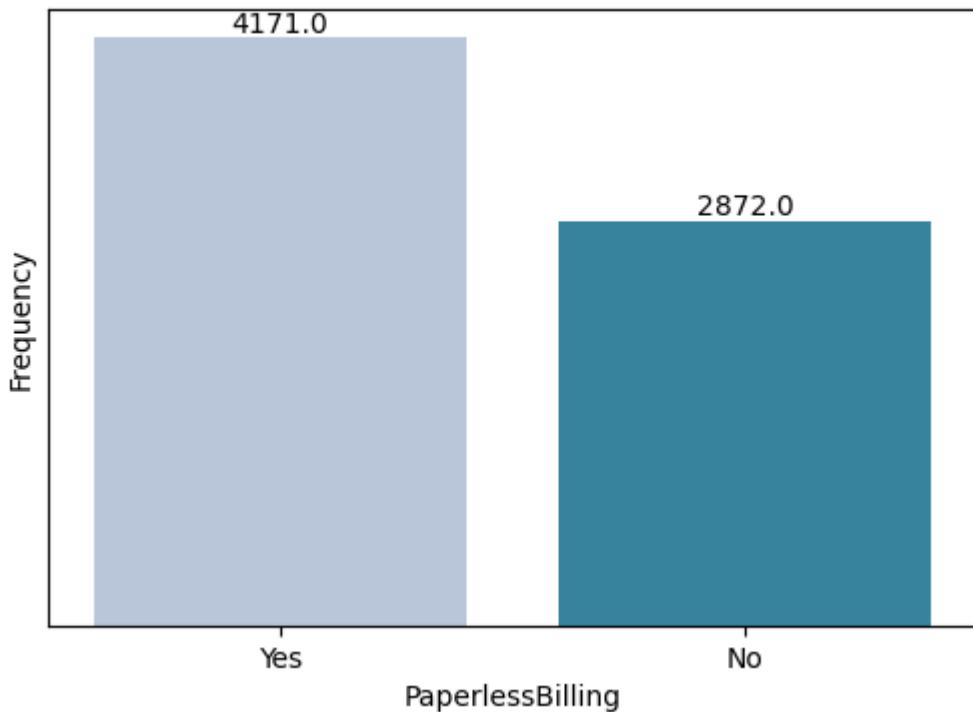
#### 3.1.14 PaperlessBilling

```
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')

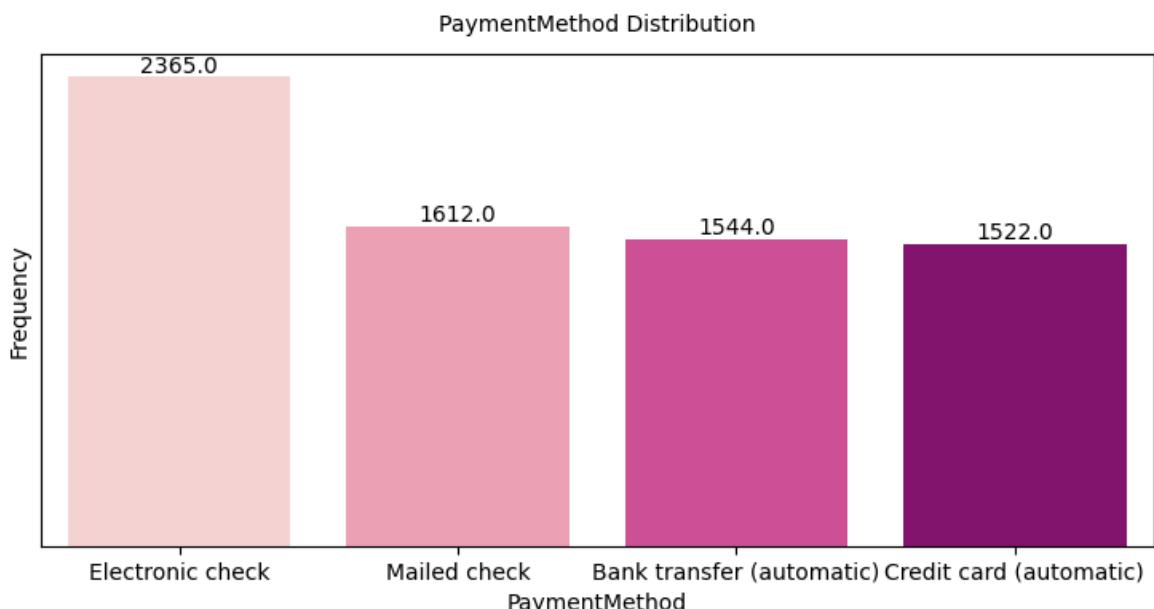
plt.title('PaperlessBilling Distribution', pad=10, size=10)
plt.yticks([])
plt.ylabel('Frequency')
plt.show()
```

PaperlessBilling Distribution



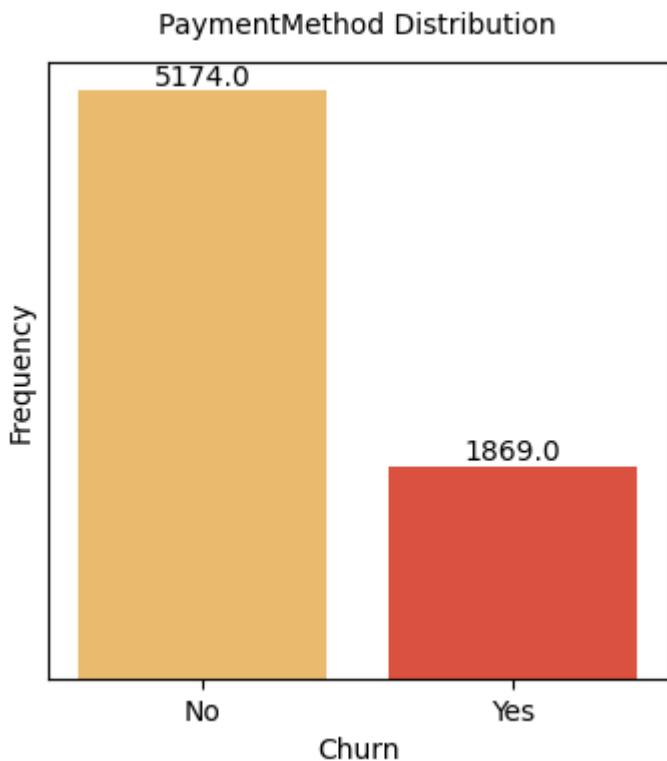
### 3.1.15 PaymentMethod

```
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()
```

	tenure	MonthlyCharges
<b>count</b>	7032.000000	7032.000000
<b>mean</b>	32.421786	64.798208
<b>std</b>	24.545260	30.085974
<b>min</b>	1.000000	18.250000
<b>25%</b>	9.000000	35.587500
<b>50%</b>	29.000000	70.350000
<b>75%</b>	55.000000	89.862500
<b>max</b>	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
<b>count</b>	7032.000000	7032.000000	7032.000000
<b>mean</b>	32.421786	64.798208	2283.300441
<b>std</b>	24.545260	30.085974	2266.771362
<b>min</b>	1.000000	18.250000	18.800000
<b>25%</b>	9.000000	35.587500	401.450000
<b>50%</b>	29.000000	70.350000	1397.475000
<b>75%</b>	55.000000	89.862500	3794.737500
<b>max</b>	72.000000	118.750000	8684.800000

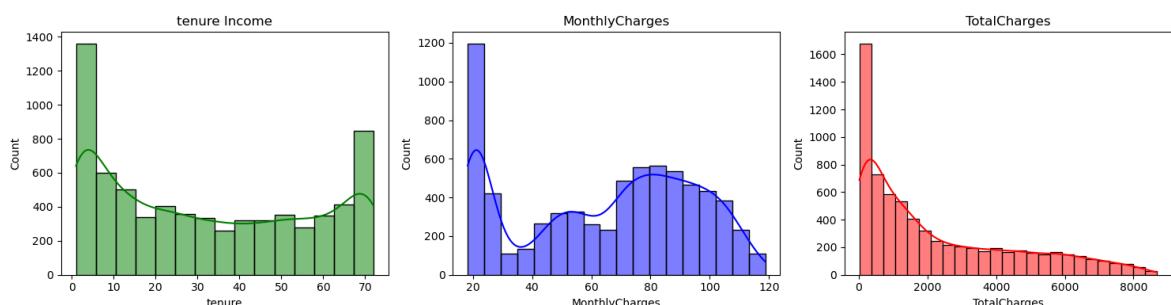
```
In [217... fig, ax = plt.subplots(1, 3, figsize=(15, 4))

# 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)
```

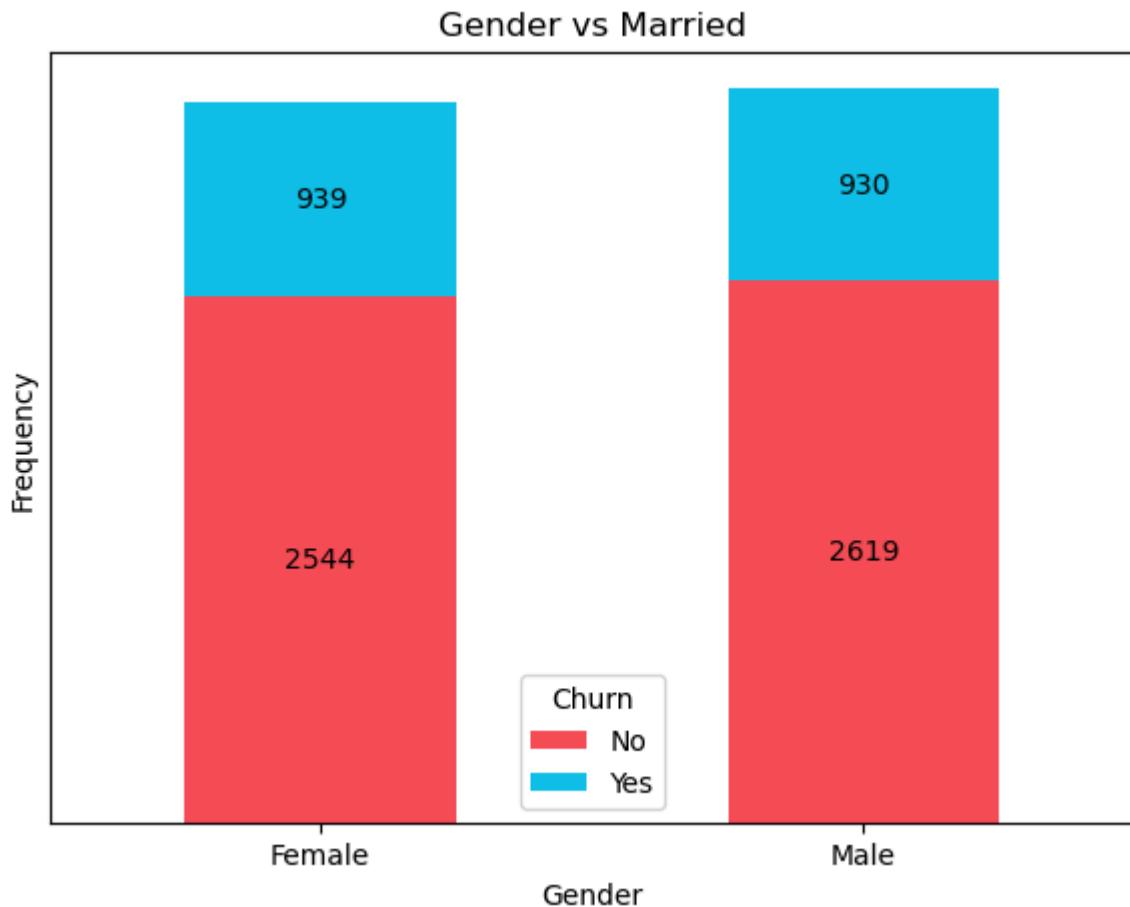
```

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()

```

&lt;Figure size 400x400 with 0 Axes&gt;



## 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)

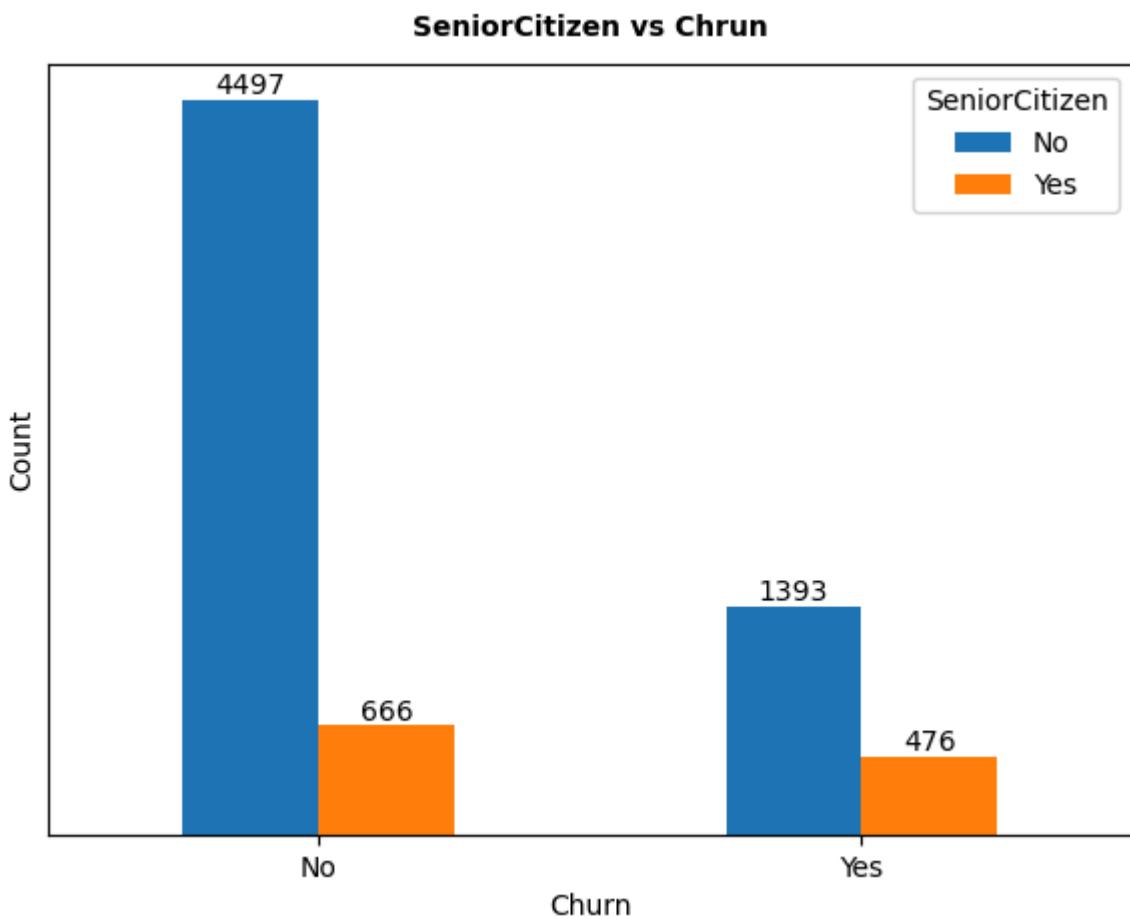
# Add Labels on each bar
for bar in ax.patches:
    height = bar.get_height()
    if height > 0: # avoid labeling empty bars
        ax.text(
            bar.get_x() + bar.get_width()/2, # X position
            height, # Y position (top of bar)
            str(int(height)), # Text Label
           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

```

```

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

```



### 4.3 Partner vs Chrun

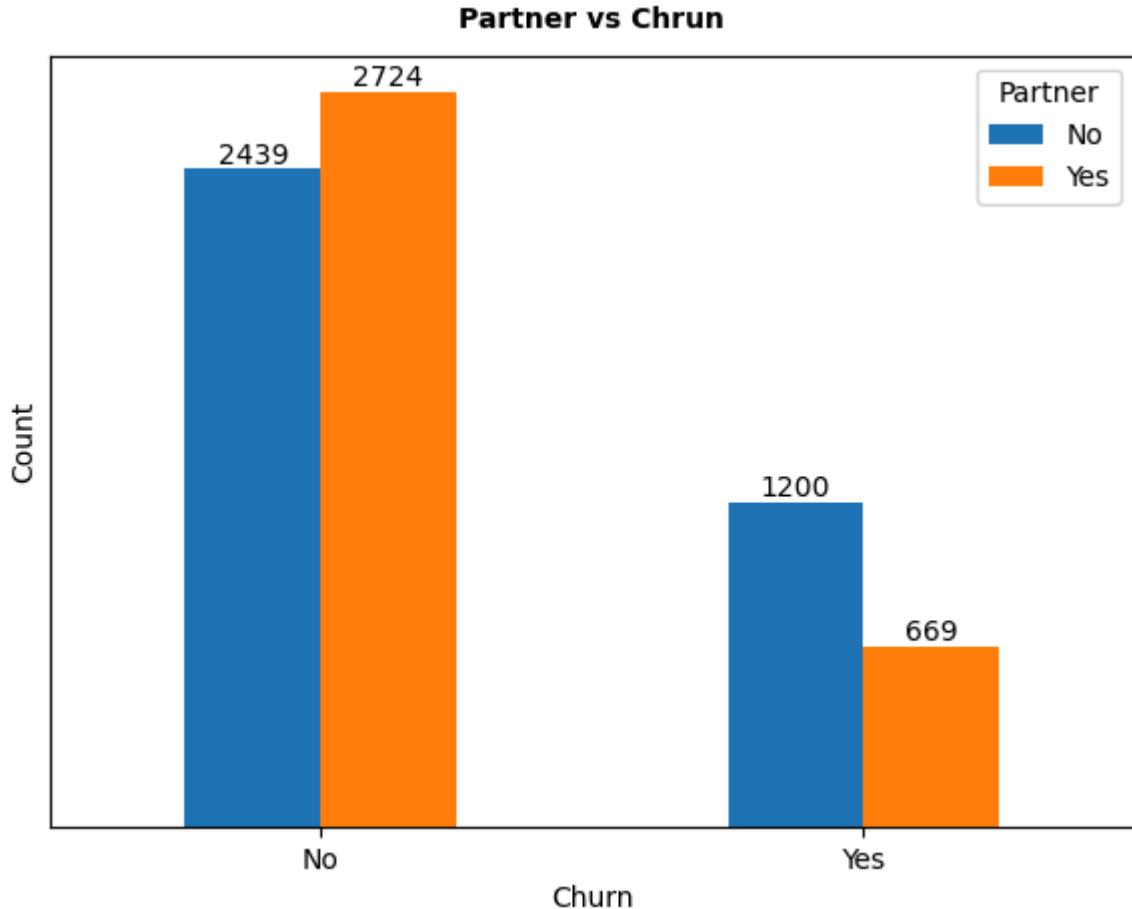
```

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()

```

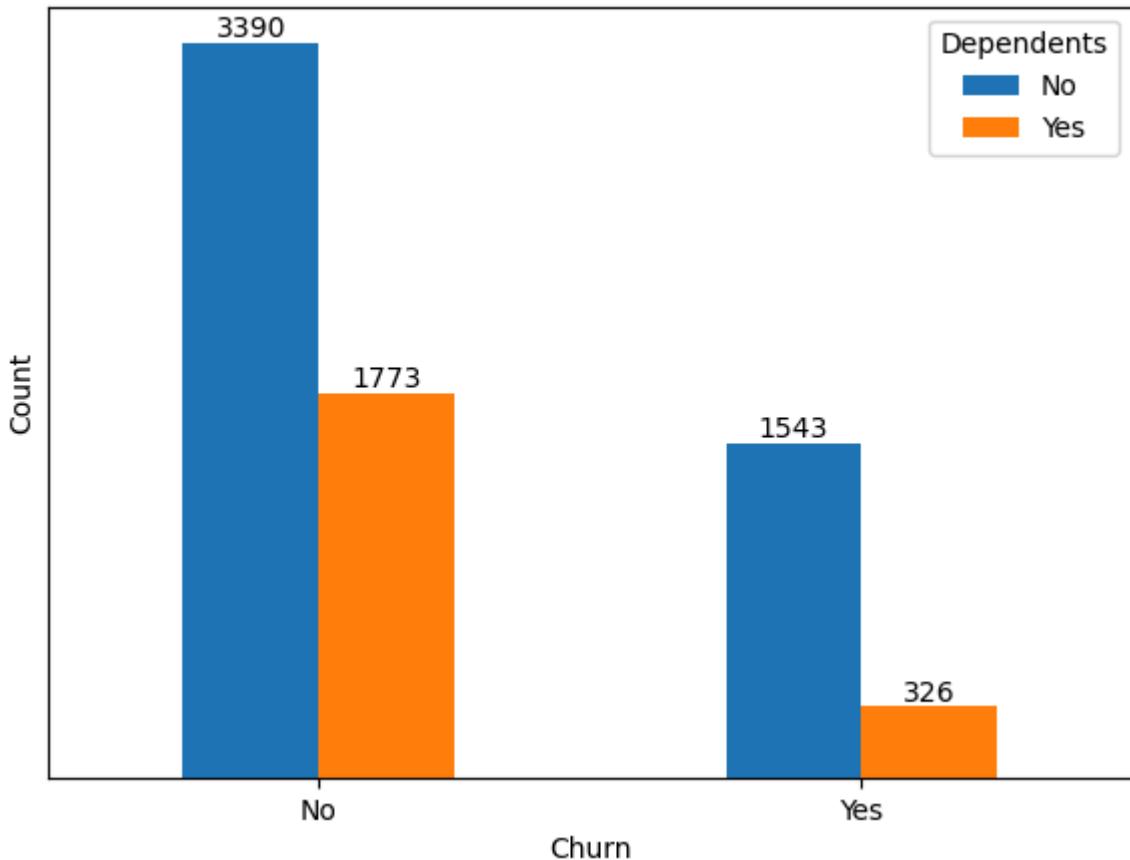


#### 4.4 Dependents vs Chrun

```
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()
```

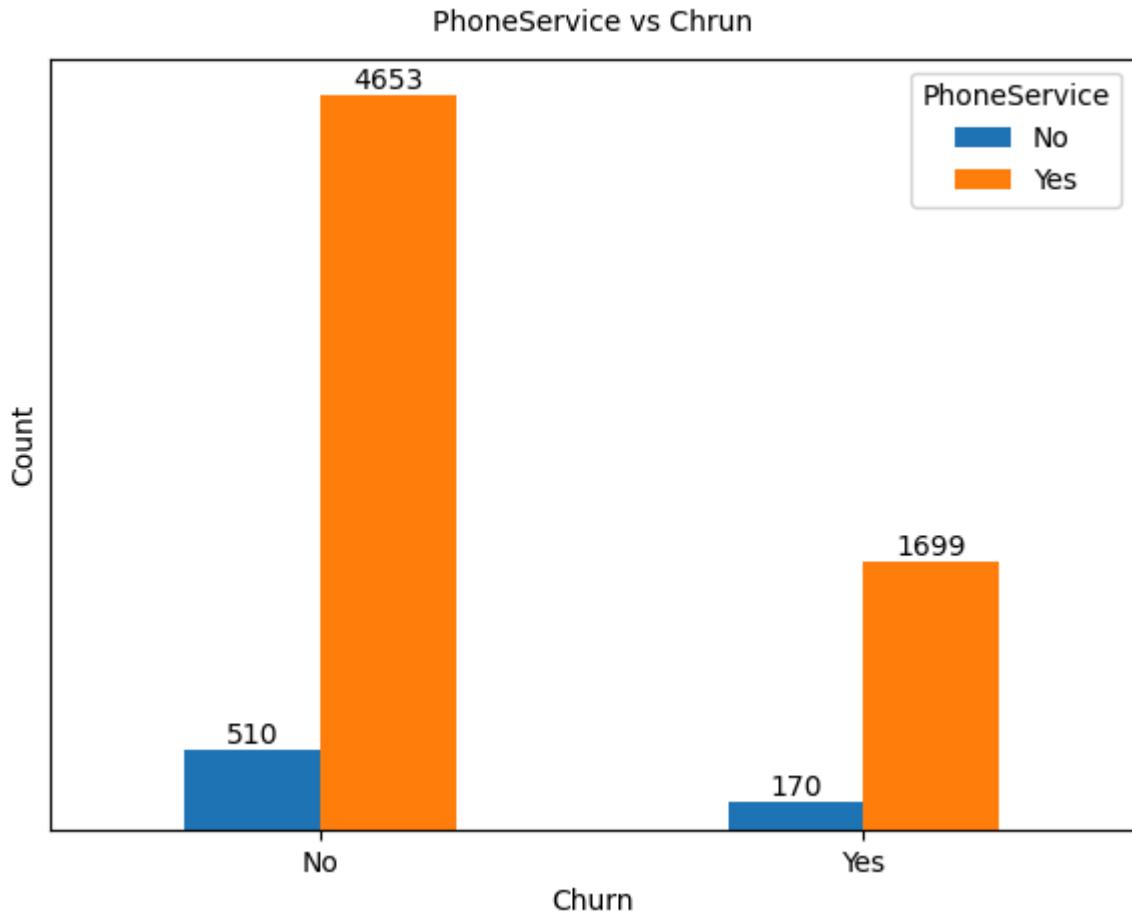
**Dependents vs Churn**

#### 4.4 PhoneService vs Churn

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

plt.title('PhoneService vs Churn', 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()
```



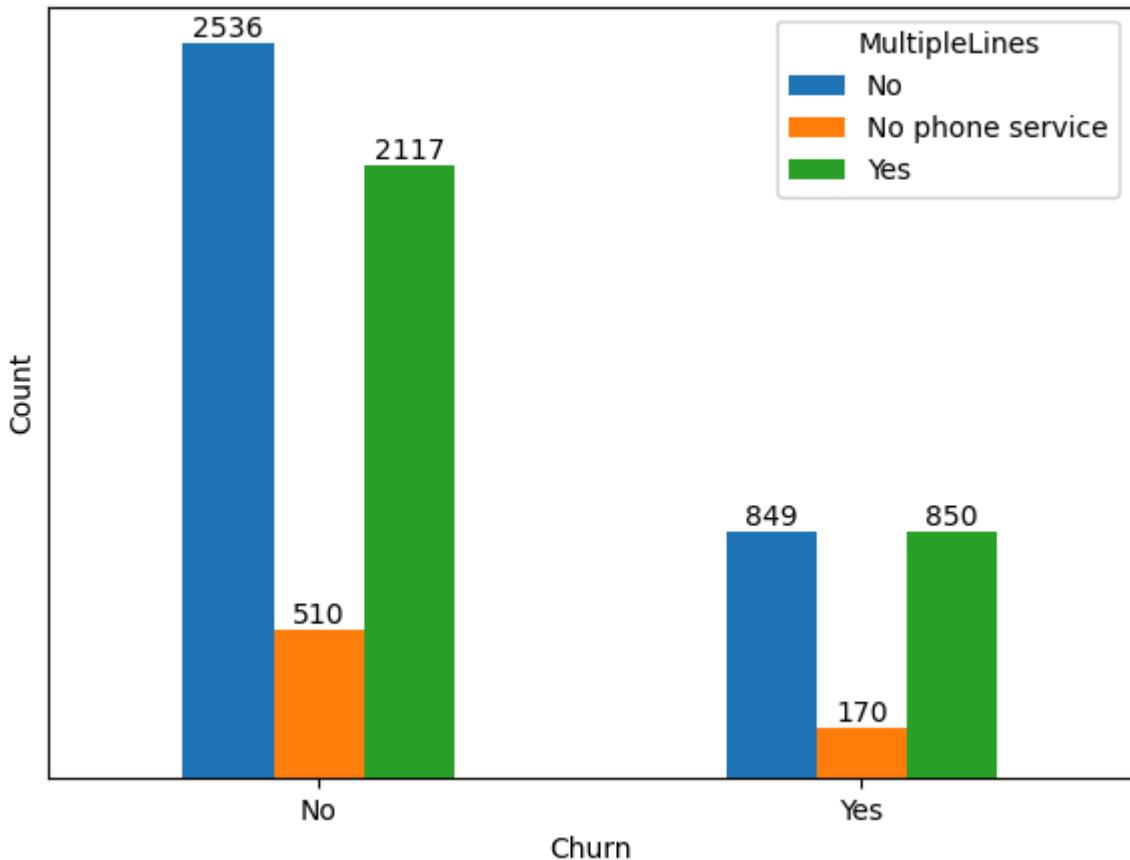
## 4.5 MultipleLines vs Chrun

```
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()
```

MultipleLines vs Chrun



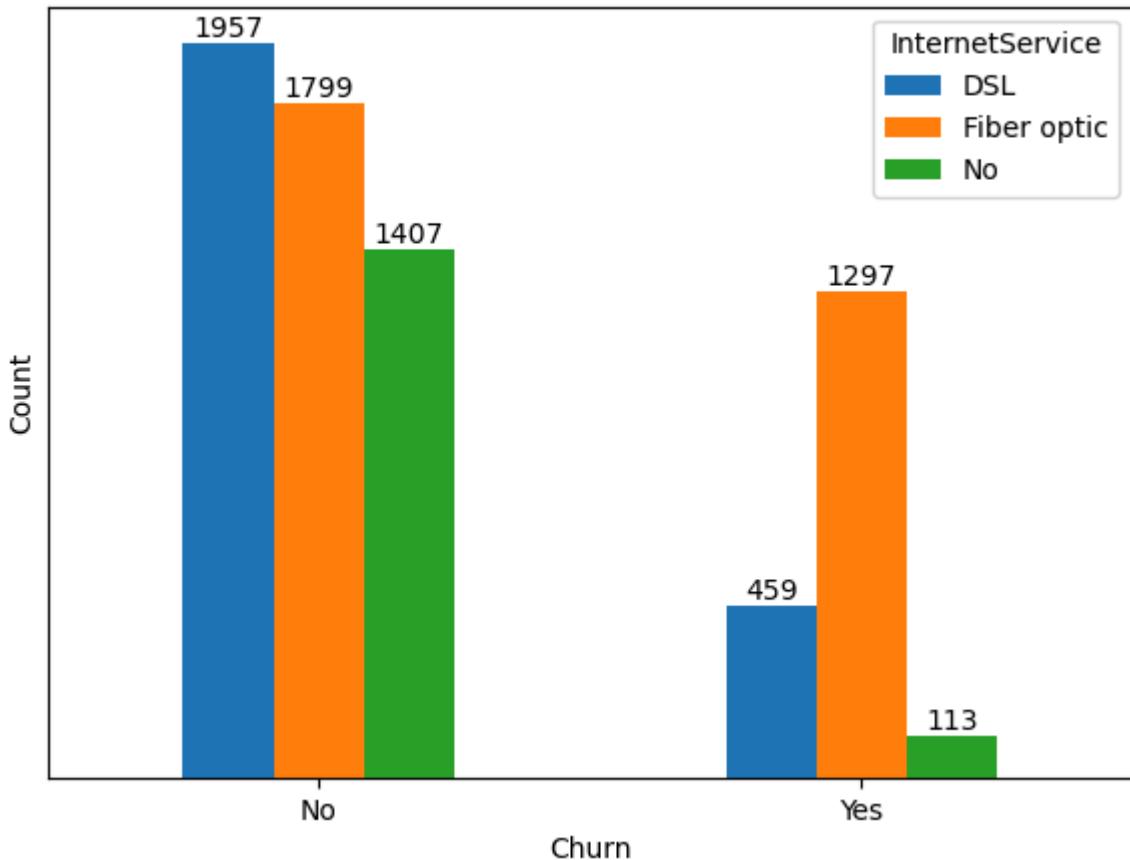
## 4.6 InternetService vs Chrun

```
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()
```

MultipleLines vs Churn



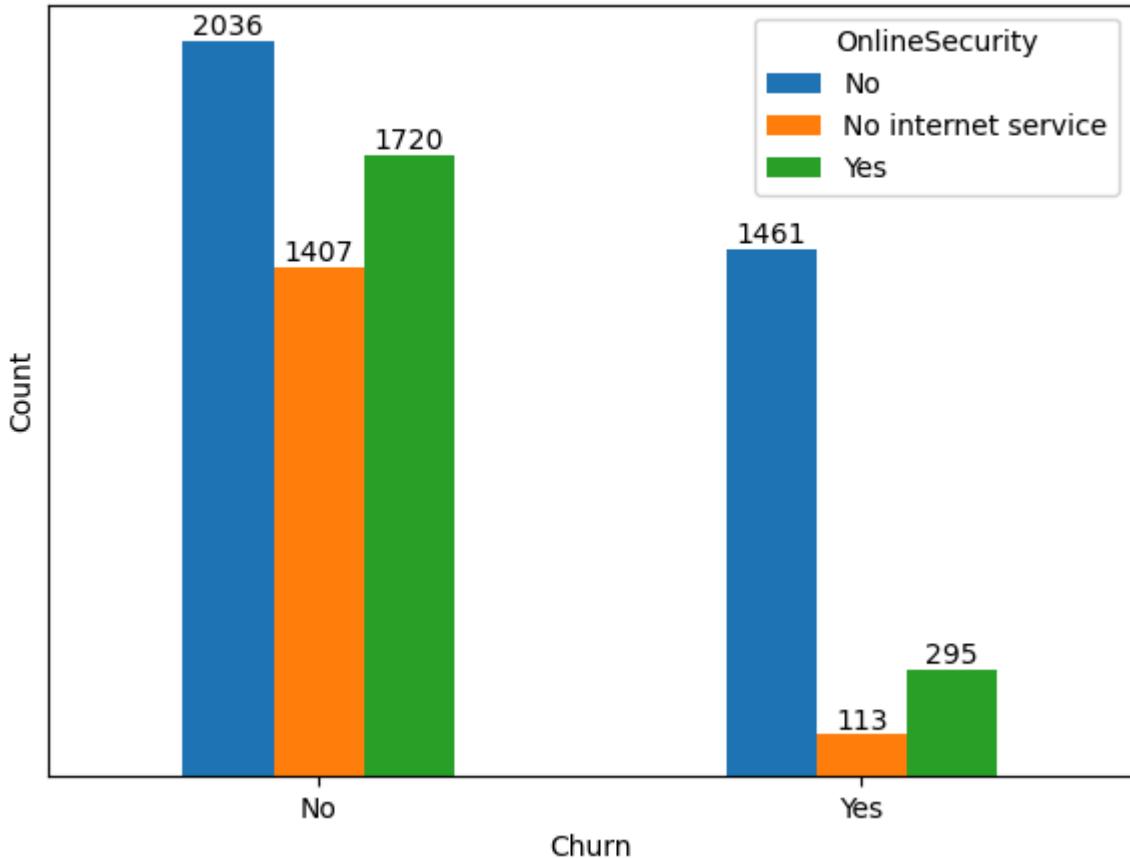
## 4.6 OnlineSecurity vs Churn

```
In [254]: ct = pd.crosstab(df.Churn,df.OnlineSecurity)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('OnlineSecurity vs Churn', 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()
```

OnlineSecurity vs Chrun

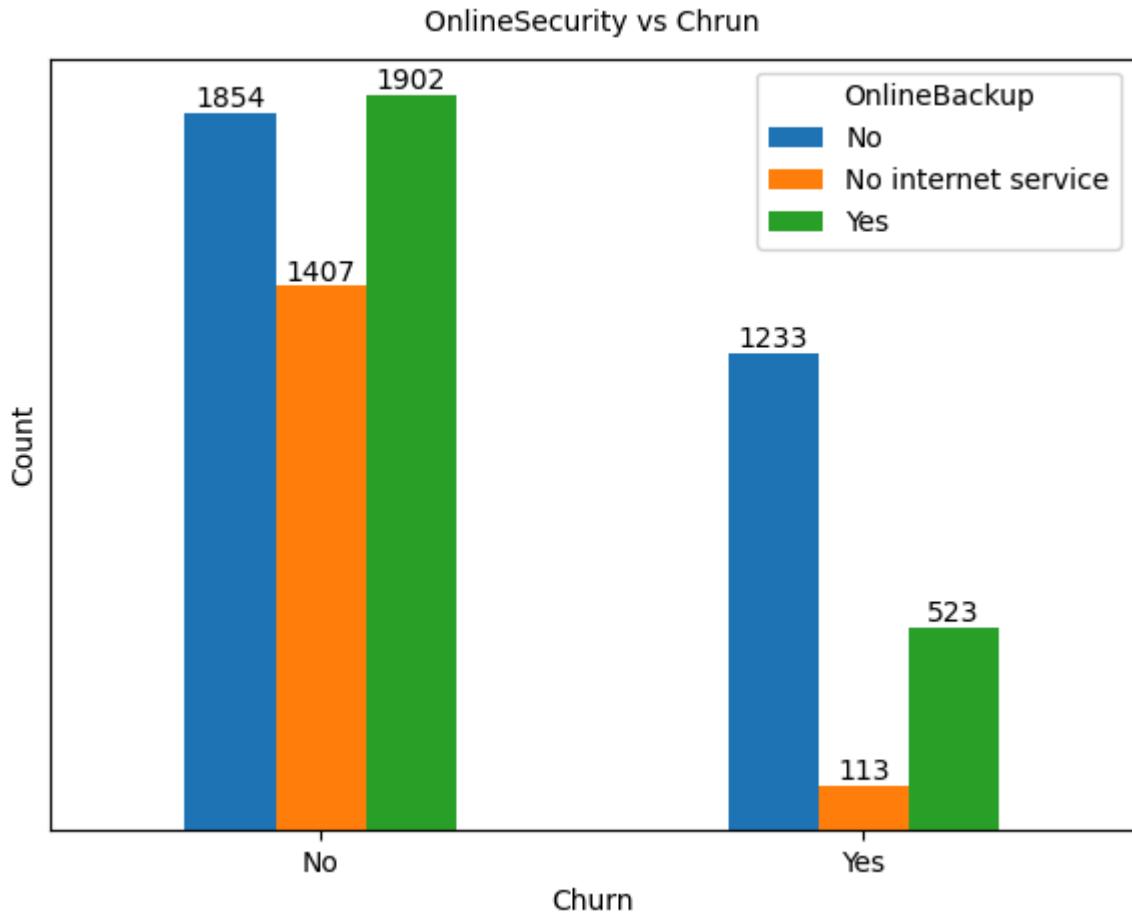


## 4.7 OnlineBackup vs Chrun

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

plt.title('OnlineBackup 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()
```

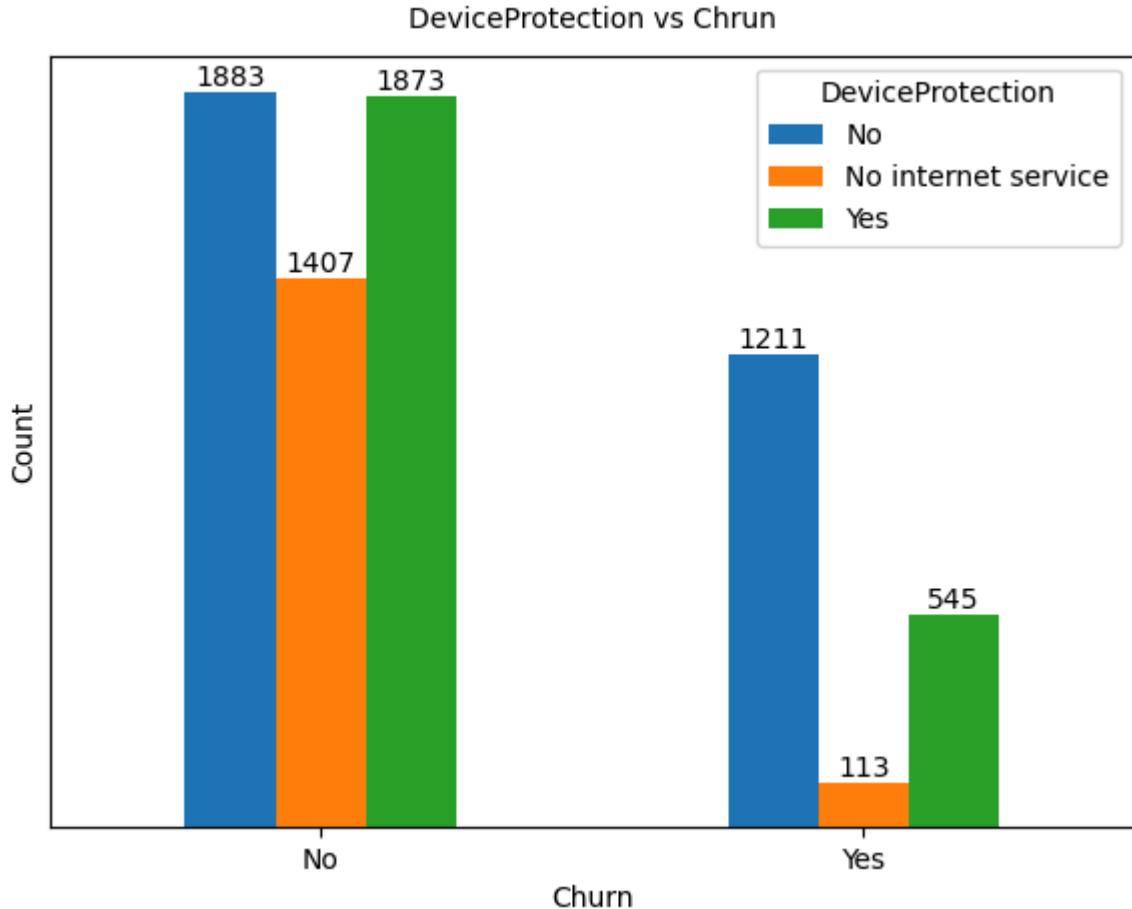


## 4.8 DeviceProtection vs Chrun

```
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()
```



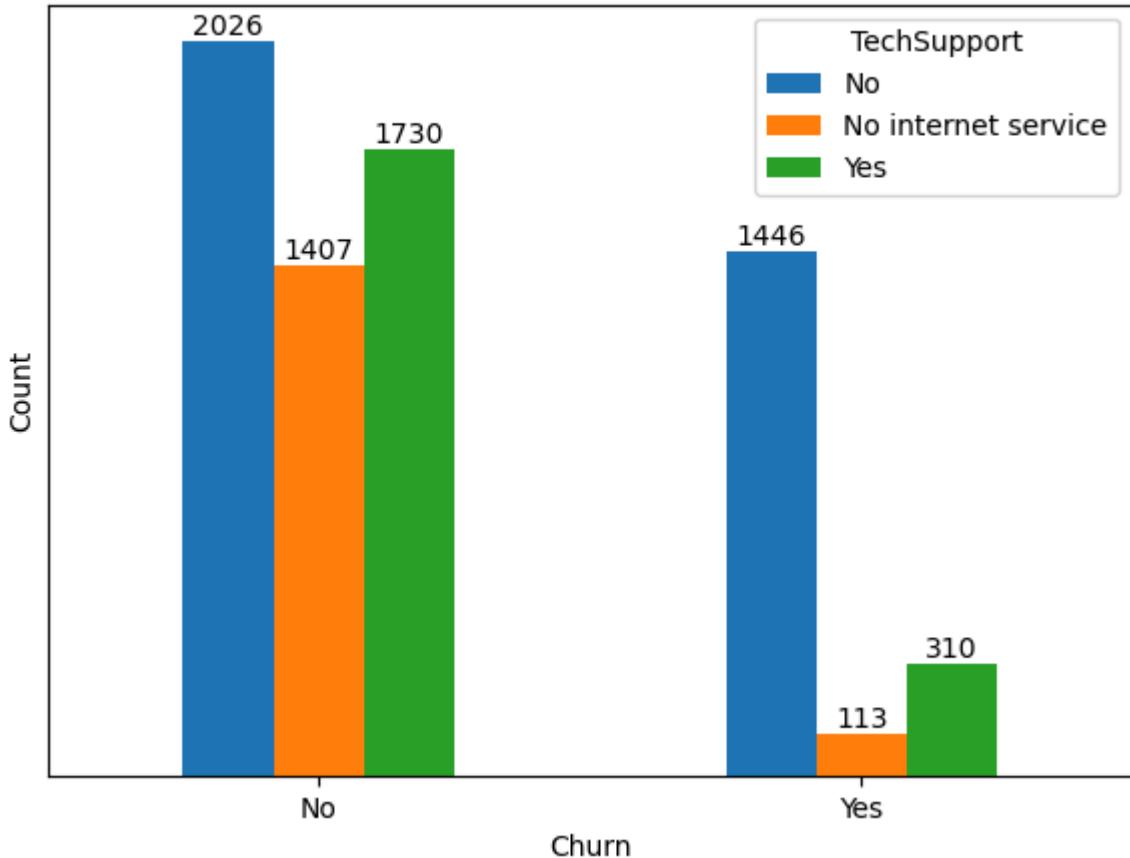
## 4.9 TechSupport vs Chrun

```
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()
```

TechSupport vs Chrun



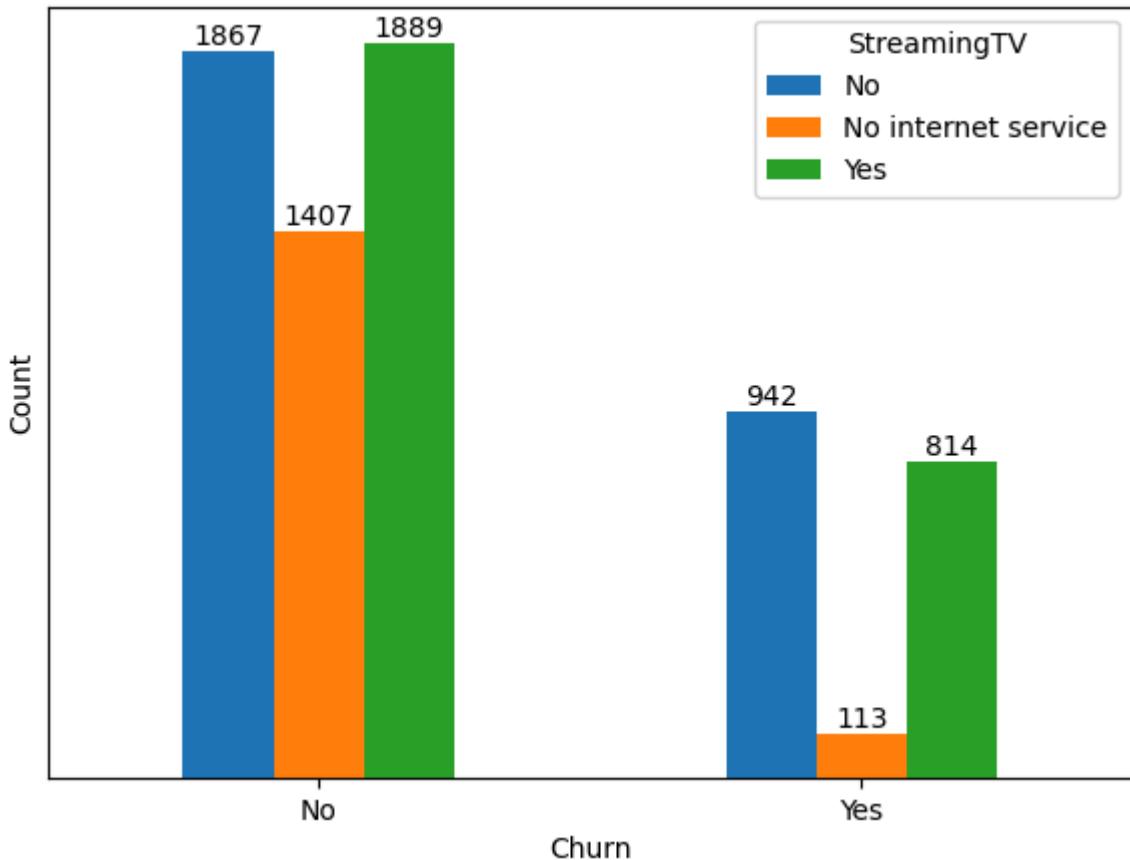
## 4.10 StreamingTV vs Chrun

```
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()
```

StreamingTV vs Chrun

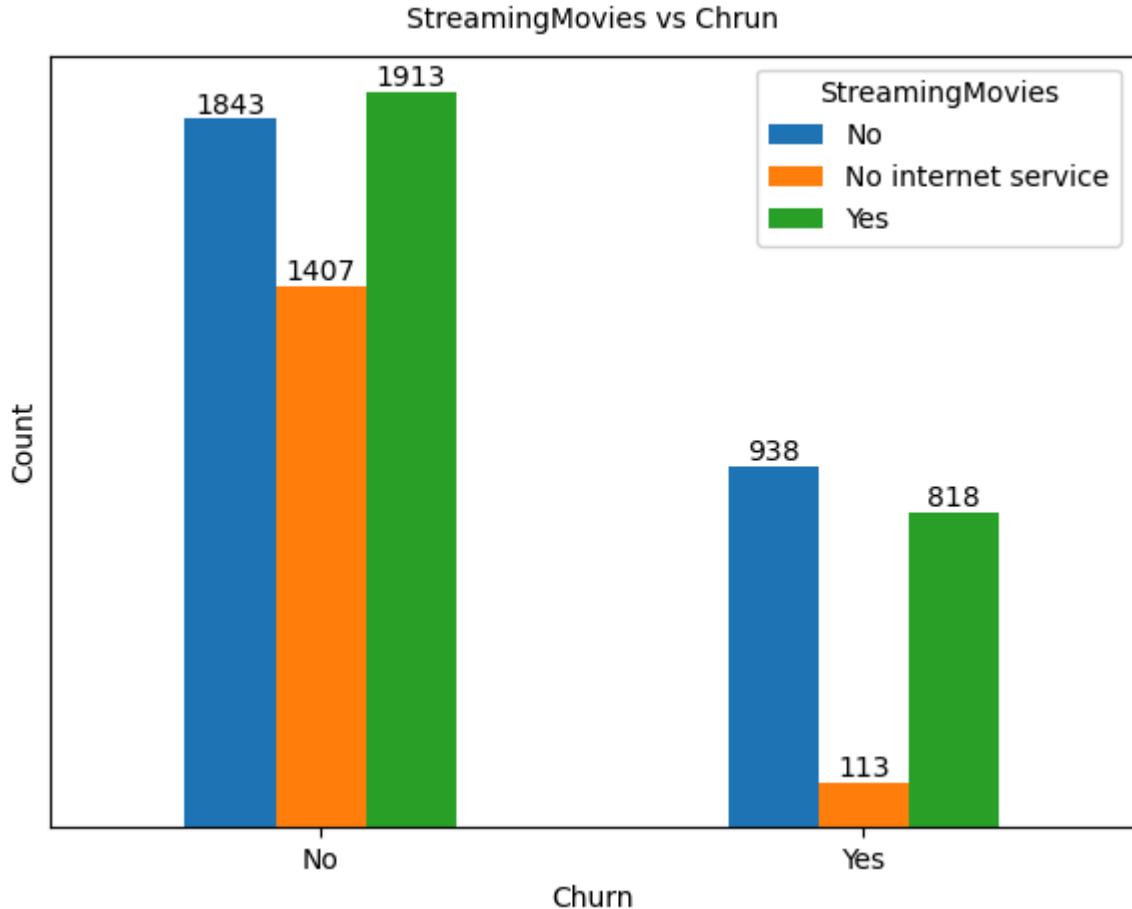


## 4.10 StreamingMovies vs Chrun

```
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()
```

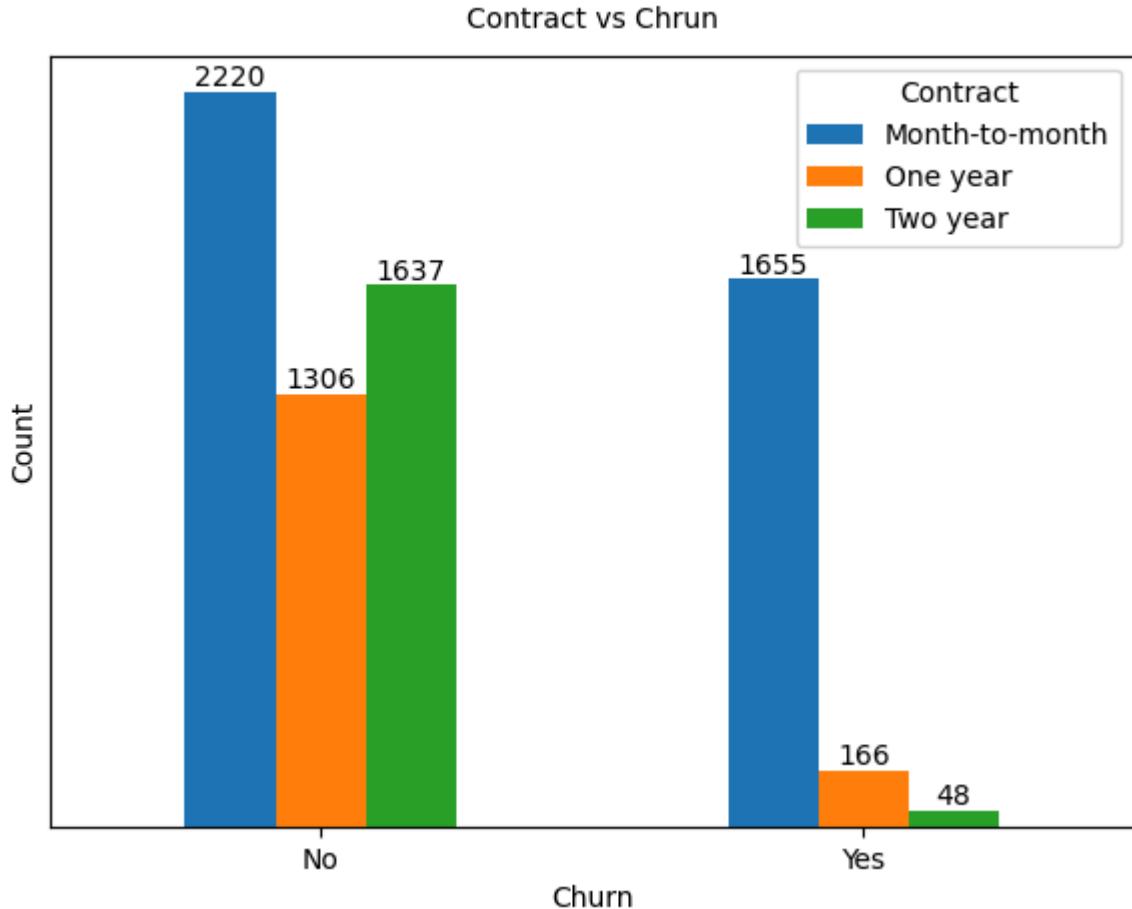


## 4.11 Contract vs Chrun

```
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()
```

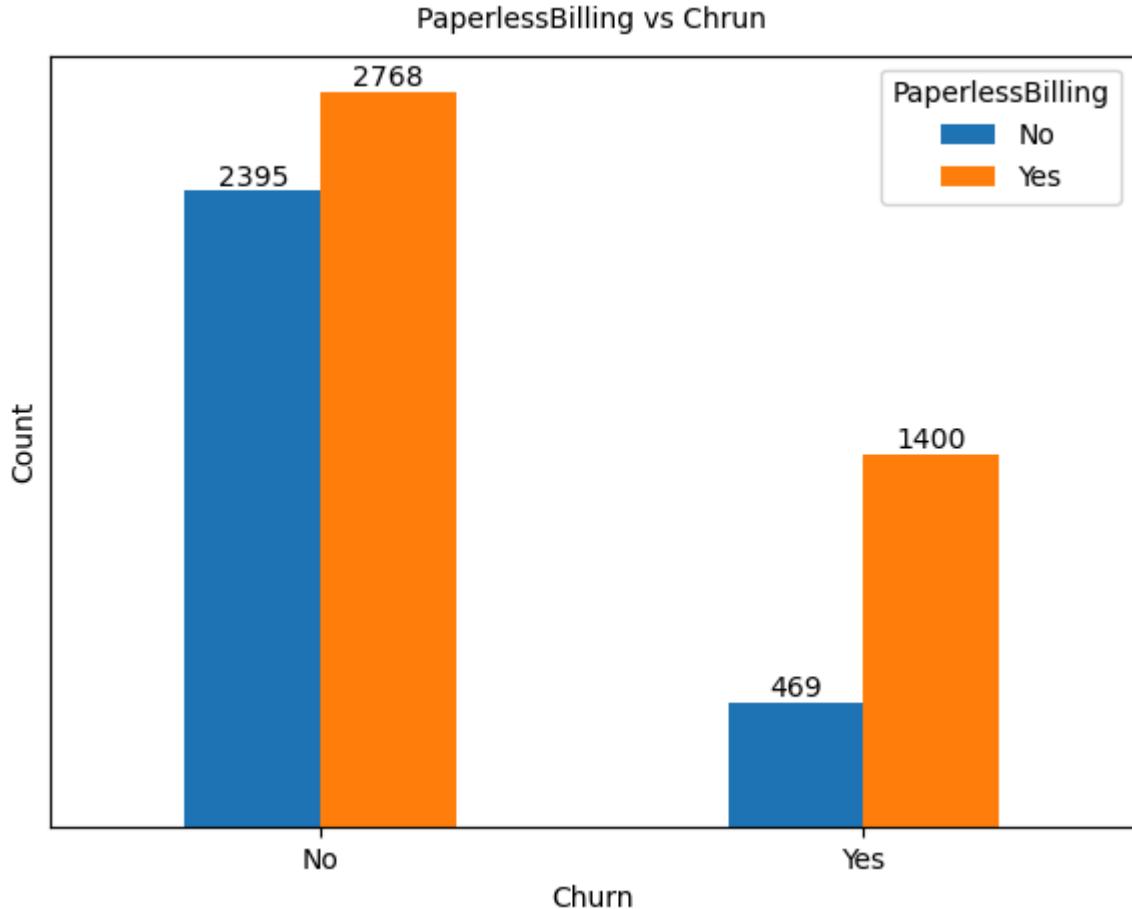


## 4.11 PaperlessBilling vs Churn

```
In [262]: ct = pd.crosstab(df.Churn,df.PaperlessBilling)
ax = ct.plot(kind='bar', figsize=(7,5))

plt.title('PaperlessBilling vs Churn', 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()
```

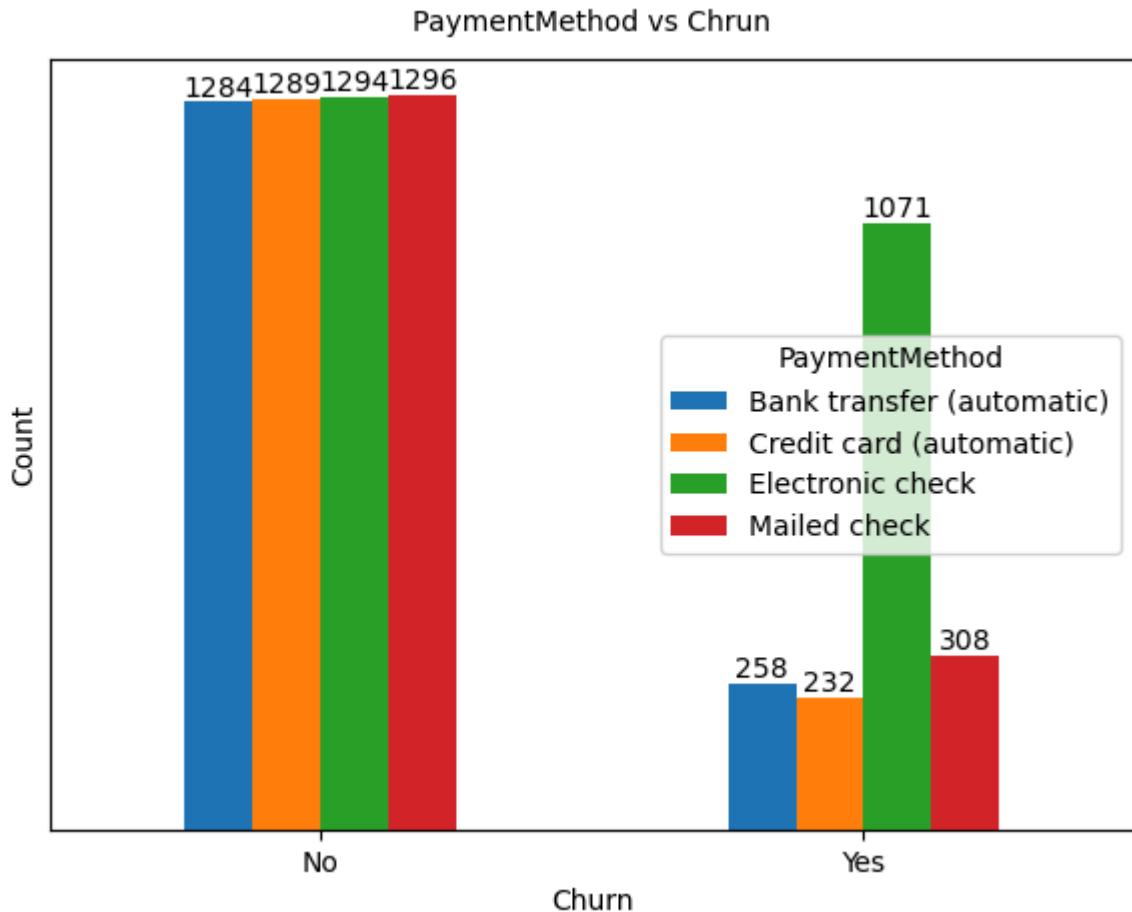


## 4.12 PaymentMethod vs Chrun

```
In [263]: ct = pd.crosstab(df.Churn,df.PaymentMethod)
ax = ct.plot(kind='bar', figsize=(7,5))

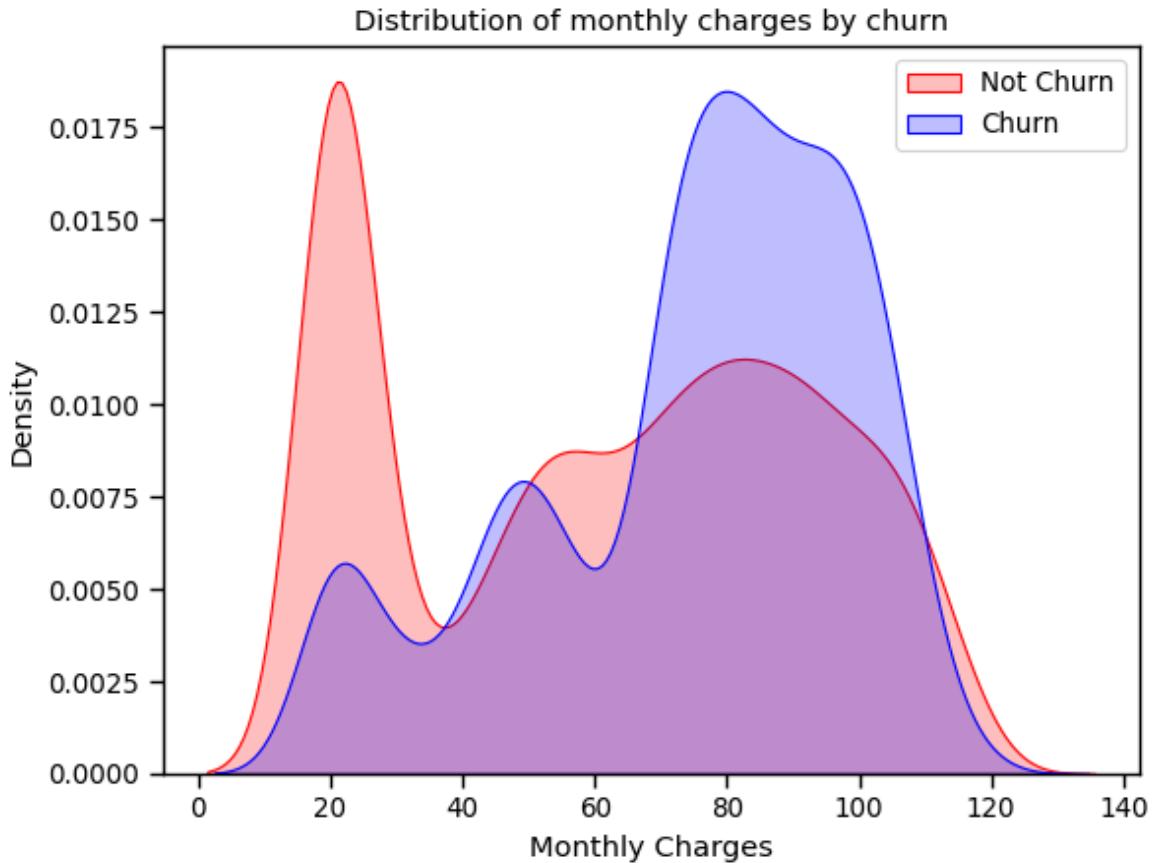
plt.title('PaymentMethod vs Chrun', pad=10, size=10)
# plt.xlabel('Internet Service')
plt.ylabel('Count')
plt.xticks(rotation=0)

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()
```



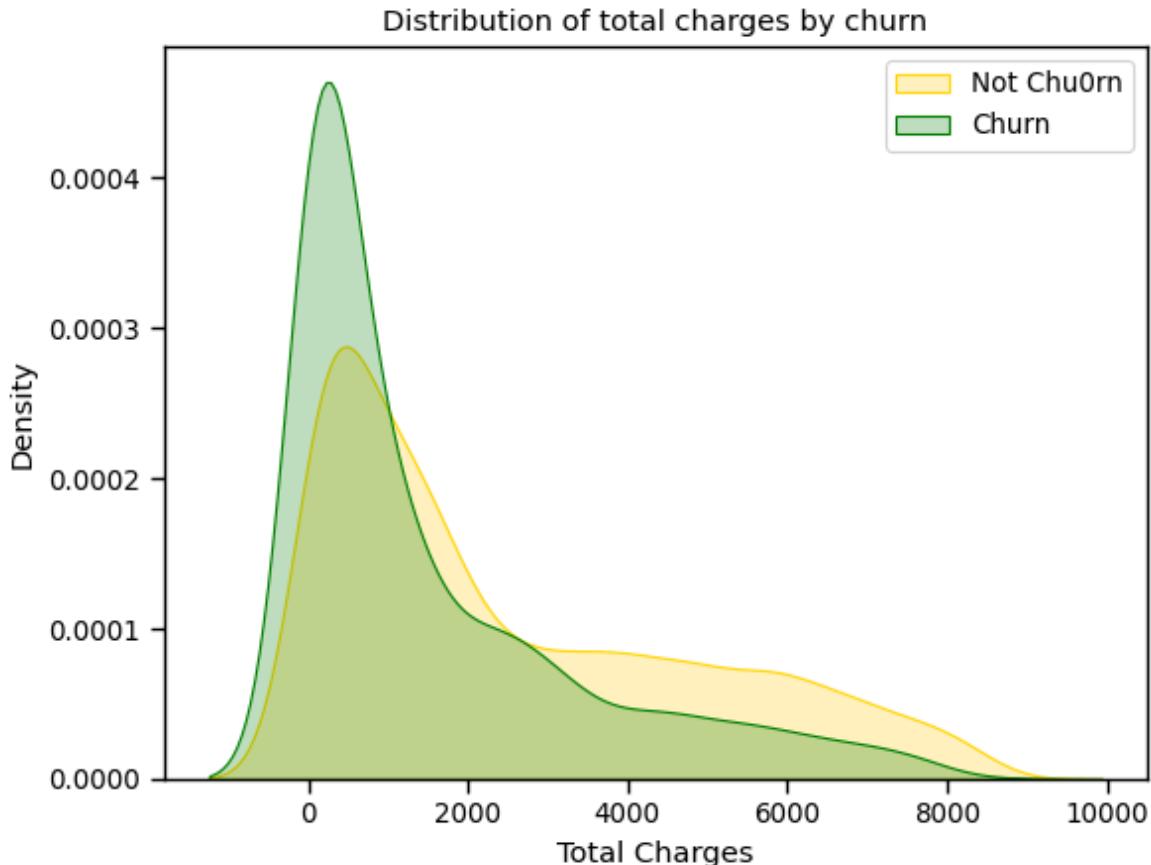
#### 4.13 Distribution of monthly charges by churn

```
In [264]:  
sns.set_context("paper", font_scale=1.1)  
ax = sns.kdeplot(df.MonthlyCharges[(df["Churn"] == 'No')], color="Red", shade = True)  
ax = sns.kdeplot(df.MonthlyCharges[(df["Churn"] == 'Yes')], ax=ax, color="Blue", shade = True)  
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**

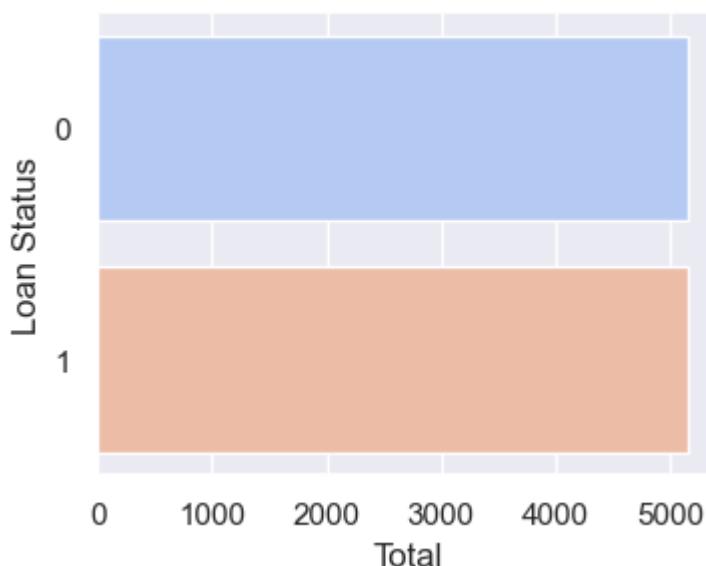
```
In [291...]: X = df.drop(columns='Churn_Yes', axis=1)
y = df['Churn_Yes']
```

## 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)
```

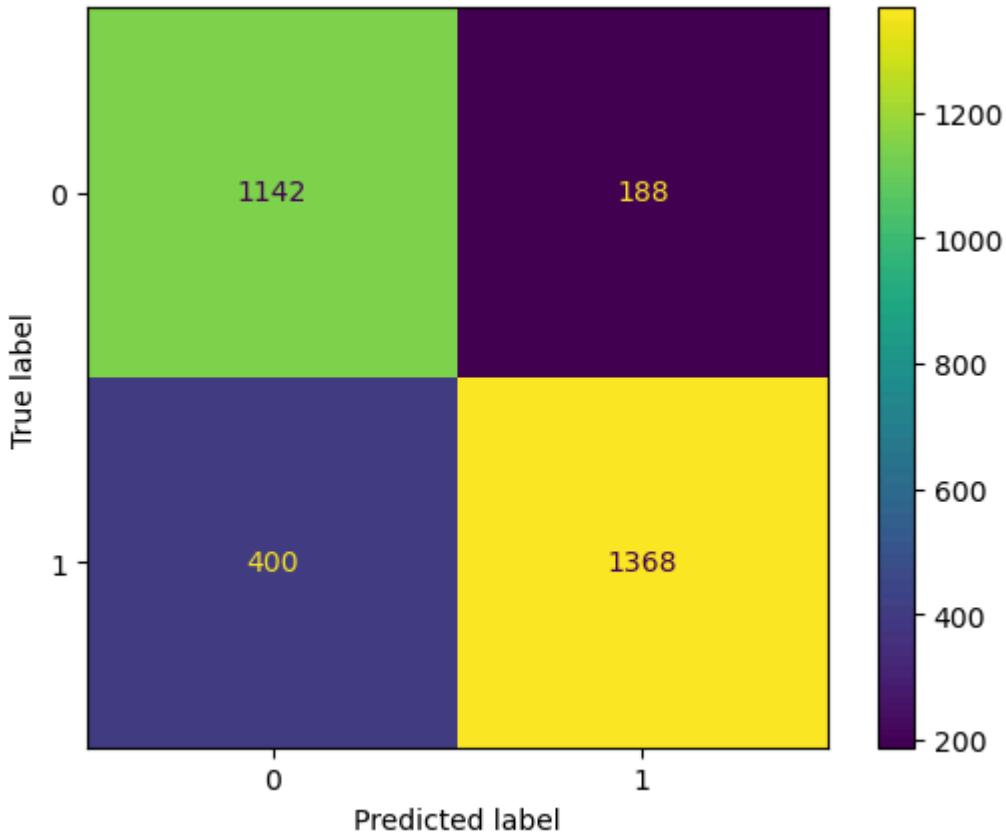
```
In [368...]: accuracy_score(y_pred, y_test)
```

```
Out[368...]: 0.8102001291155584
```

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

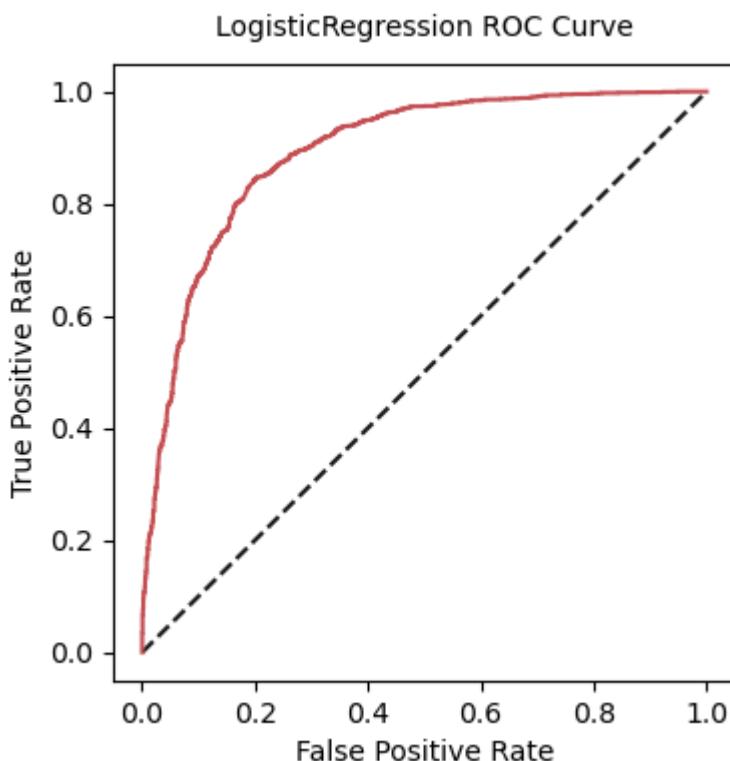
	precision	recall	f1-score	support
0	0.74	0.86	0.80	1330
1	0.88	0.77	0.82	1768
accuracy			0.81	3098
macro avg	0.81	0.82	0.81	3098
weighted avg	0.82	0.81	0.81	3098

```
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)
```

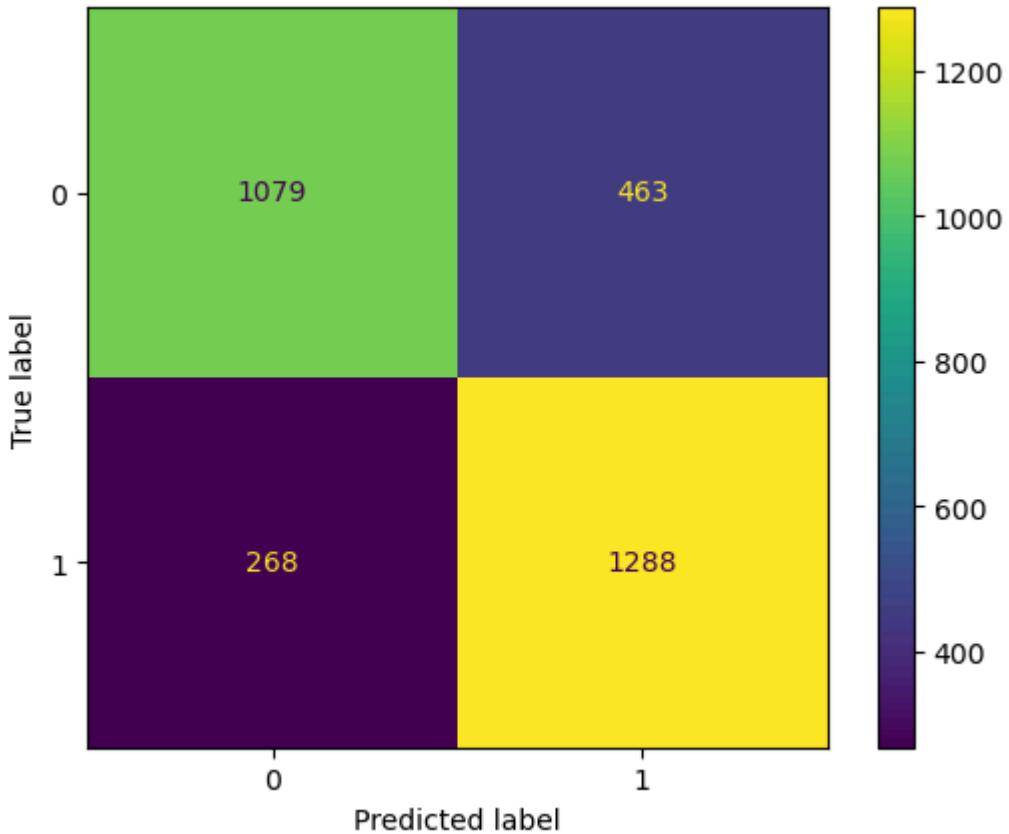
```
In [396...]: accuracy_score(y_pred,y_test)
```

Out[396...]: 0.7640413169786959

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

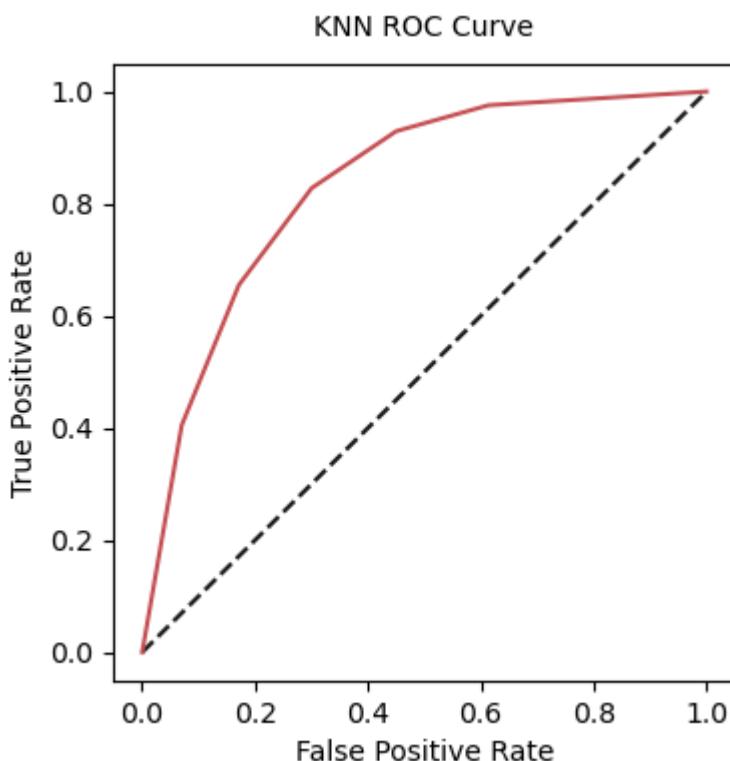
	precision	recall	f1-score	support
0	0.70	0.80	0.75	1347
1	0.83	0.74	0.78	1751
accuracy			0.76	3098
macro avg	0.76	0.77	0.76	3098
weighted avg	0.77	0.76	0.77	3098

```
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(...)
```

```
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)
```

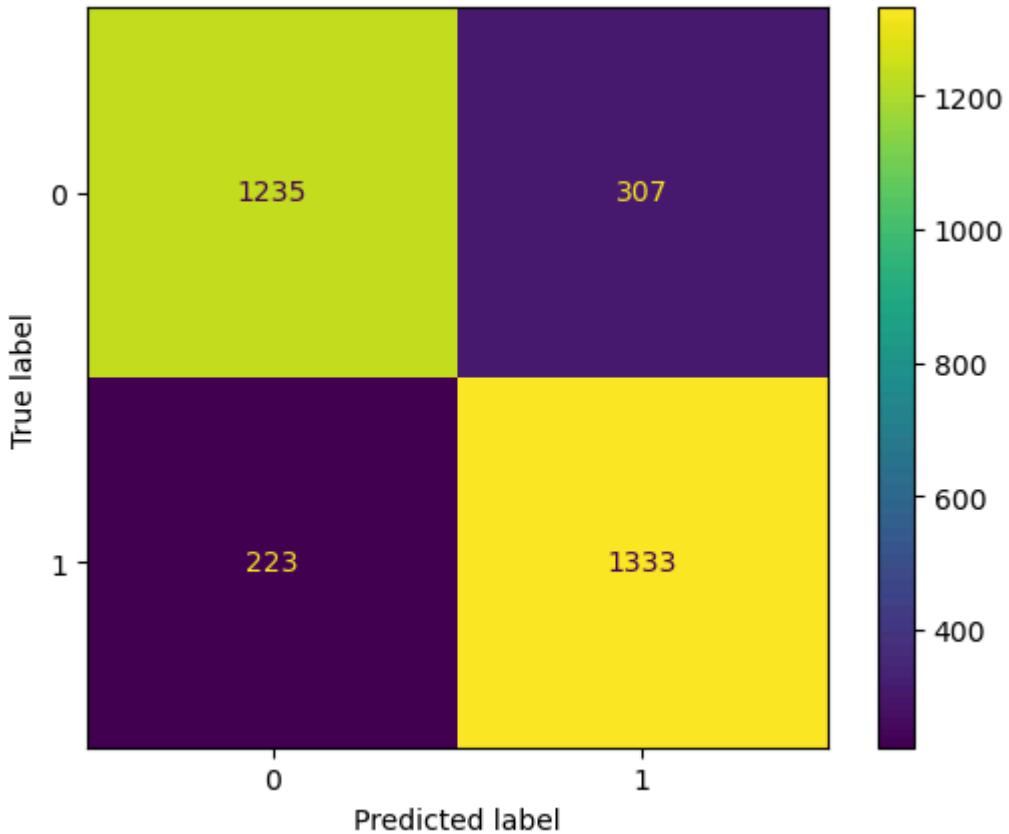
```
In [403...]: accuracy_score(y_pred,y_test)
```

```
Out[403...]: 0.828921885087153
```

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

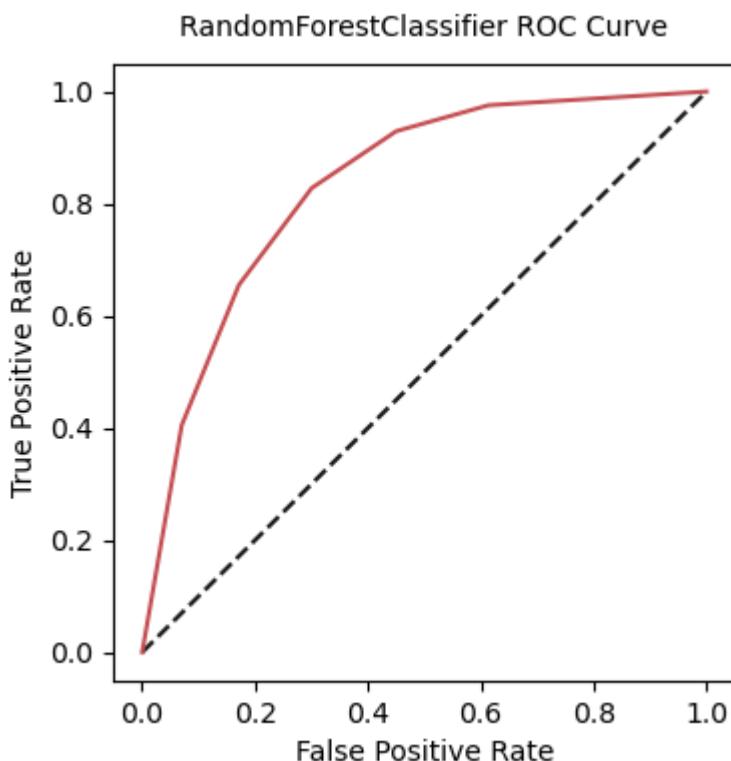
	precision	recall	f1-score	support
0	0.80	0.85	0.82	1458
1	0.86	0.81	0.83	1640
accuracy			0.83	3098
macro avg	0.83	0.83	0.83	3098
weighted avg	0.83	0.83	0.83	3098

```
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,thersold = roc_curve(y_test,proba_rf)
plt.plot([0,1],[0,1],'k--')
plt.plot(fpr_rf,tpr_rf,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)
```

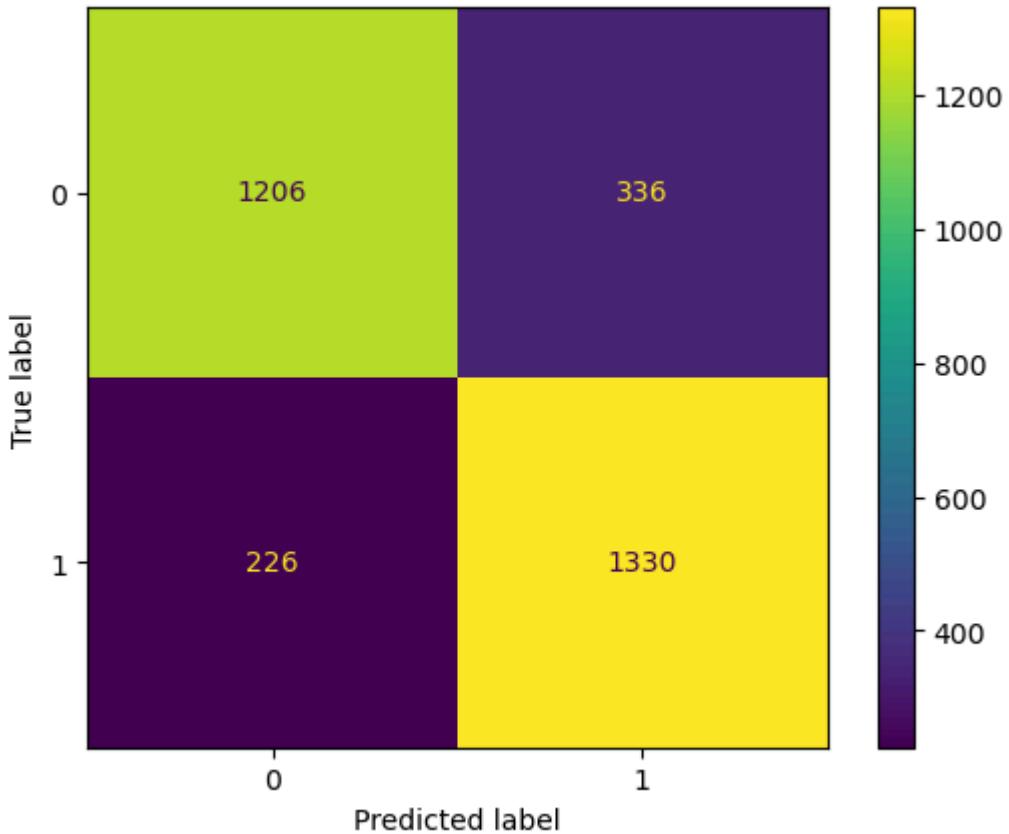
```
In [418... accuracy_score(y_test,y_pred_dt)
```

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

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

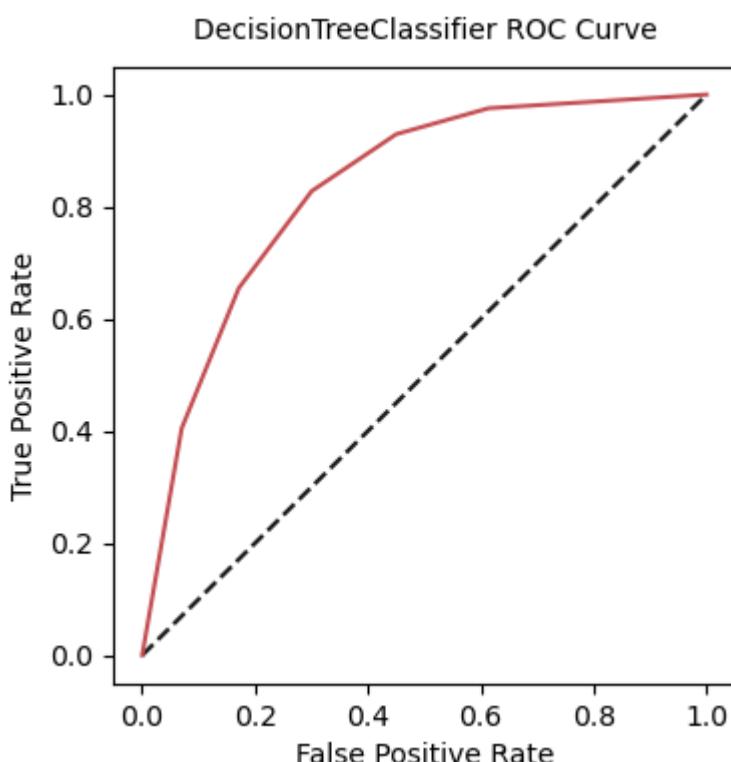
	precision	recall	f1-score	support
0	0.84	0.78	0.81	1542
1	0.80	0.85	0.83	1556
accuracy			0.82	3098
macro avg	0.82	0.82	0.82	3098
weighted avg	0.82	0.82	0.82	3098

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



In [431]:

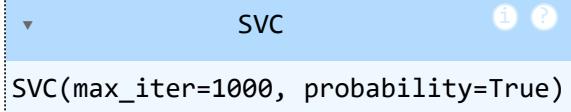
```
plt.figure(figsize=(4,4))
proba_rf = model_dt.predict_proba(X_test)[:,1]
fpr_rf,tpr_rf,thersold = roc_curve(y_test,proba_rf)
plt.plot([0,1],[0,1],'k--')
plt.plot(fpr_rf,tpr_rf,label='RF',color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('DecisionTreeClassifier 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(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))
```

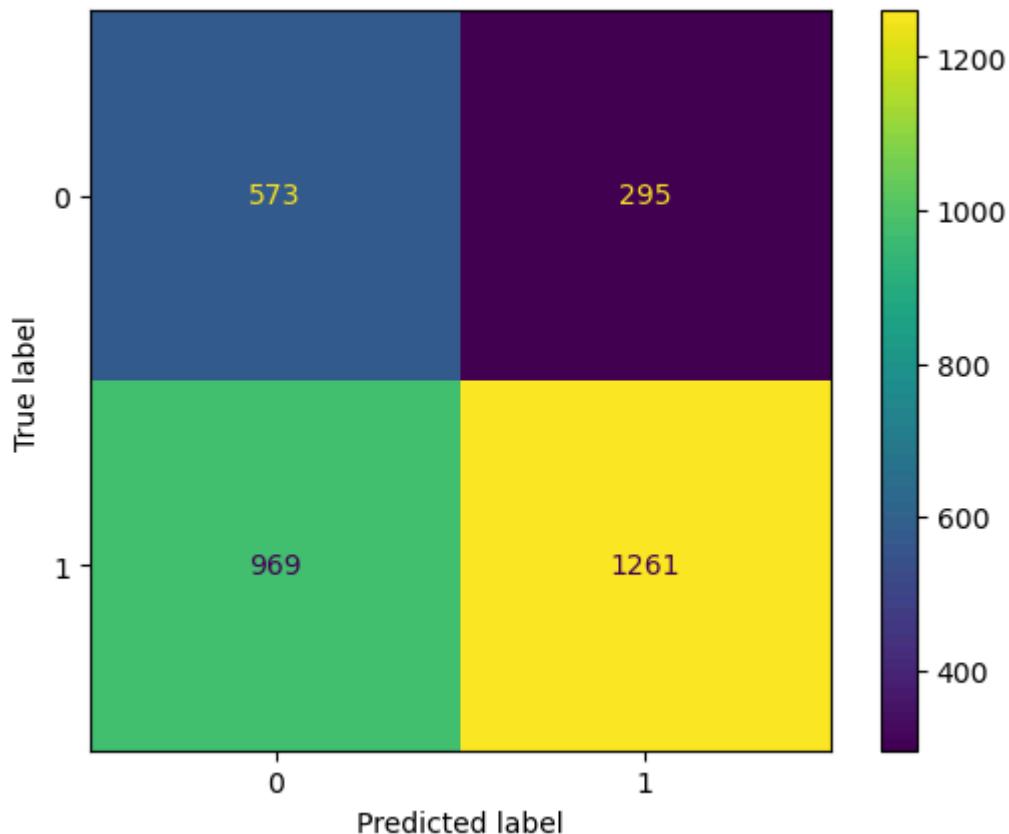
The Train Score: 0.5820420586607638  
The Test Score: 0.591994835377663

```
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()
```

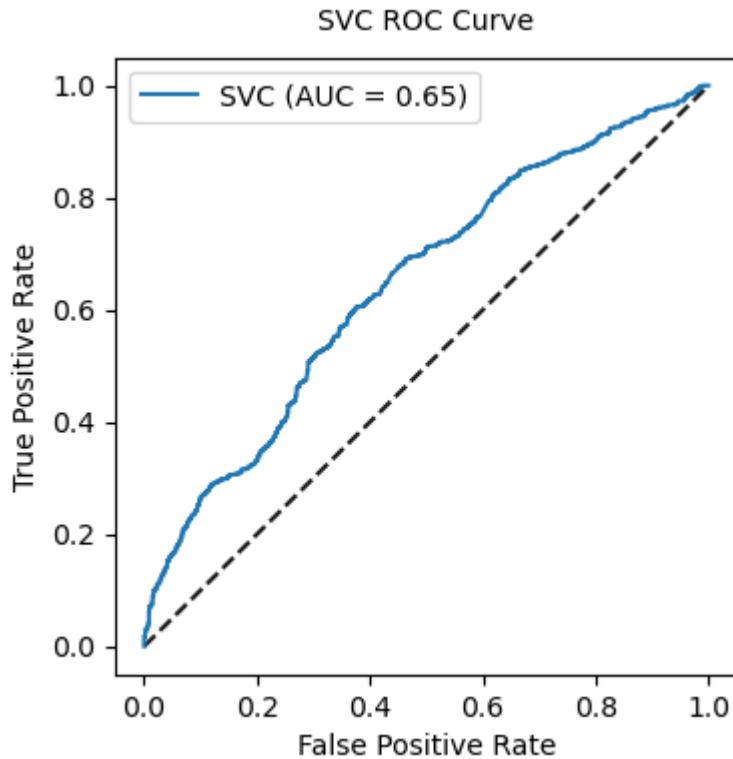


```
In [459...]: plt.figure(figsize=(4,4))
proba_svc = svc.predict_proba(X_test)[:, 1]
fpr_svc, tpr_svc, threshold = roc_curve(y_test, proba_svc)
auc_svc = auc(fpr_svc, tpr_svc)

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

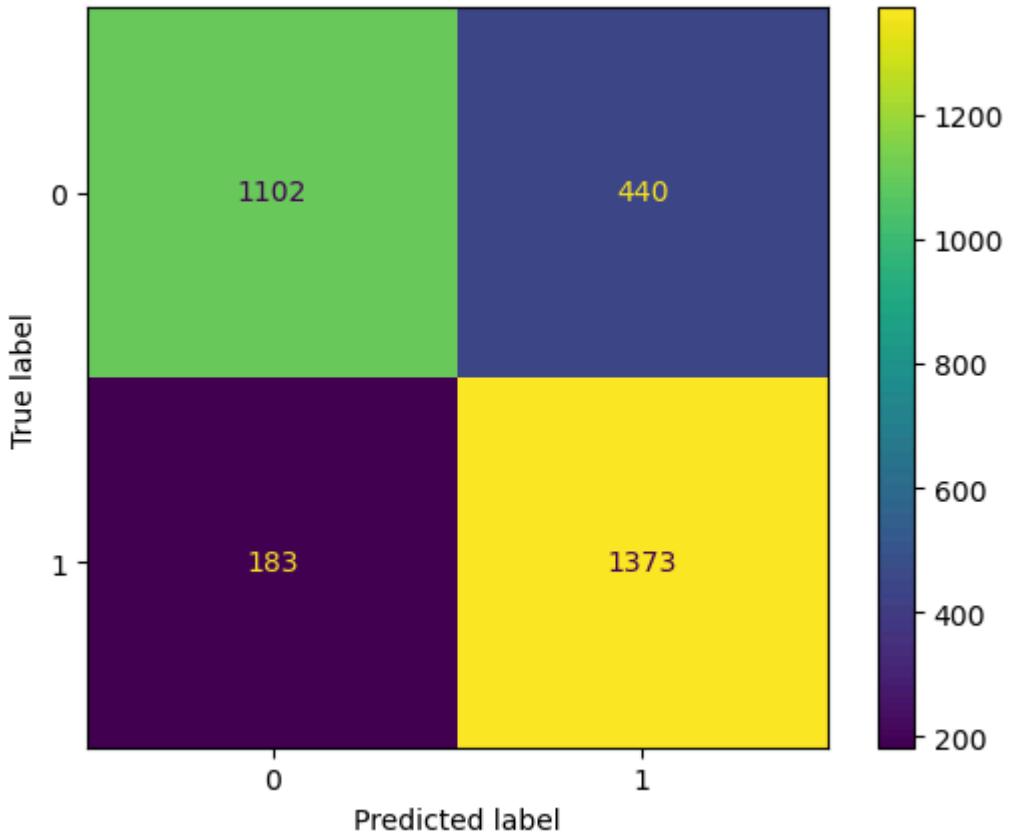
```
In [437...]: NB = GaussianNB()
NB.fit(X_train,y_train)

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))

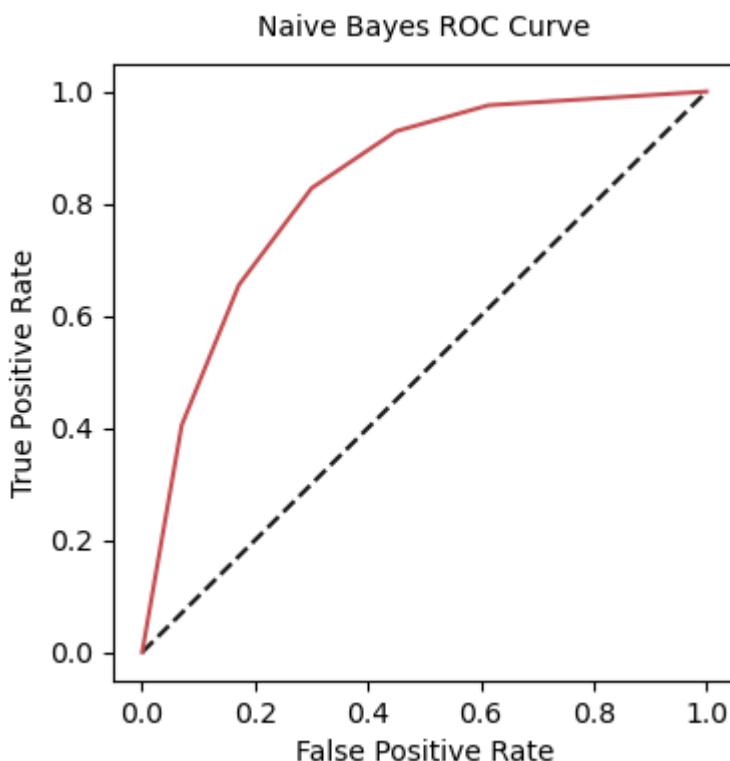
ConfusionMatrixDisplay.from_predictions(y_test, y_pred_NB)
plt.show()
```

	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_rf,tpr_rf,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...]

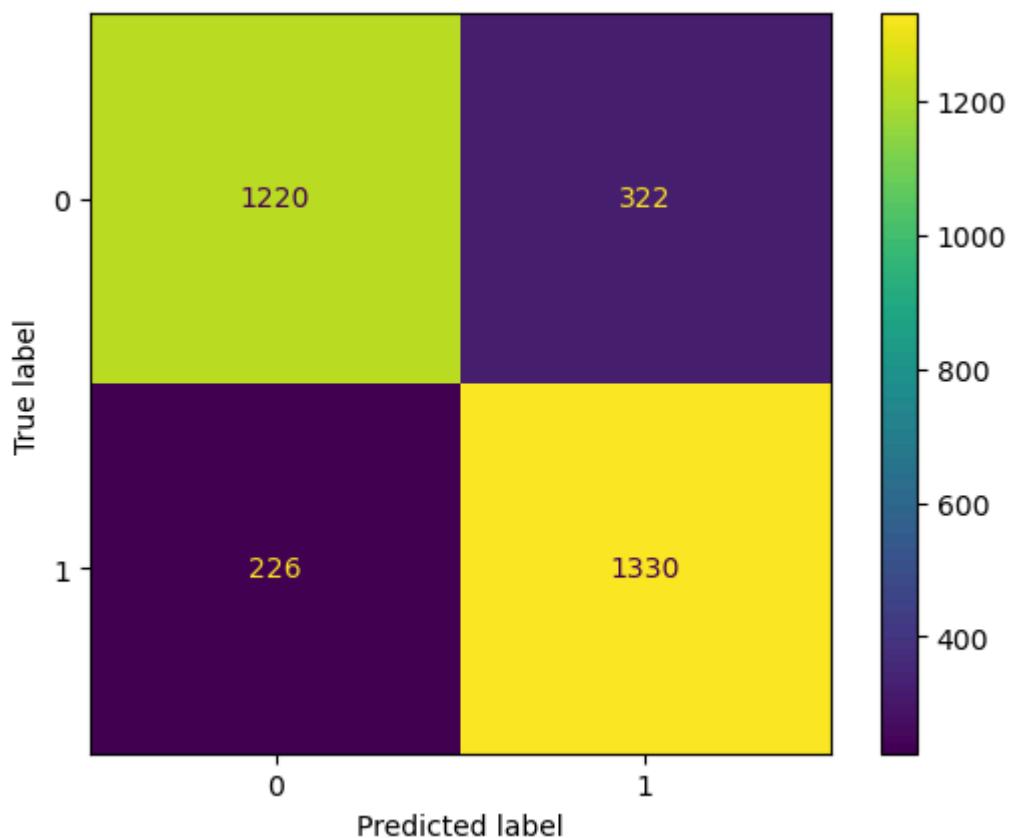
```
xgb = XGBClassifier(eval_metric='logloss', use_label_encoder=False, learning_rate
xgb.fit(X_train,y_train)
y_pred_xgb = xgb.predict(X_test)
print("Test Accuracy - XGBoost:", accuracy_score(y_test, y_pred_xgb))

print(classification_report(y_test,y_pred_xgb))

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

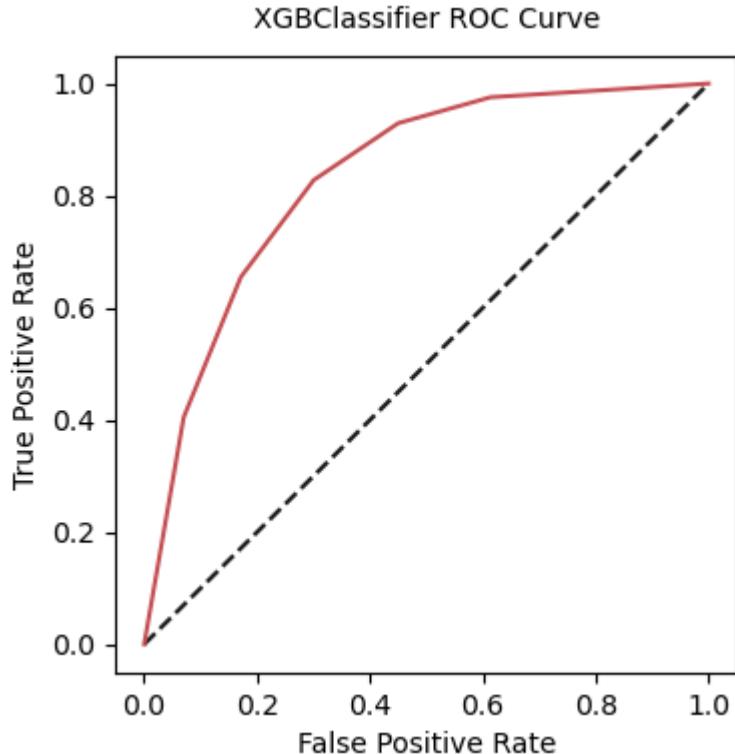
Test Accuracy - XGBoost: 0.8231116849580374

	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_rf,tpr_rf,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()
```

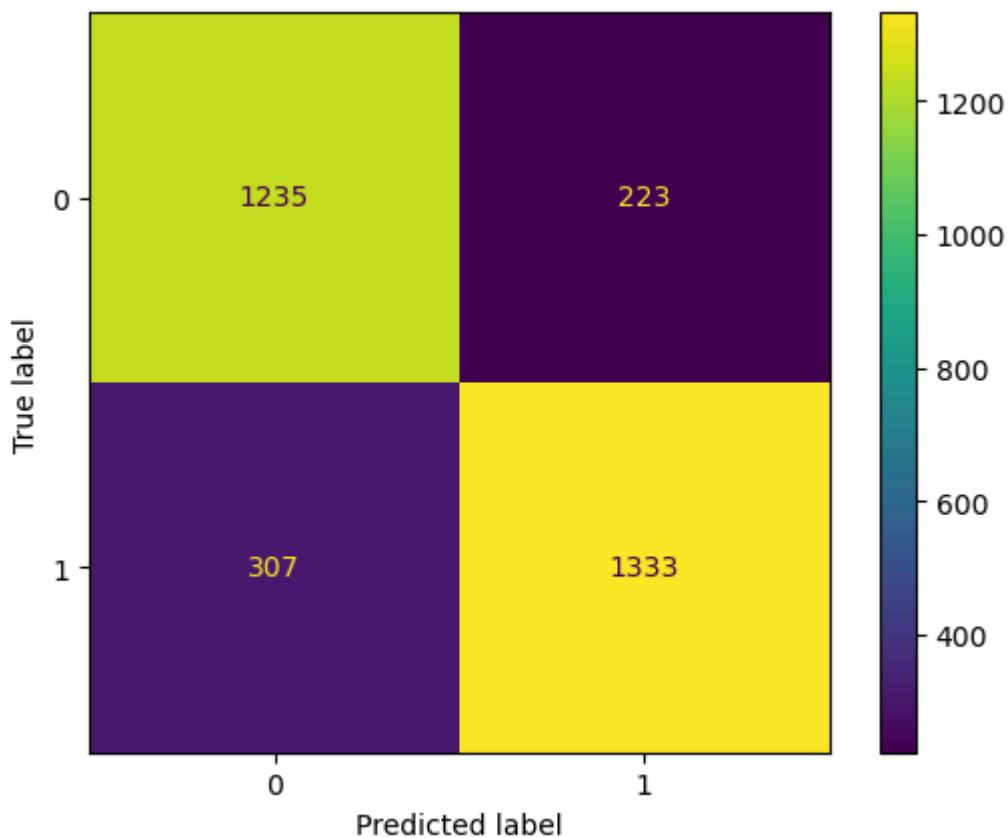


## LGBMClassifier

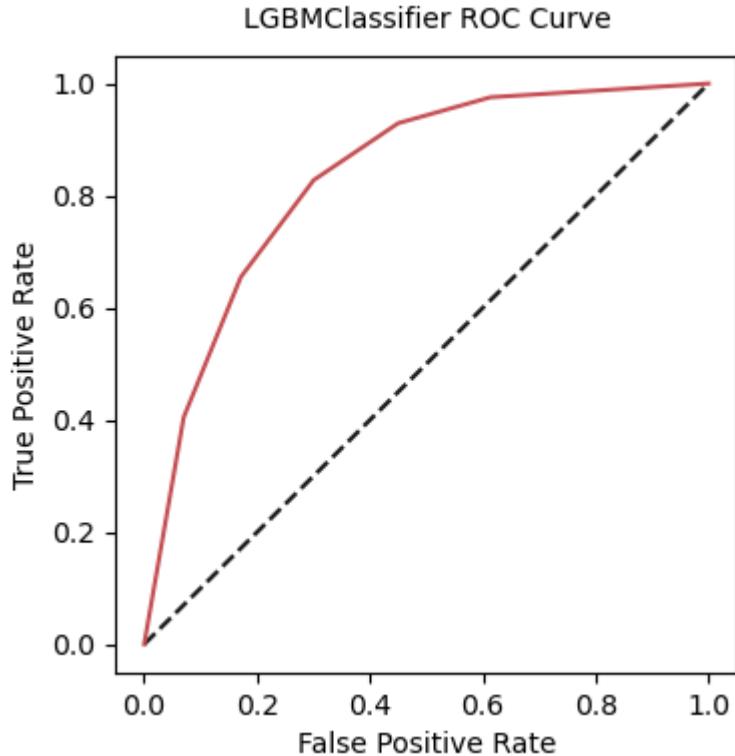
```
In [442]: lgb = LGBMClassifier(colsample_bytree = 1.0, learning_rate = 0.1, max_depth = 9  
lgb.fit(X_train,y_train)  
  
y_pred_lgb = lgb.predict(X_test)  
  
print('accuracy_score:',accuracy_score(y_test,y_pred_lgb))  
  
print(classification_report(y_pred_lgb,y_test))  
  
ConfusionMatrixDisplay.from_predictions(y_pred,y_test)  
plt.show()
```

[LightGBM] [Warning] Found whitespace in feature\_names, replace with underscores  
 [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 fea  
 tures: 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



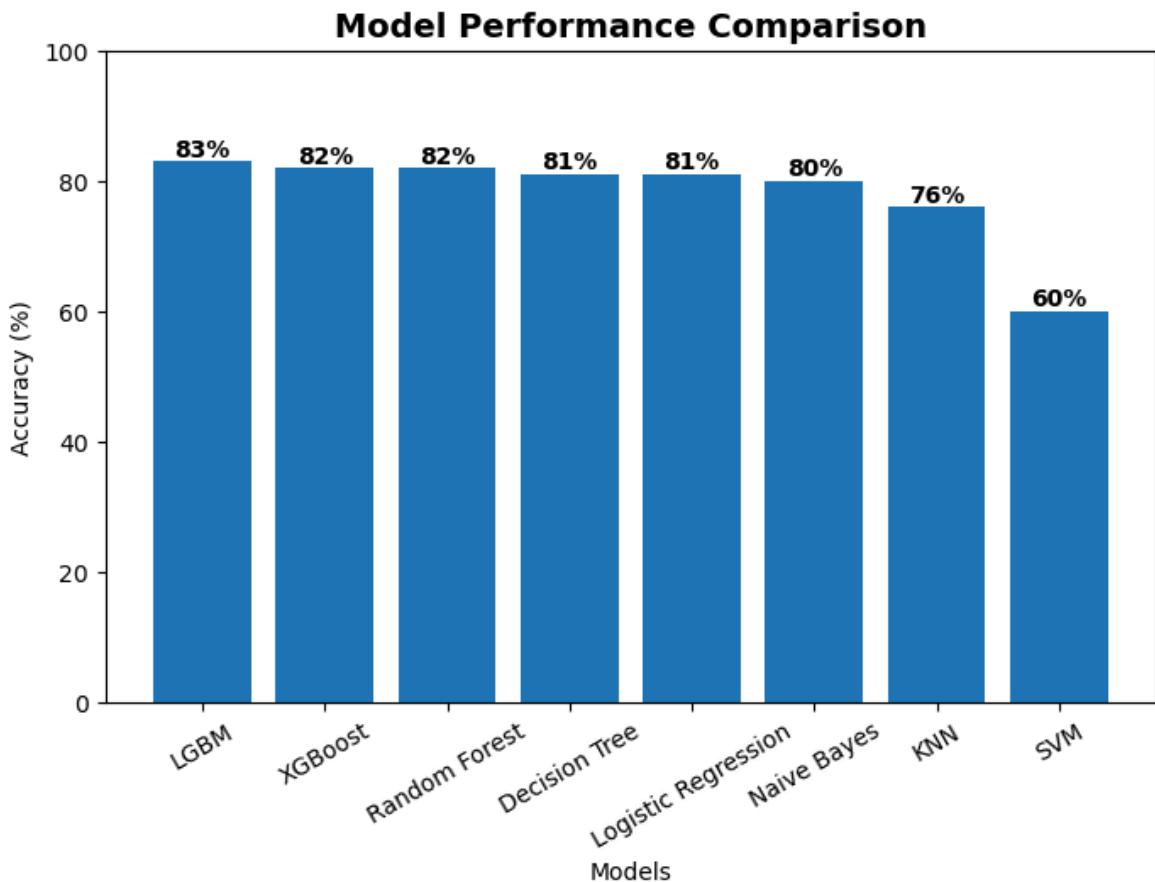
```
In [460...]: plt.figure(figsize=(4,4))
proba_rf = lgb.predict_proba(X_test)[:,1]
fpr_rf,tpr_rf,thersold = roc_curve(y_test,proba_rf)
plt.plot([0,1],[0,1],'k--')
plt.plot(fpr_rf,tpr_rf,label='RF',color='r')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('LGBMClassifier ROC Curve', fontsize=10, pad=10, size=10)
plt.show()
```



## Ranking Table

In [462...]

```
# Model scores
models = ['LGBM', 'XGBoost', 'Random Forest', 'Decision Tree', 'Logistic Regression']
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='center')
# 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 [ ]: